Manaaki Whenua
Landcare Research

ANNUAL REPORT PART 01

We present our Annual Report in two parts. Part 1 provides an overview of Manaaki Whenua, highlights of our science that show the contribution we are making towards creating value for Aotearoa New Zealand (AoNZ) through our research, people and partnerships, and an update on our strategic directions. In Part 2 we present our directors' report and financial statements.

PDF versions of both Part 1 and Part 2 are available for download from the Manaaki Whenua – Landcare Research website: landcareresearch.co.nz/report

Landcare Research New Zealand Limited
(Manaaki Whenua – Landcare Research)
Annual Report 2024

Presented to the House of Representatives pursuant to
Section 44 of the Public Finance Act 1989.

ISSN (print) 1172-7942
ISSN (web) 1177-9969

landcareresearch.co.nz

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Matt Oliver from Marlborough District Council and Manaaki Whenua soil scientist Dr Kirstin Deuss sampling soil in the Blind River area just south of Seddon, collecting data to update S-map. Image: Kim Triegaardt.

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Volucella inanis, a hoverfly introduced by scientists at Manaaki Whenua for the control of invasive German wasps. Photo: P Traub.

A word from our Chair and CEO

We are pleased to present Manaaki Whenua's Annual Report for 2023/24, the third of our Annual Reports sharing progress on "*Te Āpōpōtanga*", our current organisational strategy.

Te Āpōpōtanga established our ambition: *Kia mauriora te whenua me tōna taiao* – the life-force and vitality of the land is strong. Our science continues to focus on our core purpose, leading research into environmental issues, opportunities and solutions, improving the measurement, management and protection of terrestrial ecosystems and biodiversity, achieving sustainable use of land resources and ecosystem services, and helping industries and organisations to develop within environmental limits and meet market and community requirements.

Our science continues to be a highly collaborative undertaking, with ever more of our work undertaken in partnership with external groups. Partners across central, local and regional government, the primary sector, and iwi and hapū, help to shape Manaaki Whenua's research priorities.

Crucially, we are not industry sector or group-aligned – we work across different sectors to deliver value and build prosperity. We are well known, we have a good reputation, we are independent and we deliver excellent science. As a result, our scientists are well-positioned to help stakeholders across Aotearoa to navigate system complexities – the types of complexities that occur when science-led policies and decisions are put into practice in real life. We also remain committed to strengthening the partnership between Manaaki Whenua and iwi and hapū, as this annual report will show.

At a time of potential science sectoral change, we are working closely with other organisations across the science and research ecosystem to help inform that change and to explore how we can more effectively deliver impact for Aotearoa New Zealand.

We have enjoyed steady revenue growth over the past five years, but we are now entering a period characterised by increasing public-sector revenue uncertainties, potential reductions in future contracted work, and cost inflation. Our revenue position is outlined in Part 2 of this report.

The conclusion in June 2024 of the Bioheritage National Science Challenge, which was hosted by Manaaki Whenua over the past decade, was a major milestone (see pages 44-45 for a full report). With more than 230 research papers, 25 tools, 100 datasets – the list goes on – Bioheritage was recognised as a global leader in research culture for building the right teams and connecting with end-users, and the resulting data repository will endure into the future for Manaaki Whenua and others to use and build on.

Ahead of 2023/24, the period covered by this report, we had anticipated the current national and sectoral economic headwinds and had already begun a transformational change journey, with a focus on augmenting revenue diversification for our work plans, and on internal efficiencies for better service provision in order to ensure financial resilience – our Mahi Tahi change programme being a key component of this. We continue to actively manage for impact, further exploring opportunities to work alongside markets and commercial entities to realise a return from investments they make in climate and environment-positive actions. As a matter of priority, we are also developing a multi-sector facing commercial strategy to diversify our sources of revenue, improve our financial resilience and lift uptake of our solutions across all areas of the economy, from food and fibre to energy, tourism and finance. Implementing new commercial arrangements will help us to drive efficiency, better deploy existing funding and resources, and improve targeted outcomes.

Another key piece of organisational forward thinking, our established data and digital strategy is helping us to maintain a strong lead in eResearch. Our researchers have long been leaders in data science in Aotearoa New Zealand, particularly in remote sensing and the creation of online geospatial land management tools such as the new Whitiwhiti Ora data supermarket (see page 57). Now, we are continuing to generate value for Aotearoa New Zealand by embracing the opportunities – and challenges – of big data, deep learning, neural networks and artificial intelligence, to help solve some of our most intractable, large-scale environmental problems (see for example pages 28-29).

Digitising our collections is further extending their reach and usability, including for Māori interests, and our work over the year in attaching biocultural labels and notices where possible, places us at the forefront of international progress in supporting indigenous rights and interests over

the nationally significant databases and collections that we maintain.

With such sound organisational underpinnings, our researchers are able to create science with considerable impact. For example, an economic analysis of our work in the biocontrol of the pest weed St John's Wort showed that it has brought a return on investment of over $6200 for every $1 spent, saving around 30% of the South Island's pastureland into the process (see page 39). Our multifaceted research into landscape-scale wallaby control aims to reduce the estimated $84 million costs of this marsupial pest per annum by 2025 (see page 40), whilst in the lab our microbiologists are working with the primary sector to help understand and eliminate the problem of facial eczema in ruminants (see page 43). Combining our knowledge of primary sector practices with likely future climate change scenarios, we have also helped to quantify soil carbon stocks under different grazing regimes (see page 53) and also calculated the probable increases in milk and meat production if Aotearoa New Zealand's herds are provided with more shade to reduce heat stress in a warming world (see page 52). Our primary-sector surveys continue to be highly regarded, and our social scientists are making progress in helping all-important social licence to operate, including cultural licence to operate in pest control (see page 57).

Looking further afield, we are extending our weed biocontrol work into the Pacific, working strategically with MFAT to build biosecurity capability and resilience across the region. We are also reaching out further than ever to international research groups, with a record 61% of our published research papers having international collaborators.

Our people, of course, remain our greatest asset. We have made sector-leading progress in streamlining our systems and processes, supporting knowledge creation and enabling our scientists to concentrate effectively on their core capability – science.

We have continued to improve our infrastructure, too, including an impressive achievement in minimising our organisation's carbon emissions – down an outstanding 31% over the year (see page 73).

Finally, despite a challenging economic landscape, our subsidiary Toitū achieved a credible 8% revenue growth over the year, with over twice the business activity in emissions certification and verification compared with the previous year. Strong demand for Toitū's increasingly diversified, tailored services (see page 47) shows that businesses at a variety of scales recognise the strategic importance of helping Aotearoa New Zealand to achieve its national emissions reduction commitments.

Ngā mihi nui.

Colin Dawson – Chair

James Stevenson-Wallace – CEO

29 September 2024

He kupu nā tō mātou Heamana me te Tumu Whakarae

He koanga ngākau te tāpae atu nei i te Pūrongo ā-Tau a Manaaki Whenua mō te tau pūtea 2023/24, te tuatoru o ā mātou Pūrongo ā-Tau e tuari i te kauneke mō "*Te Āpōpōtanga*", te rautaki ā-whakahaere o nāianei.

Nā *Te Āpōpōtanga* i whakapūmau ai tō mātou awhero: *Kia mauriora te whenua me tōna taiao.* E arotahi ana tō mātou pūtaiao ki tā mātou whāinga matua, e ārahi ana i te rangahau ki roto i ngā take ā-taiao, ngā ara me ngā rongoā, e whakapiki ana i te ine, te mana whakahaere, whakamarumaru hoki i ngā pūnaha rauropi ā-papa me te kanorau koiora, te whakatutukinga i te whakamahinga pūmau o ngā rawa whenua me ngā ratonga pūnaha rauropi, te āwhina hoki i ngā ahumahi me ngā whakahaere ki te whakawhanake i roto i ngā herenga ā-taiao, me te tūtaki i ngā whakaritenga o te mākete me te hapori.

He kaupapa tino mahi tahi tō mātou pūtaiao, me te nui tonu o ā mātou mahi e whakahaeretia ana ki te taha o ngā rōpū ā-waho. Kei te tārai ngā hoa pātui puta noa i te kāwanatanga, te kāwanatanga ā-rohe, ā-takiwā hoki, te rāngai matua, ngā iwi me ngā hapū i ngā kaupapa mātāmua rangahau o Manaaki Whenua. Ka mutu, kāore mātou i te whakahāngai atu ki te ahumahi, te rāngai, te rōpū kotahi rānei – kei te mahi kē mātou puta noa i ngā rāngai ki te tuku i te uara me te whakapakari i te tōnuitanga. E mōhiotia whānuitia ana mātou, he ingoa pai tō mātou, he motuhake mātou, ka mutu, ko te pūtaiao e whakaratohia ana e mātou he kairangi. Ko te hua o tēnei mahi, kua tino rite ō mātou kaipūtaiao ki te āwhina i ngā kaiwhaipānga puta noa i Aotearoa ki te whakatere i ngā tū āhuatanga o te pūnaha – arā, ko ngā momo tū āhuatanga ka puta i te whakatinanatanga o ngā kaupapahere kua ahu mai i te pūtaiao me ōna whakatau. Ka mutu, kei te ngākau nui tonu mātou ki te whakapakaritanga o te pātuinga i waenga i Manaaki Whenua, te iwi me te hapū, e whakaaturia ai i roto i tēnei pūrongo ā-tau.

He whāinga matua te whakataunga i te marama o Pipiri 2024 o Te Wero Pūtaiao ā-Motu mō ngā Koiora Tuku Iho, he mea hautū e Manaaki Whenua i roto i te ngāhurutanga kua pahure ake nei (tirohia te whārangi 44-45 mō te katoa o te pūrongo). Me te neke atu i te 230 pepa rangahau, 25 ngā taputapu, 100 ngā huinga raraunga – haere tonu te rārangi – i āhukahuka te Koiora Tuku Iho hei kaiarataki ā-ao i te ahurea rangahau mō te hanga i ngā tīma tōtika me te honohono ki ngā kaiwhakamahi-whakamutunga, ka mutu, ka mau tonu te pātaka raraunga ka hua mai ai e mau tonu haere ake nei ki te ānamata hei whakamahi, hei whakapakari tonu mā Manaaki Whenua me ētahi atu.

I te wā o te huringa ā-rāngai pūtaiao e tū mai nei pea, e mahi pātata ana mātou ki ētahi atu whakahaere puta noa i te pūnaha rauropi pūtaiao, rangahau hei āwhina ki te whakamōhio i taua panonitanga, he tūhura hoki me pēhea te whakahāngai ake i tā mātou mahi kia nui ake ōna hua mō Aotearoa te painga.

Kua waimarie mātou i te pikinga o te whiwhinga pūtea rōnaki i roto i ngā tau e rima kua pahure ake nei, heoi anō, kei te eke mātou ki tētahi wā e whakaahuatia ana e ngā warawara whiwhinga pūtea, ngā whakahekenga torohū i ngā mahi kirimana mō ngā rā e tū mai nei me te pikinga o ngā utu. Kua whakaahuatia tō mātou tūnga whiwhinga pūtea i te wāhanga 2 o tēnei pūrongo.

I mua i te tau pūtea 2023/24, te wāhanga e whakapūrongohia ana i tēnei pūrongo, kua matakite kē e mātou ngā hau ōhanga o te wā ā-motu, ā-rāngai hoki, ā, kua tīmata kē i te haerenga panonitanga, me te arotahi hou ki te whakarahinga o ngā putanga whiwhinga hou kē mō ā mātou mahere mahi, me ngā whakapakaritanga ā-roto mō te whakapaitanga o te whakaratonga kia pai ai te manahautanga ā-pūtea – he wāhanga matua o tēnei ko tā mātou kaupapa panoni Mahi Tahi. I tēnei wā, kei te kaha whakahaere mātou i tā mātou mahi mō te nui o te whaihua te take, e tūhura ake ana i ngā arawātea ki te mahi ki te taha o ngā hinonga ā-mākete, ā-arumoni kia whai whiwhinga mai i ngā haumi ki roto i ngā mahi whaihua ā-āhuarangi, ā-taiao hoki. Hei kaupapa mātāmua, kei te whakawhanake hoki mātou i te rautaki ā-arumoni mō ngā rāngai-maha ki te whakarerekē i ō mātou mātāpuna whiwhinga pūtea, te whakapiki i tō mātou manahautanga ā-pūtea me te whakapiki i te whakamahinga o ā mātou rongoā puta noa i ngā wāhi katoa o te ōhanga, mai i te kai, te weu, te pūngao,

te tāpoi me te pūtea. Mā te whakatinana i ngā whakaritenga ā-arumoni hou e āwhina i a mātou ki te kōkiri i te māiatanga, e whakapai i te hora o te pūtea me ngā rawa o nāianei, me te whakapiki i ngā putanga i whāia.

Ko tētahi atu wāhi matua o te whakaaro whakamua ā-whakahaere, he mea āwhina tō mātou rautaki raraunga me te matihiko ki te mau kaha tonu ki tō mātou tūnga i mua i te ao o te i-Rangahau. Kua roa ā mātou kairangahau e noho ana hei kaiarataki i te pūtaiao raraunga i Aotearoa, ina koa i te rongo mamao me te waihanganga o ngā taputapu whakahaere whenua wāhi-matawhenua tuihono pērā i te hokomaha raraunga Whitiwhiti Ora hou (tirohia te whārangi 57). Ināianei, kei te whakatipu uara tonu mātou mō Aotearoa mā te pupuri i ngā arawātea – me ngā wero – o te raraunga nui, te ako hōhonu, ngā whatunga ioio me te atamai hangahanga, hei āwhina ki te whakatikatika i ētahi o ō mātou raruraru ā-taiao tino nui (mō tētahi tauira tirohia te whārangi 28-29).

Mā te whakamatihiko i ō mātou kohikohinga e whakawhānui ake ana i tō mātou toronga me te whakamahinga, tae atu ki ngā pānga Māori, me tā mātou mahi i roto i te tau e whakapiri ana i ngā tapanga me ngā pānui ahurea-koiora i ngā wāhi e taea ai te waiho i a mātou ki mua mō te wāhi ki te kauneke ā-ao i ngā mahi tautoko i ngā motika me ngā pānga ā-iwi taketake ki ngā pātengi raraunga me ngā kohikohinga ā-motu e pupuritia ana e mātou.

I runga i ngā whakaritenga tūāpapa ā-whakahaere, e taea ana e ō mātou kairangahau te waihanga pūtaiao me te papānga nui tonu. Hei tauira, i whakaaturia e te tātaritanga ōhanga o ā mātou mahi i te whakahaere ā-koiora o te tarutaru kīrearea St. John's Wort i whiwhi i neke atu i te $6200 o te haumi i te $1 i whakapaua, e tiaki ana i te āhua 30% o te whenua otaota o Te Waipounamu i roto i te tukanga (tirohia te whārangi 39). Ko ā mātou rangahau matatini e pā ana ki te whakamatua warapī e whai ana ki te whakaheke i ngā utu whakapae o te $84 miriona ā-tau o tēnei kīrearea nō Ahitereiria hei te tau 2025 (tirohia te whārangi 40), i a mātou kaikoiora moroiti e mahi ana ki te taha o te rāngai matua ki te āwhina te māramatanga me te whakakore i te raruraru o te pāpaka ā-kanohi i ngā kararehe kai-rua (tirohia te whārangi 43). E honohono ana i tō mātou mātauranga o ngā mahinga rāngai matua ki ngā momo āhuatanga panonitanga āhuarangi o te ānamata tērā tonu pea ka puta mai, kua āwhina hoki mātou ki te ine i te rahi o ngā rawa waro oneone i raro i ētahi tikanga whakataka (tirohia te whārangi 53), i tātaihia hoki ngā whakapaetanga whakapikinga i te whakaputanga o te miraka me te mīti ina ka whakaritea mā ngā māpu o Aotearoa kia nui ake te marumaru hei whakaheke i te raru o te wera i te ao e wera haere ana (tirohia te whārangi 52). Kei te whakamaungahia tonutia ā mātou rangahau rāngai matua, ā, e pana whakamua ana hoki ō mātou kaipūtaiao pāpori ki te āwhina i te whakahaeretanga o te raihana pāpori nui whakaharahara, tae atu ki te raihana ā-ahurea ki te mahi i te mahi whakamatua kīrearea.

E titiro ana ki tua atu anō, e whakawhānuitia ana tā mātou mahi whakamatua ā-koiora i te tarutaru ki roto ki te Moana-nui-a-Kiwa, e mahi rautaki ana ki te taha o MFAT ki te whakapakari i te āheinga me te manahautanga haumarutanga ā-koiora puta noa i te takiwā. E toro atu ana ki tua o tua mai mō te wāhi ki ngā rōpū rangahau o te ao, me te ekenga nui rawa o te 61% o ā mātou pepa rangahau kua whakaputaina e whai ana i ngā hoa mahi tahi nō tāwāhi.

Heoi anō, ko tō mātou tino rawa nui tonu, ko ā mātou tāngata. Kua whakatutuki i a mātou te kauneketanga arataki-rāngai i te whakapakaritanga o ā mātou pūnaha, tukanga anō hoki, e tautoko ana i te hanganga o te mātauranga, e tuku ana hoki i ō mātou kaipūtaiao kia mātua aro ake ki tō rātou āheinga matua - te pūtaiao.

Kua kaha tonu hoki tā mātou whakapai ake i tō mātou hanganga, tae atu ki te whakatutukinga mīharo i te whakahekenga o ngā pīhau waro o tō mātou whakahaere – kua heke mā te 31% mutunga rawa o te pai i roto i te kotahi tau (tirohia te whārangi 73).

Hei whakakapinga, ahakoa te wero o te whakatakotoranga ōhanga, he rawe te 8% i whiwhi ai i tā mātou whakahaere āpiti a Toitū o te whakatipuranga whiwhinga pūtea i roto i te tau, ka mutu, he neke atu i te whakaruatanga o te ngohe pakihi i ngā tiwhiketetanga me te whakamanatanga pīhau ina whakatauritea ki te tau o mua atu. E whakaaturia ana, nā runga i te pikinga o te kaha hiahiatanga ki ngā ratonga whakahāngai, whakarerekē (tirohia te whārangi 47) ahakoa te iti, te nui rānei o te pakihi kua kitea ake he mea nui ā-rautaki te āwhina i a Aotearoa ki te whakatutuki i ōna paihere whakaheke pīhau ā-motu.

Ngā mihi nui,
Colin Dawson – Heamana
James Stevenson-Wallace – Tumu Whakarae

Overview

Tirohanga whānui

We are the Crown Research Institute (CRI) for our land environment and biodiversity – an organisation of 520 scientists, researchers, and experts supporting science who are dedicated to helping the people of Aotearoa New Zealand* understand and live well with our land.

Te Āpōpōtanga, our current organisational strategy, was established in 2021. It describes our approach to creating value for Aotearoa New Zealand through our research, people and partnerships. This is the third of our subsequent Annual Reports sharing progress on *Te Āpōpōtanga*. This overview outlines the overall structure of *Te Āpōpōtanga*.

Our ambition

Kia mauriora te whenua me tōna taiao (make the life-force and vitality of the land strong).

This requires a positive reciprocal relationship between people and their natural environment – between Māori iwi and their ancestral lands.

Mauri is the Māori concept of life-force and vitality. The Māori principle of mauri expresses a deep sense of interconnectivity of people to their ancestral lands and environment. Māori trace their whakapapa (origins) to the land. The indivisible connection between people and their land is expressed in manaaki whenua – manaaki tangata (care for the land – care for the people). That phrase captures the reciprocity of our relationship. Whether Māori or not, we believe our ambition speaks for everyone.

Our purpose

Science for our land and our future – *Ko te pūtaiao mō tō tātou whenua, mō āpōpō.*

Agreed in 2010, our Statement of Core Purpose (SCP) is 'to drive innovation in New Zealand's management of terrestrial biodiversity and land resources to protect and enhance the terrestrial environment and grow New Zealand's prosperity'. Under the Crown's SCP for Manaaki Whenua, we are mandated to be the lead CRI provider for:

- improving the measurement, management, and protection of Aotearoa New Zealand's terrestrial ecosystems and biodiversity, including those in the conservation estate
- achieving the sustainable use of land resources and their ecosystem services across catchments and sectors
- improving the measurement and mitigation of greenhouse gases in the terrestrial biosphere
- increasing the ability of Aotearoa New Zealand industries and organisations to develop within environmental limits and meet market and community requirements.

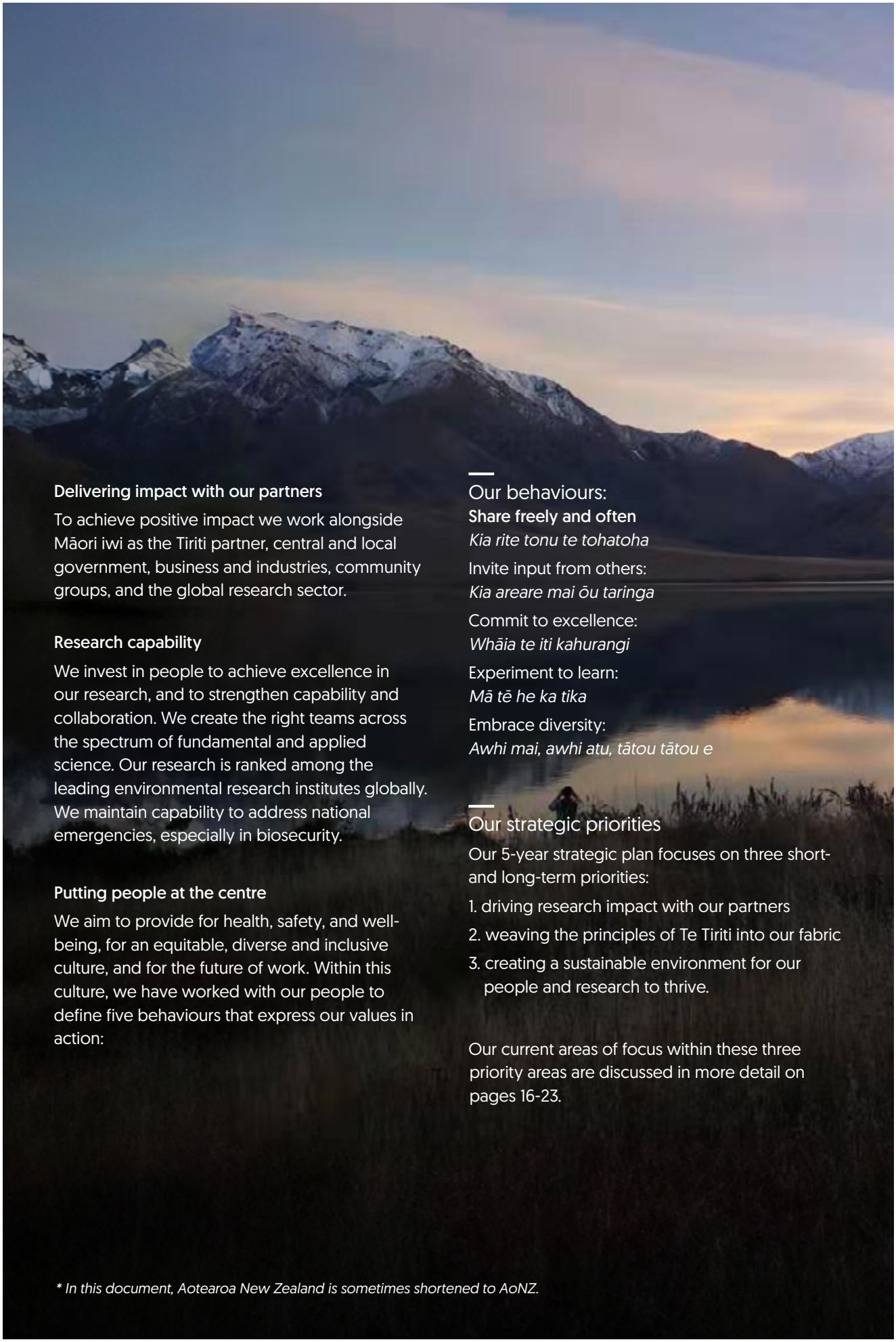
Te Tiriti

We are committed to upholding the principles of Te Tiriti o Waitangi in all our activities. These principles are Partnership, Participation, and Active Protection of Māori interests, especially in the natural environment.

Our research impacts and outcomes

We focus on four intersecting areas of research impact (see also diagram on page 26):

- enhancing soils, water and land
- restoring biodiversity, beating invasive species
- action on climate change
- people and environment.



Delivering impact with our partners

To achieve positive impact we work alongside Māori iwi as the Tiriti partner, central and local government, business and industries, community groups, and the global research sector.

Research capability

We invest in people to achieve excellence in our research, and to strengthen capability and collaboration. We create the right teams across the spectrum of fundamental and applied science. Our research is ranked among the leading environmental research institutes globally. We maintain capability to address national emergencies, especially in biosecurity.

Putting people at the centre

We aim to provide for health, safety, and well-being, for an equitable, diverse and inclusive culture, and for the future of work. Within this culture, we have worked with our people to define five behaviours that express our values in action:

Our behaviours:

Share freely and often
Kia rite tonu te tohatoha

Invite input from others:
Kia areare mai ōu taringa

Commit to excellence:
Whāia te iti kahurangi

Experiment to learn:
Mā tē he ka tika

Embrace diversity:
Awhi mai, awhi atu, tātou tātou e

Our strategic priorities

Our 5-year strategic plan focuses on three short- and long-term priorities:

1. driving research impact with our partners
2. weaving the principles of Te Tiriti into our fabric
3. creating a sustainable environment for our people and research to thrive.

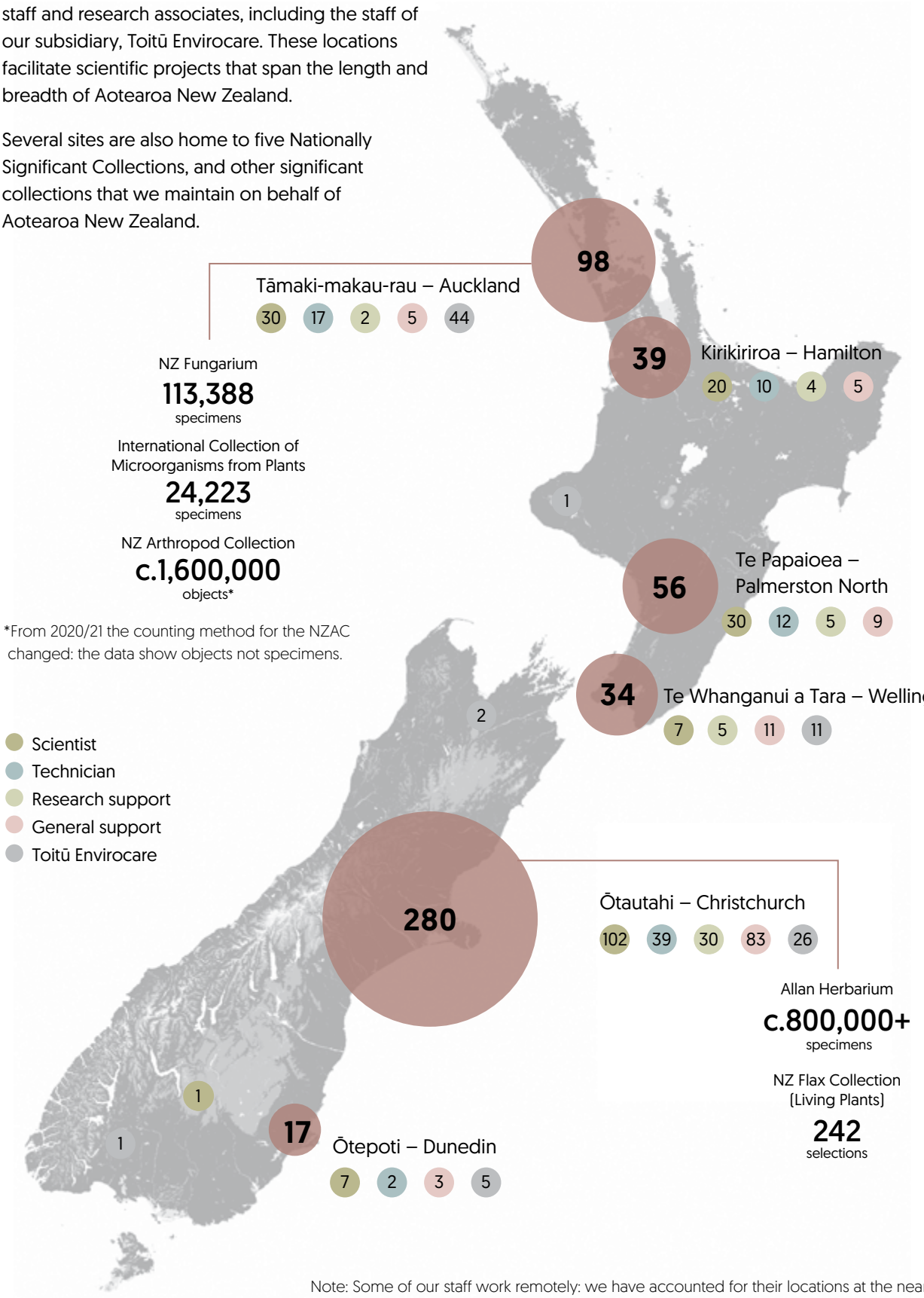
Our current areas of focus within these three priority areas are discussed in more detail on pages 16-23.

** In this document, Aotearoa New Zealand is sometimes shortened to AoNZ.*

Our locations

Our sites across Aotearoa New Zealand house 520 staff and research associates, including the staff of our subsidiary, Toitū Envirocare. These locations facilitate scientific projects that span the length and breadth of Aotearoa New Zealand.

Several sites are also home to five Nationally Significant Collections, and other significant collections that we maintain on behalf of Aotearoa New Zealand.



NZ Fungarium
113,388
specimens

International Collection of Microorganisms from Plants
24,223
specimens

NZ Arthropod Collection
c.1,600,000
objects*

*From 2020/21 the counting method for the NZAC changed: the data show objects not specimens.

- Scientist
- Technician
- Research support
- General support
- Toitū Envirocare

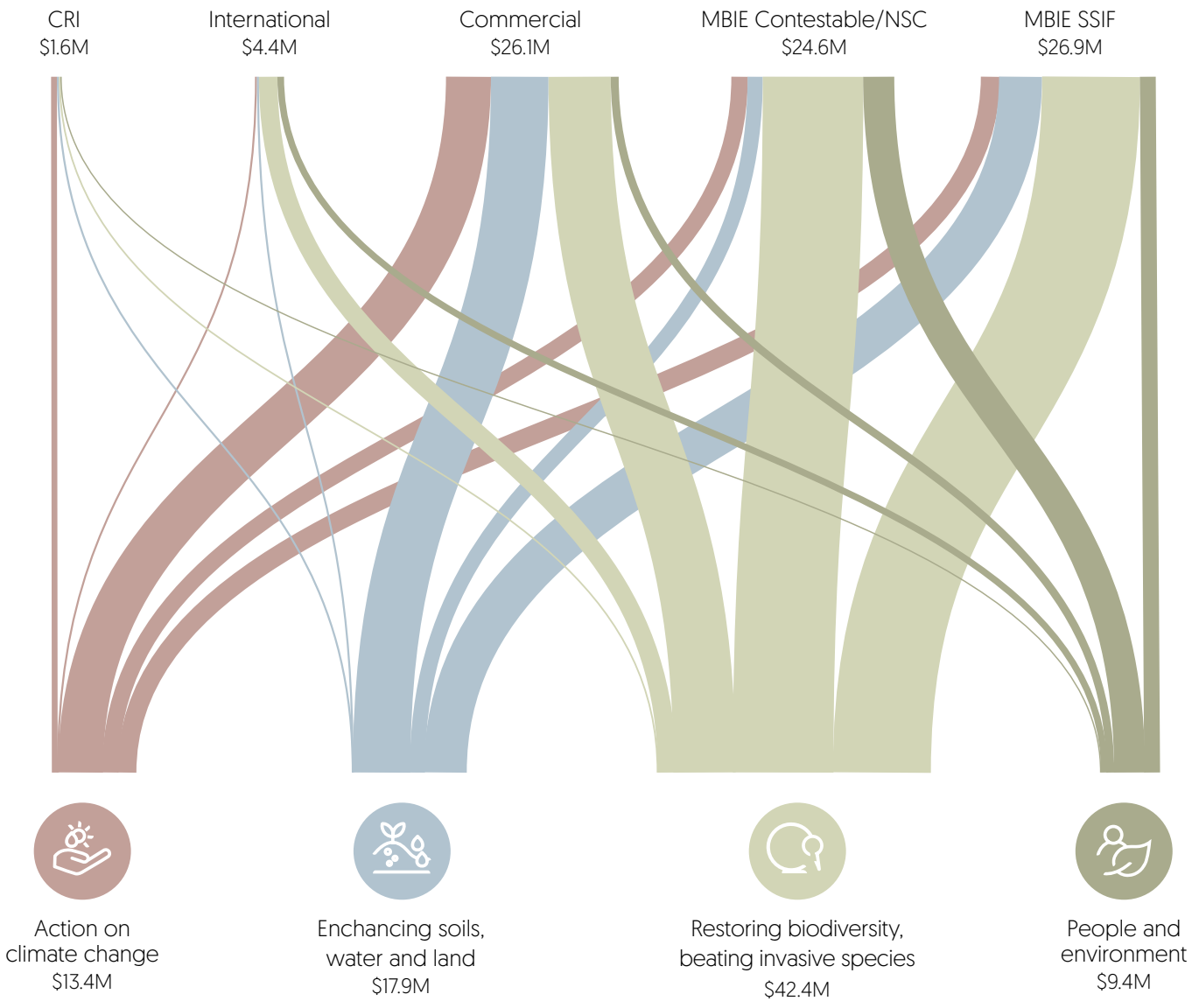
Allan Herbarium
c.800,000+
specimens

NZ Flax Collection (Living Plants)
242
selections

Note: Some of our staff work remotely: we have accounted for their locations at the nearest site.

Our investments in research impacts

Investment in our science, research, and technology comes from a variety of sources, including central and local government in Aotearoa New Zealand, industry, and international science collaborations. The following diagram is based on science revenue information for 2023/24 rather than on audited information.



Note: this diagram shows provisional revenue amounts for 2023/24. Full audited revenue amounts are shown in Part 2 of the Annual Report.

Collections and databases

Manaaki Whenua is the custodian of almost a third of AoNZ's Nationally Significant Databases and Collections. These include biological resources (e.g. reference species collections), cultural knowledge, and soil and land resources. They are important scientific, cultural, and historical public good assets. These collections provide base knowledge critical to improving the conservation of AoNZ's land-based biodiversity, including species of importance to Māori. They also provide important reference collections for identifying biosecurity risks.

In addition to our collections, we maintain a number of online databases and tools (many of which are nationally significant) that provide detailed information about our land, soils, biodiversity, biosecurity, and environment for use by our scientists and researchers, and for many other scientists, researchers, postgraduate students, government departments, regional councils, and industries across AoNZ and around the world.

Manaaki Whenua acknowledges the importance of our collections and databases for all of Aotearoa New Zealand. We also give effect to Te Tiriti, with our commitment to reconnect iwi and hapū to Manaaki Whenua's collections and databases of relevance. This is based on the relationship that tangata whenua have with their land, and extends to include anything collected, sampled or measured from, that land. This connection is informed by the principles of Te Tiriti o Waitangi, the WAI262 claim and indigenous data sovereignty. See the selected highlights below for some examples of progress in building these connections.

The principles of Te Tiriti o Waitangi increasingly informs how we approach and engage with our Māori partners and set our research agendas. Manaaki Whenua's Statement of Commitment to Te Tiriti has been in place now for 3 years, during which time a strong theme of Māori data governance has begun to emerge. This is in part due to the momentum that has been created over this period by the Te Tiriti Partnership Group (TTPG – see page 21). However, external drivers are also at play, influencing the direction of impact, including the recent report of Te Kāhui Raraunga on Māori data governance, as well as an increasingly Te Tiriti-informed authorising environment.

Manaaki Whenua continues to forge a path that builds bicultural capability for its people and both supports and encourages reflection on our Te Tiriti commitment throughout the breadth of research.

Selected highlights

Digitising our collections provides an opportunity to do some scientific curation of specimens which may result in new discoveries. This year a new exotic wasp which attacks exotic spiders was found: a predator host relationship unknown in the wasp's natural range.

We have been working with Te Uri o Hau and Ngāti Koata to extract a full list of holdings from their rohe in the nationally significant biological collections. We provided training material on how to extract this information from the online Species Collection Database. The opportunity was taken to correct any anomalous georeferences associated with the rohe collections.

Kuia Sarah Tangitu from Katikati (hapū Te Rereatukahia) selecting harakeke for the Western Bay Museum's new pā harekeke. Image: Kim Triegaardt.

Biological collections are a major source of environmental information beyond their primary purpose of taxonomic research. The NZ Arthropod Collection is working with Te Papa Tongarewa Museum of New Zealand to locate collections of native, bumble and honeybees and look at what pollen they have been collecting. This will be compared with current feeding preference by living bees to discover what effect changing vegetation and species competition has had on pollination preferences. This long-term data will allow better understanding of pollinator competition, especially between exotic and native species, and their roles in successful plant invasion.

During the process of moving and replanting the flax collection Te Kohinga Harakeke – National New Zealand Flax Collection at our Lincoln site we have strengthened several relationships. We have supplied Ngāti Kuia with 28 harakeke plants (pu/fan/tiller) to start a new pā harakeke on hapū land at Tītīraukawa, Pelorus Sound. The pā harakeke is part of a larger project with a kānuka plantation, an oil distillery, and honey production facility.

We have developed a proof-of-concept web-based software tool that allows users to query a collection such as Te Kohinga Tipu o Aotearoa/Allan Herbarium, to decide whether there is value in making a collection of an observed species. The tool can be used to see if a species has been collected from a site before and when. The species may not have been collected before, hasn't been collected for many years, or was collected at a different time of year, e.g. flowering versus non-flowering. This information can then be used to make an informed decision. The tool was developed for use by Manaaki Whenua collection managers and researchers but has potential application for the Department of Conservation (DOC) and other land managers.

We were contracted to determine whether the bacterium *Gluconacetobacter diazotrophicus* was present in AoNZ soils. This bacterium is nitrogen-fixing in non-legume plants, leading to a potential reduction of application of nitrogen fertilisers. We surveyed plants known to be good hosts for *G. diazotrophicus* elsewhere in the world – plants with a high sugar content such as sugar cane, banana, and pineapple – all grown in the north of New Zealand, but the bacterium could not be detected. This means that if products containing *G. diazotrophicus* are imported into AoNZ they will require approval under the Hazardous Substances and New Organisms Act and the Biosecurity Act.

COLLECTIONS DATA FOR 2023/24

New Zealand Fungarium (PDD)

landcareresearch.co.nz/pdd

113,388	Specimens
3,874	Accessions
1,855	Objects sent or received in 37 transactions

New Zealand Flax Collection

landcareresearch.co.nz/harakeke

242	Selections
403	Plants sent in 26 orders
155	Visitors

International Collection of Microorganisms from Plants (ICMP)

landcareresearch.co.nz/icmp

24,223	Cultures
145	Orders sent
1,203	Cultures sent

New Zealand Arthropod Collection (NZAC)

landcareresearch.co.nz/nzac

c. 1.6M	Objects
27	Loans
1,237	Identification & enquiries

Allan Herbarium (CHR)

landcareresearch.co.nz/allanherbarium

c. 800,000	Specimens
1,714	Specimens sent
382	Identification & enquiries
223	Visitors

DATABASES

National Vegetation Survey Databank (NVS)

nvs.landcareresearch.co.nz

121	New datasets
785	Plots added
7,154	New datasets downloaded or distributed

Ngā Rauropi Whakaoranga (Māori plant names database)

rauropiwhakaoranga.landcareresearch.co.nz

2,408	Database records

Land Resource Information Systems (LRIS) Portal lris.scinfo.org.nz

790,411	Page views across all portal services
190,839	Total users
16,630	Registered users

Our context

Tō tātou horopaki

Aotearoa New Zealand needs our science to solve growing environmental and social challenges. These challenges are complex, with large uncertainty, high stakes, and polarised views. Our role is to support and lead action with evidence-based understanding and capability, finding solutions from integrating our work with the work of others.

The context for our science begins with our Crown ownership and the expectations of our shareholding Ministers. The Government has laid out clear priorities for Aotearoa New Zealand that must inform our strategy and science priorities, including zero carbon, predator-free, and goals for freshwater.

To ensure our science stays relevant and on track to meet local, regional, and national needs, we adopt co-design principles wherever possible, including two Advisory Panels that draw on external expertise: one panel of scientists and one of stakeholders from government, iwi and industry.

Beyond Aotearoa New Zealand, our internationally respected scientists are involved in global efforts to address the many challenges posed by climate change and sustainability.

Mycologist Dr Peter Johnston (left) and PhD student David Hera with a fungi find in Mangapapa Conservation Area near Rotorua.
Image: Kim Triegaardt.

Aotearoa's science priorities

As this Annual Report shows, in 2023/24 we significantly contributed to priorities for the Government expressed in our shareholding Minister's Letter of Expectation.

Our guiding strategy, *Te Āpōpōtanga*, and our annual portfolio work programme organise our activities to ensure we connect back to our core purpose. Our Senior Leadership Team (SLT) reviews these plans regularly, provides oversight, and monitors progress and performance.

We will continue to deliver agile, timely, and collective responses to environmental issues that require multi-agency collaboration, and we will continue to strengthen our relationships with our Te Tiriti partners.

We are currently embedding an impact-based framework to assess our activities and the areas in which we invest. This framework guides our activities towards areas most likely to lead to real change for Aotearoa New Zealand.

Our 5-year revenue plan highlights the need for us to further deepen and diversify our commercial activities and private-sector relationships. We continue to explore opportunities to work alongside markets and commercial entities to help them realise a return in climate- and environment-positive actions from their investments.

We recognise the constrained fiscal environment and the need to remain financially responsible. We have an active work programme, focused on both lifting performance and maintaining our financial resilience, to ensure we generate a return on shareholder funds. We monitor investment decisions very closely to ensure value for money.

Dr Angela Bownes sampling water at the Clutha River, Albert Town, as part of an investigation into the native and exotic environment of the pest aquatic plant Lagarosiphon major *(also known as oxygen weed). Image: Arnaud Cartier.*

Stakeholder input

Manaaki Whenua's partner base is very broad because the natural environment touches every part of society. With a broad partner base comes a diversity of needs; but our partners have many interests in common. Our partners' interests in biodiversity, land, and water have remained consistent. Within the past decade, action on climate change has become a major theme.

By contrast, the complexity of our partners' needs has evolved quickly, and finding solutions is more urgent. Within a decade our partners have needed to integrate responses to multiple themes into their strategies, find new ways to engage with communities and address Māori aspirations, and manage higher levels of risk and uncertainty.

To understand the needs of partners more deeply we have established a range of forums with different target partner groups. These include science exchanges, co-development of research and science needs with central and local government industry bodies such as Beef+Lamb and DairyNZ; and project-focused forums covering a range of audiences, including Design Thinking workshops with members of the public. Our target is to engage more research providers in joined-up efforts of this nature.

Our Board's **Outcome Advisory Panel** (OAP) provides advice to help us fulfil our Statement of Core Purpose through strategic alignment and collaboration with key users of our science, and to provide insights and advice into diversification of our customer base. Membership of the panel spans the breadth of our major sectors, partners and research interests and consists of senior representatives from key stakeholder organisations in central and local government, iwi, and the food and fibre and energy sectors. We are also inviting the tourism and finance sectors.

The Panel meets bimonthly with representatives of our SLT and annually with the Board and SLT to explore and clarify the needs of Māori enterprise, central and local government, and Industry. The OAP provides an opportunity to explore the challenges that they are facing and providing high-level strategic advice to our Board of Directors. We continue to improve Māori input, connectivity, and our understanding of the needs of Māori, industry, and government. Effective engagement, strategic alliances and plans continue to progress with specific regional councils and central government entities (MfE, MPI, DOC) and industry.

This year the Panel has explored the challenges in government reform and fiscal realignment, specifically the opportunities that could emanate from this and the coalition government refocusing that aligns to Manaaki Whenua's science products. As Manaaki Whenua is reassessing how impact can be achieved through the uptake of science, the panel provides the opportunity to explore diversification of its client base and the broader progress to economic recovery and the impact on the ability of science information to be taken up, applied and the progress towards their environmental goals. Future OAP sessions will explore how pathways to impact can be facilitated through senior leadership interaction of the panel. The OAP provides a valuable connection with the Board on contributing to broader iwi, government and industry direction.

Our Science Advisory Panel (SAP) brings an international scientific perspective, helping us evaluate our scientific excellence, explore emerging science needs, and develop research areas. In the 2023/24 financial year we reviewed our biodiversity and biosecurity research excellence over the past 4 years. For this we constituted a new panel to ensure we had the correct breadth and depth of expertise needed. The SAP included members from overseas. We completed the review in early December 2023, and the SAP report and recommendations were presented to the Manaaki Whenua Board.

In the upcoming 2024/25 financial year we will undertake a similar review of science excellence for our soils, land-use, and climate change research. Following the same process used for the 2023/24 review, we will convene a panel with the most appropriate skills and knowledge in these areas.

Our strategic pillars

Ō mātou pou rautaki

Our main strategic pillars, current focus and ongoing priority initiatives, both within and external to Manaaki Whenua, are summarised below and explained in the following pages.

Strategic pillar 1

Drive research impact with our partners

Together with our partners we will prioritise Aotearoa New Zealand's needs from research (now and in the future) and develop strategic investment pathways. Research impact will be accelerated through user-centred developments. We will leverage data and digital technologies where they add value.

Strategic pillar 2

Weave the principles of Te Tiriti into our fabric

The Tiriti principles will guide Manaaki Whenua to a balanced state of partnership; in finding inspiration and value while engaging science and mātauranga; in influencing our strategic leadership towards equitable outcomes; and in growing both the number of Māori in the organisation and our networks among iwi and hapū.

Strategic pillar 3

Create a sustainable environment for our research and people to thrive

We will ensure our people have the right environment and personal development in which to work to their greatest potential, so that Manaaki Whenua fulfils its national role and sustains and grows its national and global impact.

For each of these three strategic pillars, our current focus as an organisation is as follows:

Strategic pillar 1

- *Impact Management Framework*
  A framework to enable our science to increase its environmental, economic and social impact.
- *Data and digital transformation*
  Leveraging data science and digital technology to increase the impact of our research.

Strategic pillar 2

- *Building our capacity to partner with Māori*
  Developing our bicultural competencies to help honour our Te Tiriti commitment.
- *Partnership in the collections and databases*
  "Connect before you collect" – early engagement with hapu and iwi.
- *Partnering with Māori for impact*
  Engaging deliberately with Māori businesses.

Strategic pillar 3

- *Mahi Tahi: Working Together*
  Ensuring our people have the processes and systems they need to deliver high-impact research.
- *Future of our Auckland campus*
  Investigation of pooling resources with Plant & Food Research.
- *Future of work*
  Helping our people to find the combination of environment, tools, and approaches to best achieve their daily goals.

Mycologist Dr Bevan Weir has collaborated with Plant & Food Research on several SFFF-funded projects to assess the feasibility of growing peanuts in New Zealand.

Strategic pillar 1

Drive research impact with our partners

This strategic pillar sets the core direction for Manaaki Whenua, supported by strategic pillars 2 and 3.

Our research has impact when it is valued and used by our partners and contributes to meaningful, positive change for society and the environment. AoNZ's environmental issues are broad, but our research resources are limited, so it is essential we work on the major priorities and accelerate the impact of that work in partnership.

Our current priority initiatives within this pillar are:

1.1: Impact Management Framework
Manaaki Whenua uses the Crown Research Institutes' Impact Planning and Evaluation Network (iPEN) impact creation cycle to conceptualise how impact from science is generated. While in reality this is more an iterative than a linear process, the cycle presents the key stages and activities required.

Progress in 2023/24
The newly-developed Manaaki Whenua Impact Management Framework seeks to identify opportunities and address barriers to increase the environmental, economic, and social impact of our work. It helps our scientists to explore and score the development of impact by asking key questions. Are we doing the research needed? Are we confident there is a credible pathway for translating our research into a solution? Are we confident the solution will be adopted? Is the work financially positive, and are our objectives, strategy and reputation reinforced?

1.2: Data and digital transformation
To an increasing extent, all our science is digital science. Our vision here is for Manaaki Whenua to embrace and leverage the disruptive power of digital technology in pursuit of high-impact research. We will enable Manaaki Whenua researchers to undertake increasingly complex, transdisciplinary research across a wide diversity of research questions. Advanced eResearch tools and techniques will not only power novel approaches to research, but will also enable us to build solutions that address the real-world problems faced by those who manage Aotearoa New Zealand's land environment.

Progress in 2023/24
We have continued to build and support a highly capable team of data scientists, software engineers and developers. We have backed this with an eResearch support team to ensure access to digital science tools and techniques. We are increasingly harnessing the power of big data and deep learning to help solve complex environmental problems (see pages 28-29).

We published a description of a formal methodology implemented in Python code for simulating human sites (buildings, camps, mines, settlements, farms, factories, etc) and routes (trails, roads, railways, canals, powerlines, etc.) in virtual landscapes.

We completed research on the issue of improving GPS positioning accuracy under indigenous forest cover. It included a literature review of GPS technology, a focus on the issue of multi-path interference, an experimental design to test receivers, the results of an initial test of that experimental design and initial recommendations for a protocol for the operational use of GPS under forest canopy. The users of this report include field scientists, for example DOC staff, needing accurate positioning under forest canopy when undertaking plot surveys.

We convened a workshop with Selwyn District Council, Christchurch City Council, Kāinga Ora, Waka Kotahi, and Environment Canterbury to demonstrate and evaluate the quality and use of GenAI imagery for visualising potential land use options in the proposed Greater Christchurch green-belt. As urban planners and spatial analysts struggle to communicate and visualise proposed green belt and urban green space projects and proposals to the public, we assessed the quality of GenAI imagery for these communication and visualisation tasks for the proposed Greater Christchurch green belt.

Typically, soil quality monitoring has been used to measure how intensive land use impacts soil and water quality at a local level. In collaboration with AgResearch we developed a tool for researchers to tap into soil quality monitoring data from 12 regional councils, property valuation data from district valuation rolls, and water quality data from nearly 800 sites to understand soil and water quality across large catchment areas.

Strategic pillar 2

Weave the principles of Te Tiriti into our fabric

This pillar recognises that Māori, iwi, hapū and whānau are key partners for Manaaki Whenua as we seek to deliver on our ambition: Kia mauriora te whenua me tōna taiao. Māori have a growing influence and indigenous body knowledge over land use and biodiversity outcomes. The Māori economy is on the rise, making Māori significant potential investors both economically and environmentally. As kaitiaki (guardians) of the whenua (land) and taiao (environment), Māori are key partners as we prioritise our research and drive impact for Aotearoa New Zealand.

Our commitment to Te Tiriti

Manaaki Whenua's tauākī ngākau titikaha (statement of commitment) to Te Tiriti was signed on 30 June 2021.

"Manaaki Whenua commits to upholding the principles of Te Tiriti o Waitangi as defined by the courts and the Waitangi Tribunal, and reaffirmed by Te Arawhiti (The Office for Crown Māori Relations) and Cabinet Office guidelines of October 2019. These can be fairly summarised as the Treaty principles of: (1) Partnership, (2) Participation and (3) Active Protection when working with iwi and Māori interests. Manaaki Whenua will incorporate these principles into our aspirations, strategy and our working practices to inform and guide us in our engagement with iwi entities and Māori land trusts and incorporations."

"E ngākau titikaha ana a Manaaki Whenua kia whakamarangahia ngā mātāpono o te Tiriti o Waitangi. Kua tautuhia ēnei mātāpono e ngā kōti me te Rōpū Whakamana i te Tiriti, ā, kua whakatūturungia e Te Arawhiti me ngā aratohu nā Te Tari o te Rūnanga o te Kāwanatanga i whakaputa i te marama o Whiringa ā Nuku 2019. Hei whakarāpopoto, ko ēnei ngā mātāpono e whai ake nei: (1) ko te rangapūtanga, (2) ko te whai wāhitanga, (3) ko te āta manaaki inā e mahi tahi nei tātou ki ngā whaipānga a te iwi, a te Māori anō hoki. E mea ana a Manaaki Whenua kia whai wāhi mai ēnei mātāpono ki ō tātou wawata, rautaki, tukanga mahi hoki hei whakamārama, hei ārahi hoki i a tātou i te wā e whakarato nei tātou i tō tatou whāinga roa."

The Treaty principles apply across Manaaki Whenua and not just to our research. Our goal is to reflect the spirit of partnership enshrined in Te Tiriti, support Māori in playing an active and equal role as a partner across Manaaki Whenua, and ensure active protection of Māori interests and equitable outcomes for Māori in our work. In being true to the principle of partnership, Manaaki Whenua will aspire to be a partnership between cultures, each bringing their own, equally valued, knowledge system.

Moving forward we will apply the principles in how we engage with iwi 'at place' and where our science is relevant to Māori. We will reach out and seek to connect early on to co-design projects and we will approach our relationship with iwi in the spirit of partnership.

Our current priority initiatives within this pillar are:

2.1: Building our capacity to partner with Māori
Manaaki Whenua continues to build capacity to partner with Māori, whether that be with iwi, hapū, rūnanga or Māori businesses. Acknowledging differences in Māori priorities – which range from the well-being of people and the environment to ensuring economic growth – contributes to determining where we should be building capability, thereby ensuring we are giving effect to our commitment to weave the principles of Te Tiriti o Waitangi into our fabric.

Progress in 2023/24
Our bicultural competency programme Kia Maia continues to provide resources, training and encouragement to staff to develop the competencies and skills to deliver on our Tiriti commitment and to engage with Māori. Initiatives include access to online te reo training, Tiriti workshops, advice on tikanga (customs) and – for tangata tiriti, non-Māori, how to prepare to arrive

as guests (manuhiri) in knowledge processes, whether supporting or doing research.

The Poipoia Kia Rere intern programme forms part of our commitment to build pathways into Manaaki Whenua for kairangahau Māori, creating new pathways for these tauira (students) to see a future in science and at Crown Research Institutes more broadly. This year seven Poipoia Kia Rere interns were supported by Manaaki Whenua supervisors across the motu.

2.2: Partnership in the collections and databases
Manaaki Whenua's collections and databases Te Tiriti Partnership Group, Te Rōpū Rangapūtanga Tiriti, was established to oversee implementation of a comprehensive strategic plan for our collections and databases, and to advise us on how best to connect hapū and iwi to the taonga we hold on their behalf as their Te Tiriti partner.

Progress in 2023/24
In March 2024 we held the second annual Te Rōpū Rangapūtanga Tiriti (Manaaki Whenua's external Te Tiriti Partnership Group) hui on the visibility of our collections and databases. The group endorsed our new collection protocol, 'Connect Before You Collect', an ambitious new framing to encourage our staff to reach out to hapū and iwi interests early in the process of gathering material or data for research. The group also acknowledged that hapū and iwi were in different states of readiness to engage with Manaaki Whenua as custodians of their taonga. They recommended we consider a range of platforms to make it easier for Māori communities to visualise what we hold from their rohe. We can now make digitally visible, via an interactive web map, the material held in a particular rohe (area). Deliberate tailoring of this type of 'data visualisation' will assist in increasing hapū and iwi interest and engagement with our collections.

Manaaki Whenua staff attended and spoke at the Local Contexts symposium held in Wellington in late November 2023. Local Contexts is a global initiative that supports indigenous communities with tools such as biocultural labels and notices to reassert cultural authority in heritage collections and data. Several months beforehand we had placed biocultural notices on all the metadata of the New Zealand-sourced physical specimens in our collections to alert researchers to the fact that there are indigenous rights and interests associated with the material. So far three iwi have placed their own notices on the specimens relating to their rohe: Ngāti Maru, Te Roroa, and Whakatōhea.

A new documentary produced by Local Contexts, *E Kore Au e Ngaro*, explores Manaaki Whenua's work with Whakatōhea, an iwi in the Eastern Bay of Plenty, to apply biocultural labels to some of these specimen samples through our Systematics Collections Data website.

2.3: Partnering with Maori for impact
Manaaki Whenua is focused on an end-user-centred approach and engaging deliberately with Māori business. This initiative will help guide how we respond to the end-users of the science and become proactive in discussing, planning, and implementing pathways to address aspirations and priorities that affect all Māori, with the benefits overflowing to Aotearoa New Zealand.

Progress in 2023/24
The Māori Business Development Plan was presented to the Board in February 2024, outlining the intention to develop a pathway to partnering our science and technological expertise specifically with Māori business organisations.

As Ao Māori lead of Whitiwhiti Ora and Whakatupu programmes, Nikki Harcourt participated in a panel titled "Practical Tools and Approaches to Begin Navigating Land-Use Change" at Te Papa Tongarewa in May 2024. Linda Lilburne was also on the panel, representing the Data Supermarket, a key output from Whitiwhiti Ora. Nikki presented the land use opportunities visualisation tool Matarau, the key output from Whakatupu. Matarau has been developed specifically for Māori landowner needs. There was much interest from the audience in tools and databases, specifically Our Environment. The MPI Māori Agribusiness team are keen to understand how we can work together in Māori land-use support and build on existing tools, and will invite us to a follow-up meeting.

Nikki Harcourt and Luise Schulte are producing resources to support active participation by Māori communities in conversations about biocontrol of weeds. Supported by the Impact Enterprise Fund and other SSIF the pair have run wānanga with participants from different hapū and iwi environmental groups have helped to shape the look and feel of resources, including a booklet and animated video to ensure they are useful and meaningful for Māori communities.

Strategic pillar 3

Create a sustainable environment for our research and people to thrive

This pillar focuses on ensuring that our operating model, processes and systems are optimised to support efficient, high-impact research delivery.

Our current priority initiatives within this pillar are:

3.1. Mahi Tahi
The Mahi Tahi: Working Together programme is primarily an investment in future efficiency and sustainability. The primary target benefit is creating more time for science through improvements to processes, systems, and task allocation. Additional benefits include increased staff satisfaction, and a continuous improvement approach for key parts of the organisation.

Progress in 2023/24
Over recent years pressure has grown on our researchers to manage more than their research. Our project lifecycle systems and processes (linking design to delivery of research contracts) needed to be reset to ensure we had the right people doing the right things, with the right skills and tools. The Mahi Tahi programme was established to explore this further. Mahi Tahi's vision is to help our research and support staff to work together as one team, supported by the processes and systems they need.

In Phase 1, we mapped 73 Manaaki Whenua processes, with the goal of simplifying or improving research project delivery. In doing this, we also gained a better understanding of the role that systems played within these processes, compared with process design, behaviour and policies. We found that while our systems were contributing to some of the pain experienced by our research leaders and staff, a major contributor was the processes that had evolved over many years. The outcome of Phase 1 was a business case presented to the Manaaki Whenua Board in June 2023, which considered the opportunity: 1) to undertake process simplification, 2) for some system improvements, and 3) to adjust roles and responsibilities relating to project delivery.

The Board approved the business case in November 2023 and Phase 2 of the Mahi Tahi programme commenced in February 2024. Phase 2 is organised around three stages: 1) Design, 2) Implementation, and 3) Transition to Business. The Design stage concluded in June 2024, with the focus for 2024/2025 on implementation through a series of four, six-monthly tranches. These tranches are centred on the research project lifecycle consisting of 1) Idea to Project, 2 and 3) Project to Output, and 4) Output to Impact. The first tranche will be delivered in October 2024. The programme will transition to the business in mid-2026.

3.2 Future of our Auckland campus
We are in the early stages of investigating whether pooling resources with Plant & Food Research at the Mt Albert site would drive stronger economic outcomes for Aotearoa New Zealand through novel foods and early detection of biosecurity threats.

This hub would match research readiness preparation (for incursions and biodiversity protection) with the response regulatory function of MPI. Biological collections and research on organisms would be combined with expertise in novel foods to accelerate innovation in novel products from Aotearoa New Zealand's biota. The combination of skills from both research organisations would remove the artificial barrier between managed and natural landscapes.

All of this would be achieved in partnership with mana whenua to ensure indigenous data governance and novel revenue sources for the indigenous owners. This initiative is also consistent with building long-term financial resilience and sustainability.

Progress in 2023/24
During the year we contracted Ascent Technology and Rau Paenga (RP) to support the Indicative Business Case stage of the proposed co-location with Plant & Food Research. This stage is expected to finish on schedule in September 2024 and within budget. All procurement activity is now complete. We undertook preliminary steps in engaging site investigation, quantity surveying and design/ architectural services. We also established engagement with Ngāti Whātua Ōrākei, one of the hapū from the wider Ngāti Whātua iwi, located in and around the Tāmaki isthmus.

3.3 Future of work
Equipping our people for the future of work is a critical priority for Manaaki Whenua.

Progress in 2023/24
Manaaki Whenua operates under a matrix structure that influences how science activities and business support functions are arranged. This structure was originally created to break down silos between teams, projects, and capabilities. In September 2023, a decision was made to review the matrix structure to see if it is still fit-for-purpose and to understand whether we have the right settings in place for Manaaki Whenua. Five staff advisory groups informed this work, looking at: the interface between the two sides of the matrix – science capacity and direction-setting; workflow management; business development; and functions of leadership.

We commenced development of a People Strategy during the year – *Manaaki Whenua, Manaaki Tangata, Haere Whakamau – Care for the land, care for the people, go forward*. This strategy will set out the key shifts the organisation is aiming to make to deliver our strategic goals and improve the well-being of our staff and the well-being of Aotearoa itself. There are five pillars in this strategy: Diversity for impact, Kia whakatinana ngā mātāpono o Te Tiriti (Giving substance to our Treaty commitment), Digitally capable, Fit for our future, and Purpose-led culture.

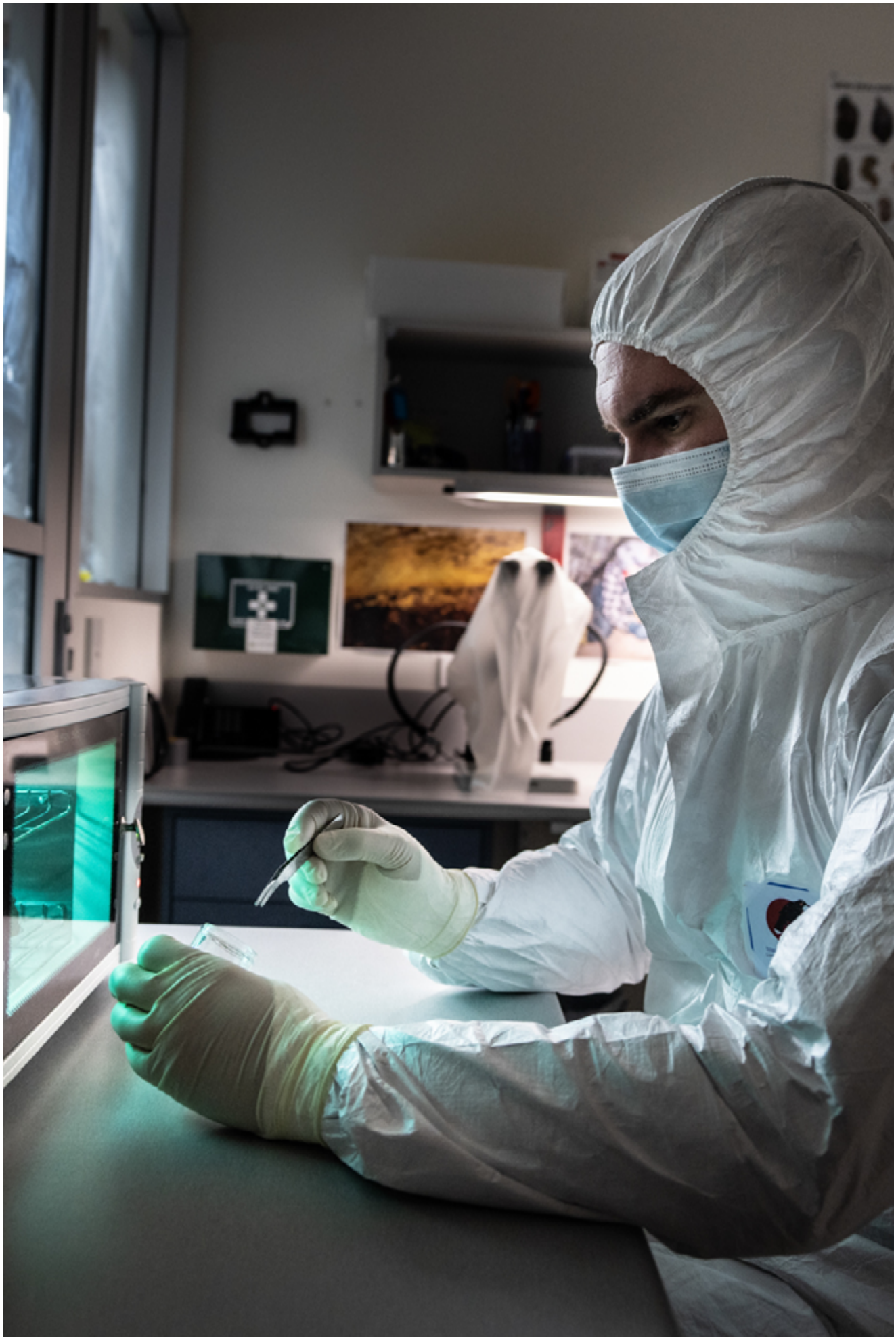
Our people are being equipped to work alongside and with emerging technologies such as generative AI and other AI-based technologies (including machine learning and deep learning: see pages 28 and 29). These technologies are already changing the way our people work and challenging us to consider how we upskill and cross-skill to use them.

Our science
Tō tātou pūtaiao

Delivering on our core purpose, to fix the complex environmental problems facing Aotearoa New Zealand, requires exceptional science and research integrating a wide array of scientific disciplines.

Manaaki Whenua acknowledges mātauranga Māori (New Zealand indigenous knowledge) as a world view complementary to Western science. We believe that our work and impacts are enriched when we build understanding between scientific and Māori world views. Mātauranga Māori stands alongside our science in providing insights into our land and our future for all New Zealanders.

Innovation stories can be found on the Manaaki Whenua website:
landcareresearch.co.nz/innovation-stories



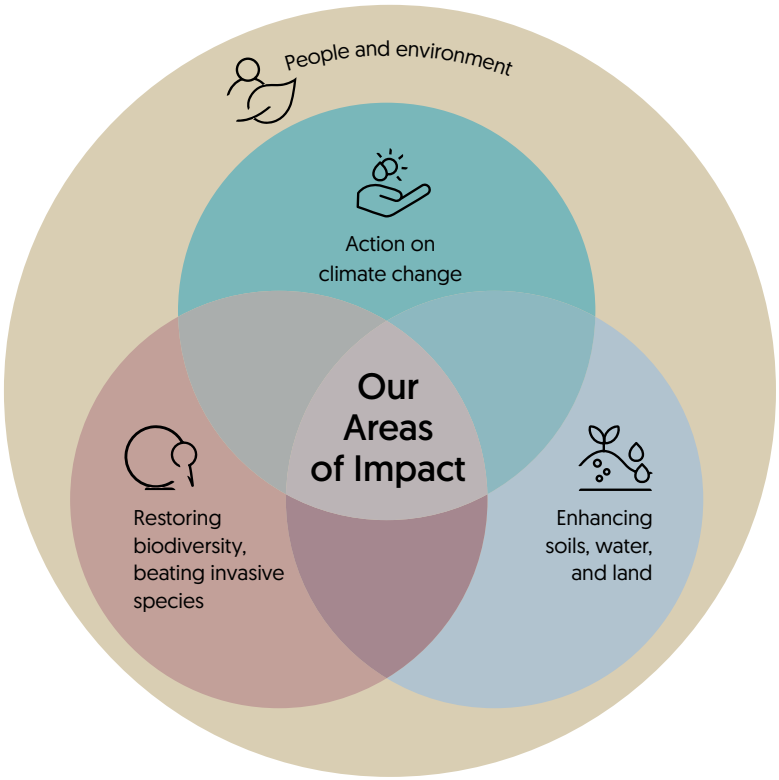
Paleoecologist Dr Kieren Mitchell in our Long-Term Ecology Lab, where the ecology of past environments is reconstructed to inform present-day conservation.

Our four research impacts

Our four areas of research impact are designed to present our science and research in an approachable and meaningful way, for all people in Aotearoa New Zealand to engage with.

Much of our research work is focused where these four areas of research impact overlap. This integration is important to many of our partners, who must address issues collectively and not in isolation. Our partners address not only the integration of land, water, and biodiversity, but also the integration of social, economic, and cultural dimensions.

Our research in these four areas has 12 research outcomes, which are needed by our partners.



Our 12 research outcomes

1. Critical knowledge of the wealth, state, and trends in our biodiversity, soils, and lands informs natural resource decision-making

Our environmental data resources and foundational knowledge provide fundamental information for Aotearoa New Zealand's economy, environmental management, environmental recovery, and social development. Our data are used by policy makers and land managers across the country and further afield in the Pacific region to underpin wise choices and decisions about land use.

2. Hapū and iwi act confidently as kaitiaki of their whenua using science and mātauranga Māori

In a post-Treaty of Waitangi settlement landscape, iwi, hāpu, and whānau are repositioning themselves to enable active kaitiakitanga, from the bottom up and the top down. Across Manaaki Whenua, but particularly through our Manaaki Taiao rōpū (group) of kairangahau Māori (Māori researchers), we work with iwi, hapū, and communities to develop strategic planning, policy, and monitoring tools informed by mātauranga Māori and science to support kaitiakitanga. Over time we are building strategic partnerships with our Māori partners for mutual benefit.

3. Māori land trusts and incorporations achieve their aspirations for their land

Following Treaty settlements, Māori entities are increasingly important landholders in Aotearoa New Zealand. We aim to provide tools and enhance capabilities in partnership with Māori land trusts and other incorporations to support their management decisions.

4. Ecological restoration is guided by knowledge of past and present ecosystems
Our research provides baseline information to show how species and ecosystems respond to environmental changes and human activities, and to help inform conservation management plans and policies.

5. Land use, soils, and erosion are managed to improve freshwater quality
We undertake a diversity of research and consultancy projects, including fundamental understanding of erosion processes, landscape dynamics and response in a changing environment, erosion and sediment modelling, and tools for the control and mitigation of soil and land degradation.

6. Productive lands are regenerative at the landscape scale
We support the productive sector to make effective decisions to improve productivity, reduce costs, and operate sustainably as part of the drive towards a sustainable food and fibre sector.

7. Risk and harm from invasive organisms are mitigated
Our native biodiversity and our ability to derive income both from primary industries and from our unique landscapes are constantly threatened by invasive weeds, pests, and diseases. Our work enables Aotearoa New Zealand to better respond to biosecurity threats, reduce pest, weed, and disease impacts, and better protect our native taonga.

8. Biosecurity tools are available with social licence
We design and develop socially acceptable biosecurity tools for wildlife management, and for the control of invasive plant species.

9. Communities and regulators have adaptation pathways for climate change
We have built significant expertise, capability, and capacity and positioned ourselves as one of the leading science providers in Aotearoa New Zealand for climate risk, resilience, and adaptation research, with a growing international profile through high-impact publications and collaborations. Working with a wide range of stakeholders, we have developed new tools, frameworks, and processes to support adaptation planning, risk and resilience assessment, monitoring, and evaluation frameworks.

10. Greenhouse gas emissions and removals are managed to mitigate climate change
Sustainable land management to create climate-smart landscapes is an essential part of ensuring Aotearoa New Zealand reaches its climate emission targets. Our science enables the right decisions to be made and the right policies to be put forward to manage our greenhouse gas emissions now and in the future.

11. Environmental decisions are underpinned by advanced geospatial information
Mapping and regular monitoring of land cover and land use are critical to understanding environmental state, health, and pressures. Our nationally significant digital databases of land use are the authoritative information source for this work.

12. National environmental outcomes are improved by integrating social practice theory, policy tools, and economics.
Our team of social and economic scientists is the largest in the Southern Hemisphere dedicated to researching the human dimensions of environmental management.

Progress in 2023/24

The following pages showcase the innovative science we undertook in 2023/24, taking each research impact area in turn.

CASE STUDY:

Big data and deep learning at Manaaki Whenua

Deep learning has been revolutionising the field of computer vision, with networks such as Google's Inception dramatically increasing the accuracy of image labelling (image classification). Traditionally difficult problems like segmenting imagery by class (semantic segmentation) and separating individual objects (object detection) have also become much more tractable thanks to innovative deep-learning architectures.

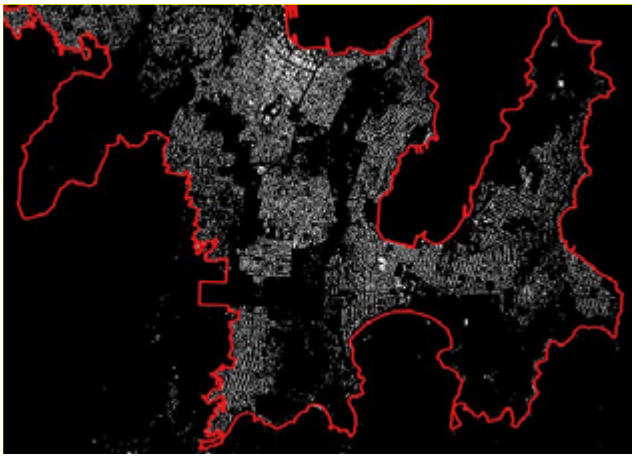
Our Big Data Remote Sensing project, made possible by SSIF funding from the Characterising Land Resources research portfolio, has been running since 2019, with the ambition of developing our capability in advanced data science technology and methods.

Most recently this project has focused on deep learning – a subset of machine learning involving large neural networks that learn to interpret patterns in imagery. Deep learning holds enormous promise when coupled with remote-sensing data because it can enable large volumes of imagery to be automatically transformed into maps.

The objectives of our Big Data Remote Sensing project are to:

- explore deep learning's capabilities in real settings by 'deep diving' into a variety of domains and problems to support our core competencies in environmental science.
- build capability in deep learning to keep us at the forefront of remote-sensing technologies, especially for regional/national mapping.
- develop tools to facilitate research and output generation so that Manaaki Whenua researchers other than data scientists can become effective adopters.
- disseminate findings and share expertise through webinars, workshops, papers and reports.

With our developing capability in deep learning, Manaaki Whenua has been successful in securing a wide variety of research and commercial contracts.



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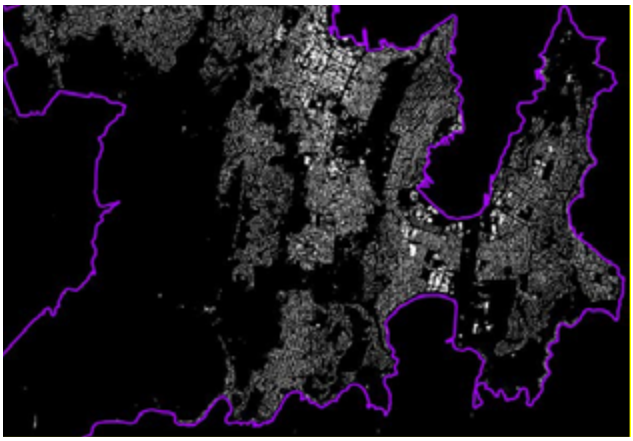

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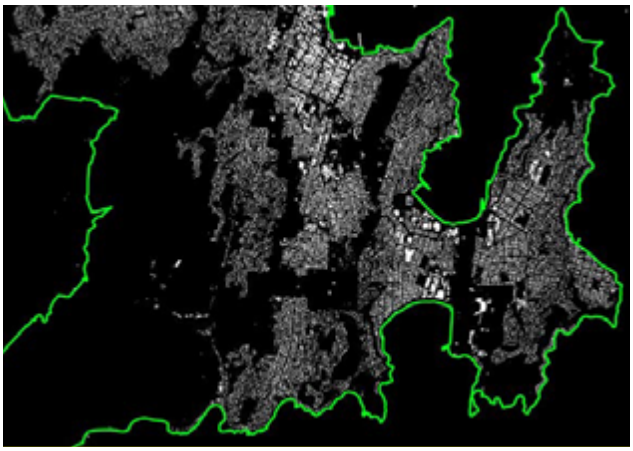


2016

Wellington's built footprint for 1940, 1980 and 2016, showing the city's changing extent and density. These images were generated from historical black-and-white aerial imagery using deep learning. They were used to estimate changes in urban green space for input to a report – Are we building harder, hotter cities? – *by the Parliamentary Commissioner for the Environment.*

Examples of our work in big data and deep learning

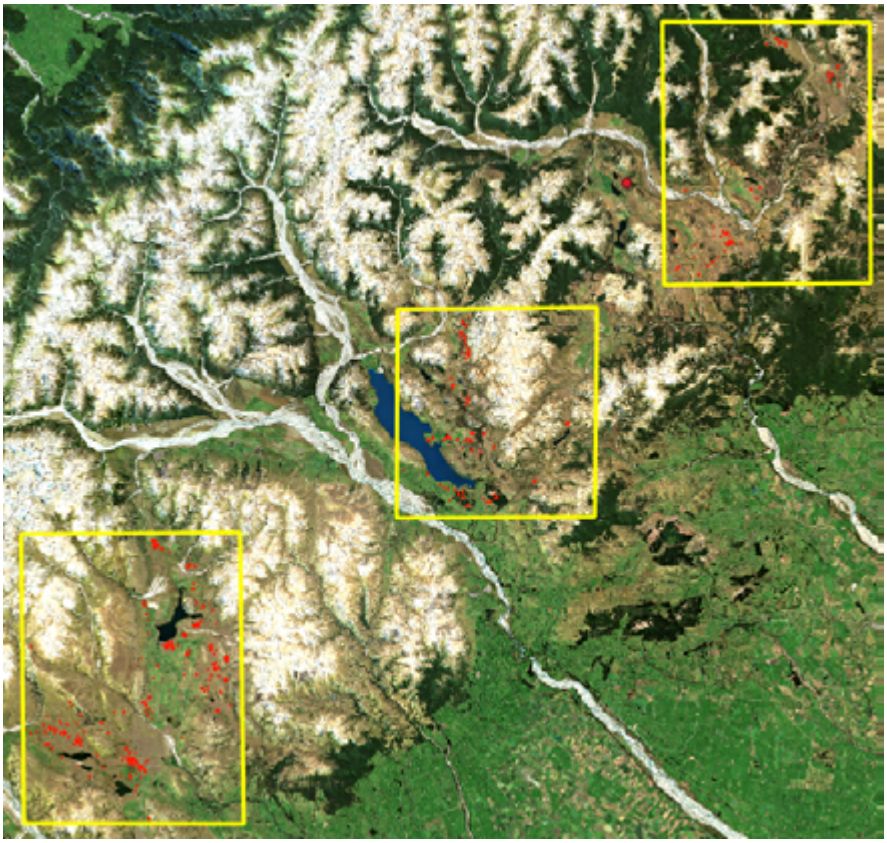
Urban tree detection, identification and modelling
We created a map of 1.8 million urban trees, in collaboration with Wellington City Council, to assist in urban planning. The ten most common species in the Wellington Urban Tree Explorer were classified to a cross-class average of 60% precision and 40% recall.

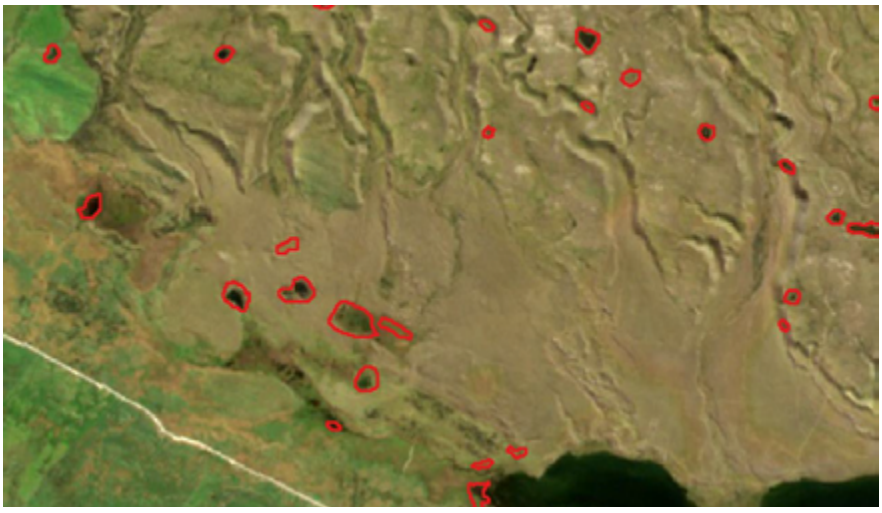
Monitoring of urban green spaces
A study for the Parliamentary Commissioner for the Environment used building footprint maps for the 1940s and 1980s that were sufficiently accurate to map trends in open space provision in Auckland, Hamilton, and Wellington.

Plantation and rural tree detection
We have mapped wilding conifer infestations for MPI, and used LiDAR to help Hawke's Bay Regional Council detect and map the extent of pine and exotic forest.

Wetland mapping
We assisted MfE with a project mapping "difficult" (hard to delineate) wetlands.

AI trap cameras
CamTrapNZ camera trap species detection software was trained on photographs of various predator and exotic animals and classified them by species with an overall accuracy of 80-85%.





Top: Training areas (yellow rectangles) showing mapping of ephemeral kettle-hole wetlands.

Middle: Mapping of potential ephemeral wetlands in the central South Island.

Bottom: A clear image of a stoat, identifiable by the long, black-tipped tail.

Senior researcher in soil biochemistry Dr Suzanne Lambie sampling water in a constructed wetland system in Taupiri, Waikato..

Enhancing soils, water, and land

Soils are critical to our productive and natural landscapes, and their health is thus central to society's well-being. 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 values.

Soils hold more water than our rivers, lakes, and aquifers. They are the pathways for pollutants from land use, and the source of sediment entering waterways from erosion. Soils are being lost by erosion from productive lands at unsustainable rates. Our work provides understanding of soils, capability to manage the effects of land use, and confidence to deploy mitigation approaches.

Selected highlights

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Dr Ursula Jewell led a team that spent 2 years curating, digitising and cataloguing the world's most extensive collection of Antarctic soil samples dating back as far as 1957. During the project, researchers transferred 8,837 rare, pristine, microplastic-free soil samples, topping the scales at more than 1.5 tonnes, to a robust storage container where each sample was weighed, photographed and labelled with a unique identifier. The samples are now fully curated, stored and preserved at the Quarantine Facility of the National Soils Archive at Manaaki Whenua in Palmerston North. The data pertaining to those samples are available for download within the Antarctic Soils Explorer website.

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Manaaki Whenua senior researchers Dr Jo Cavanagh and Dr Pierre Roudier worked with a team from GNS Science and The University of Auckland to produce a new *Geochemical Atlas of New Zealand*, which maps the concentrations of 65 different elements in our soils. This information helps identify where trace elements may need to be added to enhance productivity or improve the nutritional quality of food crops for livestock and people.

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Manaaki Whenua researchers are assessing the impact of urban development on soils, quantifying if urbanisation is making soils less "spongy" and more vulnerable to flooding. The team is collaborating with engineering colleagues at AECOM, who will undertake modelling to better define the risk of flooding in various storm events, and with Koru Environmental to investigate policy responses. By early 2025 the project team plans to have a draft technical guidance document for regional councils, the construction industry, and individual property owners to improve our resilience to a changing climate.

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We applied the latest version of our sediment and soil erosion modelling tool SedNetNZ in the Manawatū-Whanganui region for Horizons Regional Council, and updated the assessment of the impact of soil conservation work to date, including upgraded LiDAR DEM-derived digital stream network and rainfall-induced landslide susceptibility geospatial layers. The Council also wanted to model sediment loads under future climate change conditions for two different policy scenarios. Our researchers have also completed SedNetNZ-based analysis of erosion and suspended sediment loads for Southland, Taranaki, Bay of Plenty, and Hawke's Bay, while SedNetNZ modelling is currently underway for the Waikato region.

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The 8-year research project Te Whenua Hou, Te Whenua Whitiora (The New Land, the New Horizon) led by Ngāi Tahu Farming is now established on two dairy farms in North Canterbury, side by side, to compare the performance and impacts of their different practices. One 286-hectare farm uses regenerative farming practices while the adjacent 330-hectare farm uses conventional methods.

We helped to construct lysimeters for the project to measure soil water movements, and we are undertaking greenhouse gas monitoring and quantifying the environmental benefits of diverse pastures.

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S-map, the digital soil map for AoNZ, was updated in April 2024 to include an improved model for estimating soil hydrological properties (including available water). S-map soil hydrology information is widely used, underpinning farmer decision-support tools such as the Overseer nutrient budget model, and IrriCalc, used to support decisions on irrigation allocation and scheduling. More accurate soil moisture information will lead to better knowledge of irrigation demand and nutrient losses, with much richer soils data meaning better modelling, which in turn supports better decision-making.

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We released a new 'one-stop shop' website for information and knowledge on the national Land Use Capability Classification System (LUCCS). The LUCCS consists of the New Zealand Land Resource Inventory (NZLRI) and the Classification of Land Use Capability (LUC). The LUCCS has been widely used over the last 40 years by central and local government, research institutes, farmers, consultants, and primary sector organisations. It is also widely used in farm production and environment plans in a number of regions.

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We provided Northland Regional Council with a high-resolution geographic land-use map layer, with the capability to integrate key region-scale information. This layer was identified by the council as critical for improved freshwater accounting, economic impact assessment, policy development, and efficient implementation of land management mitigation measures.

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Our scientists have found evidence that keeping the pasture renewal period (without vegetation) as short as possible is important for reducing soil carbon losses and therefore supports good management decision-making for farmers to maintain soil carbon stocks. This finding will also feed into future emissions modelling work to improve New Zealand's greenhouse gas accounting and inventory.

Research technician Graeme Rogers at the lysimeter installation for Te Whenua Hou, Te Whenua Whitiora. Image: Kim Triegaardt.

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Manaaki Whenua's remote sensing group completed a rapid preliminary assessment of land damage from Cyclone Gabrielle for MfE. This work assessed land damage from landslides in hill country areas of the North Island, predominantly across the Gisborne, Hawke's Bay and Wairarapa areas. Analysis of Sentinel-2 remote sensed imagery indicates there were >300,000 landslides, and that the frequency/density of landslides varied spatially as well as with different vegetation types.

Innovation stories

Scouting out soil data

Although the stony soils of the upper Wairau Valley, Marlborough, have underpinned the success of winemakers, they have made soil mapping there a slow and arduous task.

Any digging below the surface often requires a crowbar, and quick observation methods using an auger are simply not possible. Using diggers within vineyard rows is also problematic, with limited access and health and safety concerns putting landowners off. Observation pit sites need to be chosen very carefully because they are costly and time-consuming.

In a project with Marlborough District Council in May 2023, Manaaki Whenua scientists Dr Pierre Roudier, Dr Kirstin Deuss, Kishor Kumar, and Dr John Triantafilis embraced innovation as part of a regular S-map survey. They developed and tested a new proximal soil-sensing platform that used gamma and electromagnetic data that combined with the soil survey data, as well as aerial imagery and LiDAR.

In this way the technology acted as a 'scout' for pedologists, revealing almost in real time what was under their feet.

Mapping as part of a study into landslide susceptibility and connectivity in Te Rawhiti Gisborne.

"Usually pedologists and soil-sensing people don't tend to work in such an integrated way," says Pierre. "Our novel approach in the Wairau Valley used a mixture of pedological knowledge and sensing to identify important changes in the soil, and which enabled targeted and rapid selection of where to spend time digging a soil pit."

For Matt Oliver, an environmental scientist at Marlborough District Council, this work is a crucial part of the council's efforts to optimise land and water management in the valley.

"The soils of the Wairau Valley were last mapped in 1939. It has been great to work alongside Manaaki Whenua's team, using the latest technology to accurately and quickly remap these areas to meet our increased demand for high-quality soils information," he says. "It very much feels like we have brought soil mapping in Marlborough into the 21st century."

S-map expands further

2023 closed out with a significant achievement for S-map, Aotearoa New Zealand's comprehensive on-line resource delivering authoritative soil maps. Through a funding collaboration between MPI and 12 Regional Councils, Manaaki Whenua has completed an extra 500,000 hectares of new soil mapping coverage across some of AoNZ's best food-producing land. The partnership is on track to deliver a further million hectares of new mapping over the next two years.

Pedologist Emily McKay, who conducted fieldwork in Northland with Senior Researcher Dr Scott Fraser, reported back that the soils in the region were "highly interesting, incredibly variable, and can be really hard to dig!"

"We encountered the famous Kerikeri Oxidic soils, and Allophanic soils formed on young basalt flows, both really valuable for horticulture," says Emily. "The most interesting feature so far among many of the Ultic and Podzol soils is the presence of a silica-rich layer that makes your auger squeak and spin in circles, and are some of the most difficult soils for farmers to manage."

Developed and updated by Manaaki Whenua, S-map provides the best available soil survey data for AoNZ. Displaying basic soil property data like depth, stoniness, and clay content, as well as more complex data like water-holding capacity and nitrogen leaching risk, S-map provides comprehensive and accurate soil information to support sustainable management of our soil resource. There are also tools that help land managers and consultants find the S-map soil type that best matches on-farm field observations.

Soil scientist Dr Sam Carrick says richer soils data mean much better modelling assumptions, which in turn support better decision-making on the ground. "A major focus has been on provision of soil hydrology information, soil attributes that have significant effects on farmers' nutrient budget calculations," says Sam. "More accurate soil moisture information will lead to better knowledge of irrigation demand and nutrient losses."

The new mapping in the most recent release includes nearly 80,000 ha on Banks Peninsula in Canterbury, 143,000 ha in the Catlins region of Otago and nearly 60,000 ha from Waitara to Hāwera in the Taranaki.

Mapping has also been upgraded for the Awatere Valley in Marlborough, Eltham in Taranaki, and approximately 170,000 ha covering the Rotorua Lakes catchment and north to the coast between the Kaituna River and the Pikowai Stream in the Bay of Plenty.

Sam says advances to S-map data have led to its extensive adoption in farm environmental planning, monitoring, and reporting.

In addition to the popular S-map Online website, data are supplied directly to an expanding list of Agri-service business tools including those used by fertiliser companies, dairy companies, most regional councils, and banks. S-map data are a critical input in the NZ Water Model (NIWA), the Agricultural Production Systems Simulator crop model (Plant & Food Research and AgResearch), IrriCalc (Aqualinc) and the Overseer nutrient budget tool.

"These tools provide critical information to public organisations, farmers and the agri-service sector across Aotearoa New Zealand," he says.

Additionally, S-map data are used by scientists for erosion, crop production, nutrient management, irrigation, and other hydrological research. Regional councils rely on S-map in the development of regional plans focused on water quality and consenting for water takes.

"Through a collective multi-agency collaboration we have put a large effort into developing easily accessible land resource assessment capability for New Zealand," says Sam. "S-map Online usage continues to grow, with more than 27,000 registered users downloading 51,000 soil factsheets every year."

How data science can shape tree modelling for sustainable land management

A four-year data science programme involving a joint Aotearoa New Zealand-Singapore research team working to accelerate the development of data science capability in both countries has wrapped up demonstrating valuable connections between remote sensing, ecology and social sciences. Funded through MBIE, and Singapore Data Science Consortium (SDSC), the Bridging the gap between remote sensing and tree modelling with data science programme has developed methods that are already underpinning projects. These include mapping tasks in urban and native forest environments on tree species identification and large-scale vegetation mapping of entire regions in Aotearoa New Zealand.

Manaaki Whenua senior researcher Dr Jan Schindler says that as well as new ways of detecting trees from aerial imagery and 3D LiDAR point clouds, researchers also developed novel deep-learning approaches, and were able to draw connections between data science, urban trees and well-being."The developed methods have already found their way into practical applications by enabling and supporting new research and commercial projects," says Jan.

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

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

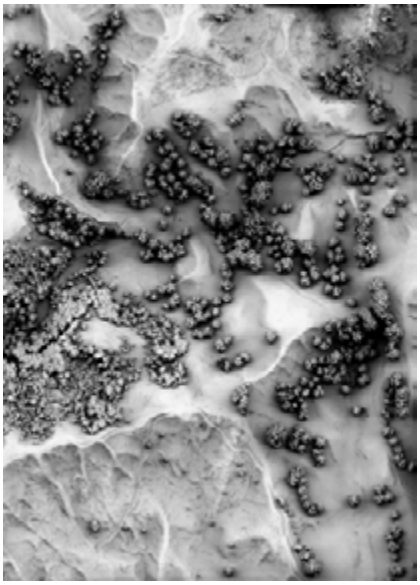
The research project successfully translated state-of-the-art AI technologies into practical outcomes for stakeholders. "We strengthened collaborative relationships among all New Zealand and Singapore teams, expanded our network to include external partners, and fostered the growth of a new cohort of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

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

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

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

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



Forest management on steep slopes can be challenging especially at harvest. Right: LiDAR tiles can extract high-resolution details of tree cover. Below: Aerial images of land in Hawke's Bay enable zooming in to very small detail.

Closing the window of vulnerability

Most commercial forests in Aotearoa New Zealand are clear-fell harvested. Trees of harvest age are cut down in areas called coupes or compartments. In many forests, these compartments often include steep hillsides, which go from being forested for decades to being bare and visible almost overnight. The years following harvesting are when forests are more susceptible to erosion; and this has been termed the 'window of vulnerability' (WoV).

Dr Chris Phillips, a senior researcher in erosion processes at Manaaki Whenua, says better information on the WoV can help forest managers develop appropriate risk management strategies. "This is a period of several years, where the landscape is particularly susceptible to rainfall-triggered shallow landslides between crop rotations. It is also often when the impacts of large storms such as Cyclone Gabrielle are at their greatest."

Chris recently led a project that looked at the WoV in steepland plantation forests in three regions that had been affected by large rainfall events.

"Using forest company information, LiDAR and satellite imagery we manually discriminated rainfall-triggered landslides for each of our three study areas. Landslides were 'tagged' to vegetation cover, time since harvesting, whether associated with forest infrastructure such as roads and landings, and if they connected to the stream network or not."

Maximum landslide density occurred on land clear-felled 2–4 years before the rainfall event that triggered them. Landslides also occurred in older forest age classes and on areas with different vegetation covers (mature indigenous forests, pasture, scrub, etc). "There were fewer landslides associated with forest infrastructure than those deemed to be 'natural' slope failures, and half the triggered landslides reached the stream network," he says.

Chris says better information on the period of susceptibility to rainfall-triggered landslides following forest removal will help forest managers know what can and can't be done to mitigate the effects of rain events that result in landslides and in some cases often disastrous off-forest impacts.

Dr Bob Brown collecting wasp nests in Little River, Canterbury, for his research into potential biocontrol agents. Image: Kim Triegaardt.

Restoring biodiversity, beating invasive species

Aotearoa New Zealand's indigenous biodiversity evolved in isolation and much is globally unique. We curate national and Pacific collections of biodiversity on land (plants, invertebrates, fungi, and microorganisms), and our research helps users understand and value its richness, observe changes and risks from exotic species, and find new uses for biological materials. Our research provides understanding of how ecosystems function, the threats they face, and how they can be restored. The potential for Māori whānau, hapū, and iwi to generate economic returns from indigenous plants continues to be a strong area of interest. We contribute to national biosecurity through providing capability and confidence in assessing biological threats and using control tools – especially at landscape scales – for weeds, pests, predators, and diseases.

Selected highlights

Effective biosecurity requires very high levels of skill and confidence in identification of intercepted insects, and Lepidoptera (moths and butterflies) have again become of great concern since the arrival in this country of fall armyworm in 2022. The fall armyworm feeds on 350 plant species, including important crops as corn, asparagus, beans, peas, beetroot, brassica, capsicum, cucurbits, eggplant, onions, kumara, lettuce, and tomatoes. We have provided training in Lepidoptera identification to MPI to increase the speed and effectiveness in responding to Lepidoptera samples for identification.

A limitation of the use of environmental DNA (eDNA) is that many of the species detected are unknown and unnamed. A lack of names (Latin binomials) means the significance of their presence or absence form a site cannot be understood. Fungi are often the most frequently detected groups in eDNA extractions, so we have developed a method to rapidly catalogue our unknown organisms and incorporate those data into informal taxonomic summaries, rather than a conventional taxonomy. We focused on the fungal family Lachnaceae and using this method have determined that there are 66 Aotearoa New Zealand species with DNA sequences available, only about 18 of which have names.

We delivered a geospatial raster map to DOC showing locations of potential heavy beech tree flowering for spring 2023, helping them to plan predator control efforts well in advance of potential seeding in autumn 2024. The layer was made available as an interactive map using Google Earth Engine.

We are currently progressing biocontrol solutions, all at varying stages in the research process, for 12 weed species in Aotearoa New Zealand and 10 species in the Pacific, all concurrently. Within the past 4 years Manaaki Whenua has released four new biocontrol agents against four target environmental weeds in Aotearoa New Zealand, and five new agents against four target weeds in the Pacific.

Chromolaena gall fly (*Cecidochares connexa*) was released on Bikini Atoll in the Marshall Islands against the flowering weed chromolaena (*Chromolaena odorata*). As with the leucaena release, the project is supported by GEF-6 (funded by the Global Environment Facility) and Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP, funded by MFAT).

Leucaena psyllid (*Heteropsylla cubana*) was released against leucaena (*Leucaena leucocephela*) on Funafuti Atoll in Tuvalu with the assistance of collaborators at the Departments of Environment and Agriculture. The project has also been supported by GEF-6 (funded by the Global Environment Facility) and MISCCAP (funded by MFAT). This is the first weed biocontrol agent to be released in Tuvalu, and the culmination of 4 years of work and planning. Leucaena is one of the worst invasive species in the world, and has been spreading in Tuvalu in recent decades, forming impenetrable thickets. If the psyllid is as effective in Tuvalu as it has been elsewhere in the Pacific, it will provide significant benefits for food security and protection of native biodiversity and will improve the overall resilience of the people of Tuvalu to the impacts of climate change.

German wasps were first found in New Zealand in 1945, and the common wasp first recorded in 1978. Since then, they have spread throughout New Zealand, with the beech forests in Te Tauihu/top of the South Island having the highest densities of wasps in the world. Wasps cost New Zealand up to $130 million per annum in damages and management, and the collective biomass of wasps in New Zealand is greater than any of our native species. In April, years of research and trials came to fruition when Dr Bob Brown released a small number of *Volucella inanis*, (a species of European hoverfly that lays its eggs inside wasps' nests where the larvae feed on wasp grubs) on a farm in Rai Valley within the Te Hoiere Project area. Ngāti Kuia representative Ruihana Smith led the first release on the semi-organic farm where no Vespex control is undertaken.

Stephanie Morton with Makereta Ranadi, Ministry of Agriculture, Fiji, on a tour of the ministry's greenhouses. Stephanie was visiting to advise on best rearing protocols for a new biocontrol agent, the African tulip tree beetle. The weed in the image is Koster's curse (Miconia crenata).

A field restoration experiment aimed at re-establishing native vegetation in a grey willow-dominated DOC wetland involved planting kahikatea saplings in a range of light treatments from full willow canopy removal, partial removal, and manual clearing of light wells. After 5 years, we found saplings grew best under partial clearing of willow canopy, with growth rates slower under the other two treatments. DOC and other managers will be able to jump-start succession back to native-dominated forest with partial clearing, saving time and minimising costly interventions.

We ran an Identification Training Programme for Plant Parasitic Nematodes for the Biosecurity Authority of Fiji (BAF). Ensuring our Pacific partners have the tools to deal with incursions will prevent their arrival in Aotearoa New Zealand from these places.

More Birds in the Bush research programme MSc student Oscar Clendon published the first paper from his thesis, examining climate drivers of tawa seeding. This project was a collaboration with the Tūhoe Tuawhenua Trust. Tūhoe Tuawhenua elders have observed declines in tawa seeding over the past few decades. Tawa is one of the most common tree species in Aotearoa, and an important food source for kererū and other fruit-eating native birds. The paper showed that warming temperatures and reductions in rainfall associated with climate change are likely to be a key mechanism behind the reduced seed crops observed by elders.

We determined that kiwi in captivity show antimicrobial resistant bacteria at very young life stages. We identified highly mobile and shared plasmid-carrying multidrug resistant genes, reflecting the wider antibiotic usage in captive facilities.

We found that peat moss used as a bedding material in captivity is the vector for these deleterious bacteria. Kiwi hatcheries and the 'Operation Nest Egg' programme (Kiwi for Kiwi), have now released national guidance to stop using peat moss in hatcheries, thereby avoiding antibiotic resistance, and potentially increasing survival of birds both in captivity and in the wild.

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Dr Nikki Harcourt co-led a Precision Pest Control wānanga with Billy van Uitregt (Ngā Rauru Kiitahi) at Kai Iwi Marae (Whanganui) with many other of our staff attending. The Selective Pest Toxins Endeavour programme aims to develop advanced pest-control tools that target specific pests – a major breakthrough in pest control. Grounding the technical researchers in the places and spaces of their Māori partners is critical to building shared understanding and enables the co-development of outputs that are meaningful and useful to all parties.

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We prepared a MiSeq library for wasp meconium samples, in order to investigate their predation preferences. We want to know what *Vespula vulgaris* feed their larvae (such as other insects and/or native lizards), because knowing their preferred diet will help target the pathways to eradication.

Innovation stories

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

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

In AoNZ infestations of St John's wort were particularly serious in hill country dryland farms, reducing the productivity of pasture and poisoning livestock into the bargain. The plant was a toxic scourge, and its seeds were widely transported around the country, especially in roading gravel. Now it clings on in pasture as a minor weed only in a few parts of Otago. Where did all the St John's wort go? Our farmers' reprieve is all thanks to weed biocontrol – the release of two beetles with very specific dietary requirements – and a fair amount of patience.

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

But what if nothing had been done?

Recently, two of our weed biocontrol researchers, Dr Simon Fowler and Dr Ronny Groenteman, along with informatics specialist James Barringer and Dr Grant Humphries (Black Bawks Data Science Ltd, Scotland), revisited the history books to do a retrospective economic analysis of this flagship biocontrol project.

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

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

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

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

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

Hop to it: eliminating Aotearoa's marsupial menace

Wallabies arrived in Aotearoa New Zealand in the late 19th century, courtesy of Sir George Grey (Governor of New Zealand from 1845 to 1853). Around the same time, a farmer introduced Bennett's wallabies near Waimate in South Canterbury for recreational hunting. Wallabies from Kawau were later released in the Rotorua district. Now, more than 150 years on, Aotearoa New Zealand has a wallaby problem. They are a significant agricultural and conservation pest. While the brush-tailed rock wallaby, and the swamp wallaby, are still contained on Kawau Island, the three wallaby populations on mainland AoNZ – Bennett's wallaby in South Canterbury and dama and parma wallabies in the Rotorua lakes area – have slowly been spreading outside previously contained areas.

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

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

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

Research technician Emily Lawrence at a wallaby bait feeder in Otaio Gorge, South Canterbury. Image: Graham Hickling.

There are more than 20 projects underway or recently completed at Manaaki Whenua that are focused on wallabies. These include tracking wallabies as they invade new areas, scent lures, monitoring and detection methods and human behavioural studies conducted through social science surveys of people's motivations for transporting and releasing wallabies around the country – which is illegal under the Biosecurity Act.

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

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

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

Because estimating the number of wallabies in the wild is difficult, the researchers fitted GPS collars on captured wallabies, which recorded location data at high frequency (every 5 seconds) after the wallabies

were released, providing a known number of wallabies for potential detection.

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

He says there is a clear need for innovation and the development of new methods to detect animals at very low densities so they can be eliminated.

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

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

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

As part of the Tipu Mātoro programme, Manaaki Whenua also surveyed and analysed data on people's beliefs, attitudes, and motivations regarding the illegal catch and release of wallabies.

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

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

New guidelines suggested for ecosourcing seed

When it comes to ecological restoration in Aotearoa New Zealand, obtaining plant seeds with a known local wild origin has been widely advocated and practised for the past 50 years. This approach, known as ecosourcing, ensures the seeds used for restoration come from nearby areas and maintain the genetic integrity of a plant species.

Now, researchers at Manaaki Whenua and the University of Otago say it's time to relax these strict guidelines if we want to build resilience into our changing environments. Instead, the researchers suggest creating nine broad ecosourcing regions, within each of which it is permissible to use seeds. They believe this will lead to improved restoration outcomes by increasing species and genetic diversity, mitigating the negative effects of inbreeding, and facilitating the genetic rescue of threatened species populations.

The concept of ecosourcing was introduced by Eric Godley in 1972 to address concerns about planting species outside their natural geographical range and into remnants of indigenous vegetation, which could disrupt their evolutionary trajectories. This would lead to unsuccessful restoration outcomes due to poor environmental matches. "However, we believe that this approach has become overly restrictive," says Manaaki Whenua's Dr Peter Heenan. "Ecosourcing at a strictly local scale limits genetic diversity, confines species to their historical ranges, and reduces conservation options for threatened species," he says.

For instance, tree species in Aotearoa New Zealand that are commonly used in restoration projects have low genetic differentiation within populations because they readily interbreed throughout their range. The strict ecosourcing of tree seeds provides limited benefits. The researchers use the example of kānuka (*Kunzea ericoides*), previously thought to comprise several different species. Research by Peter and colleagues has revealed that kānuka shows geographical variation across Aotearoa New Zealand but no fine-scaled genetic variation.

Peter says it would be better to use larger ecosource areas instead of smaller ones, to help avoid problems associated with inbreeding and allow for a better match with a local environment. "To effectively protect and restore ecosystems, conservation efforts

need to adapt to these changes in contemporary biotic landscapes that have been profoundly altered by climate change, habitat loss and fragmentation, species extinctions, the spread of invasive species, and the emergence of novel habitats," he says.

There has been considerable interest from regional councils, DOC, and community groups in how the new recommendations for enlarged seed-collecting zones can be applied to seed collection for future restoration projects.

Tracking vertebrate pests using landscape genomics

The challenge in keeping an environment free of predators is to make sure any remaining populations of animals in other areas don't reinvade. For Manaaki Whenua's genomics researcher Dr Andrew Veale, this means making use of technology to ensure researchers understand how predators move around their environment and using those answers to guide pest management.

"In the past, traditional genetic methods have been used to compare the similarities between populations of animals, involving tens of genetic markers," says Andrew. "Now, with modern genetic sequencing methods, we are moving the field to look at pedigrees of animals to understand individual movement."

Investigating how target species move at a landscape scale to better-understand reinvasion pathways and how to use management tools and, potentially, natural barriers to block them, will be key to meeting Aotearoa New Zealand's attempts to eradicate mustelids, rats, and possums by 2050.

The first stages of this work have involved a series of large, site-based programmes where various combinations of pests are targeted for local elimination. Individual-based landscape genomics is a novel field and one of many strategies used to identify relationships between environmental factors and the genetic adaptation of organisms in response to these factors. Manaaki Whenua has several landscape genomics programmes underway for almost all pest mammals in Aotearoa New Zealand, which are world-leading in terms of their methods and applicability.

Studies using landscape genomics for possums in Aotearoa New Zealand include one for OSPRI (the national agency responsible for eliminating bovine TB) in Westland, one for Towards Predator Free Taranaki, and another study for Predator Free Hawke's Bay aimed at understanding whether possums can be eliminated from a peninsula.

In the study for OSPRI, researchers used chew cards to survey possums on farmland and in forest on both sides of a river. Andrew says the possums were then captured for DNA genotyping. "We sequenced the genomes of 280 possums and calculated their pairwise relatedness, which indicated extremely high genetic differentiation between possums on each side of the river – with two exceptions. The exceptions were captured within 350 m of the only bridge within the study area, indicating they had probably crossed the river using the bridge."

A 'hybrid' possum with an intermediate genotype was also captured in the same place, indicating one of its parents had probably also crossed the bridge. "We found that the river forms an almost complete barrier to possum movement, but the bridge appears to permit some movement of possums across the river," says Andrew.

The study showed no long-distance dispersal from the deep forest, where TB is prevalent, to the farmland, leading researchers to conclude the source of TB infection to cattle in the area is probably through stepwise possum-to-possum transmission rather than long-distance dispersal.

"From these results we were able to provide OSPRI with specific management recommendations for their control programmes to minimise the spread of TB from possums to livestock in this region," says Andrew.

On Mount Taranaki, DNA sequencing showed that wide rivers with continuous flow stopped possum reinvasions, unless there were any bridges or points of canopy closure over the river. These acted as potential invasion points that would need to have vigilant control measures concentrated on each side of the breach.

Researchers were able to supply specific maps showing areas of reinvasion risk to assist Toward Predator Free Taranaki to create zero possum density zones. "If successful, this region will be the largest area of the mainland managed for possum elimination," says Andrew.

The dispersal story is quite different for stoats and weasels. After using landscape genomics to investigate mustelid movements on the Taranaki ring plain, researchers found that no landscape features affected stoat or weasel dispersal. They also travel long distances, sometimes, in the case of stoats, as far as 40 km. These results show that predator control needs to be maintained over large landscape scales to decrease reinvasion.

"From the genetic evidence in this study, and based on what we know about stoat biology and from other stoat eradication programmes, it appeared likely that

most recruitment is from surviving residents in a control area rather than immigrants, so detecting and removing residents remains the primary concern for managers," says Andrew.

There are many more ongoing studies in this research area, including possums on Māhia Peninsula, rats in Wellington, wallabies across the country, and stoats on Waiheke Island, in Fiordland, and in Wellington. Manaaki Whenua is creating novel methods to address these fine-scale questions of movement and aims to create a generalised system for planning such studies based on the ecology of each species.

New partnership targets deadly livestock disease

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

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

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

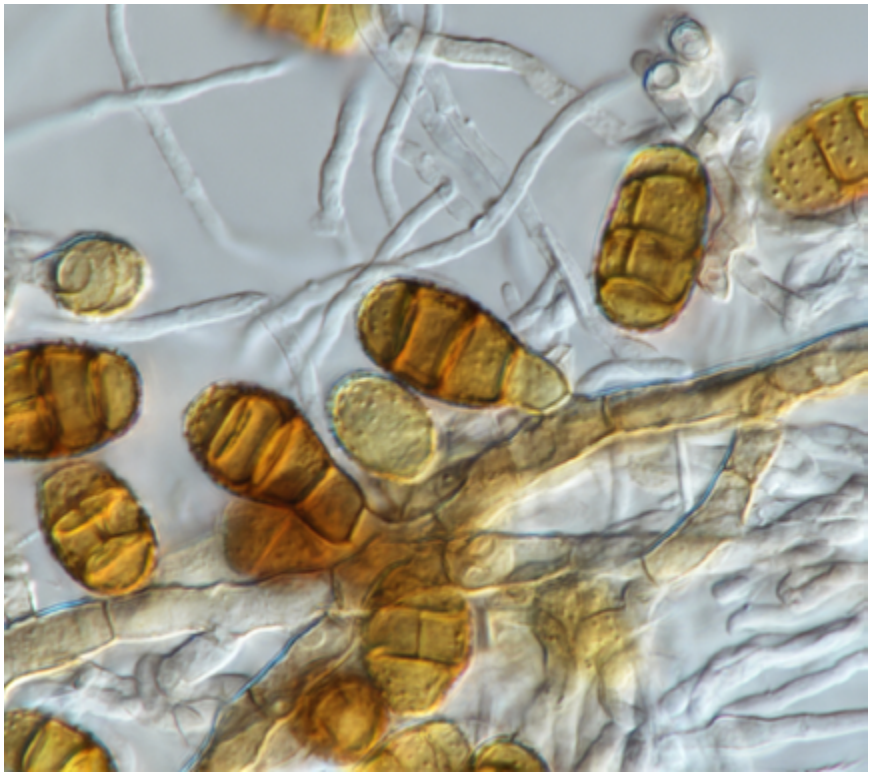
Manaaki Whenua senior researcher Dr Bevan Weir says the programme involves taking a new approach to solving the nearly 100-year-old problem. "Our research will allow us in the future to equip farmers with the tools, knowledge and solutions that they can adopt into their farm systems. While the fungus that causes FE can't be eradicated, we can eliminate the impacts." Initially, research will focus on unravelling the mysteries of the disease and identifying distinct species, which will pave the way for targeted management strategies. "We need to look at improving the diagnostics of FE, especially as the incidence of the disease is expected to rise along with warming temperatures," says Bevan.

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

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

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

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



Microscope image of Pseudopithomyces*, the causal agent of facial eczema.*

New Zealand's Biological Heritage National Science Challenge: Ngā Koira Tuku Iho

Ten years of doing science differently – a decade of research, discovery and impact

BioHeritage has challenged the way science is done in Aotearoa New Zealand. Established in 2014 as one of 11 National Science Challenges, BioHeritage's mission was to reverse the decline of biological heritage by protecting and managing biodiversity, improving biosecurity, and enhancing resilience to harmful organisms. While funding ended for the innovative collaborative programme in mid-2024, BioHeritage's knowledge, expertise, capability-boosting and partnerships, along with tools and new technologies helped transform the way we safeguard our primary production-based economy, our native flora and fauna, and our unique environments into the future.

With a total MBIE investment of $63.7 million over 10 years, BioHeritage has expanded scientific knowledge on how to protect and restore our biodiversity, and empower New Zealanders to enact environmental stewardship. More than 230 research papers have been delivered, along with numerous reports, presentations and lay summaries, and more than 25 tools produced, ranging from decision-making frameworks and apps to strengthen biosecurity through to molecular solutions and games to enable informed discussions. BioHeritage research teams produced 'on-the-ground' impact, developing collaborative partnerships with Māori and community groups, and forging connections with over 75 communities.

Many organisations re-prioritising their research investments to align with the BioHeritage mission. Across the life of BioHeritage, Challenge Parties aligned more than $650M of research contributing towards the mission, with Manaaki Whenua aligning over $165M. The additional BioHeritage-funded research equated to only around 10% of that aligned over the 10 years, demonstrating the enormity of the mission.

BioHeritage's success can be attributed to how it worked collectively across the science system with 18 Challenge Parties, including Manaaki Whenua (host), AgResearch, AUT, Cawthron Institute, DOC, ESR, GNS Science, Lincoln University, Massey University, MPI, NIWA, Plant & Food Research, Scion, University of Auckland, University of Canterbury, University of Otago, University of Waikato, and Te Herenga Waka – Victoria University of Wellington, along with a network of communities and partners spanning the research and innovation sector, iwi and hapū, non-government organisations, business, industry, and the public.

For 2023–2024, five key achievements include:

1. Restoration tools – launched an open-access suite of digital tools to guide land management decisions for biodiversity.

2. Gene technologies for Varroa mite – pioneered the use of RNAi gene-silencing technology to control Varroa mites in honeybee hives, and investigated social and cultural perspectives on the use of RNAi technology.

3. Predator control planning tool and biosecurity guide – launched TrapSim Plus as an online tool for predator-control groups to enable better decisions and planning supporting Predator Free 2050, and produced a decision-making guide for biosecurity managers.

4. Support for collectives and volunteers – produced manuals to assist agencies and communities with volunteers in conservation and restoration efforts and campaigns.

5. Kauri and myrtle protection – concluded the four-year Ngā Rākau Taketake programme, successfully delivering new knowledge, tools, and practices for the protection and restoration of kauri and myrtle species.

Doing science differently

BioHeritage's unique approach was recognised as a globally-leading research culture by its International Science Advisory Panel. Among the key factors were being values-driven, building the 'right teams', communicating and connecting with varied audiences,

valuing non-science roles such as knowledge brokers to bridge the gap to end-users, prioritising stakeholder needs, developing a flexible contracting approach, being 'Tiriti-led' through co-governance and co-leadership, and embedding Māori values. Performance metrics were designed to measure impact better. Our scoping process received international recognition with professor of Rural Entrepreneurship at Scotland's Rural College Mark Reed noting "...New Zealand shows the rest of the world how to fund genuinely co-productive, impactful research".

Enduring outcomes

From the decade of research investment, there are many highlights:

1. Ensuring data sovereignty – developed a national eDNA virtual hub for environmental monitoring, and laid the groundwork for a Tiriti-guided national DNA reference library for Aotearoa.

2. Empowering environmental stewardship – explored attitudes of people towards novel pest control technologies for future environmental protection, and mapped practical actions identified as environmental stewardship.

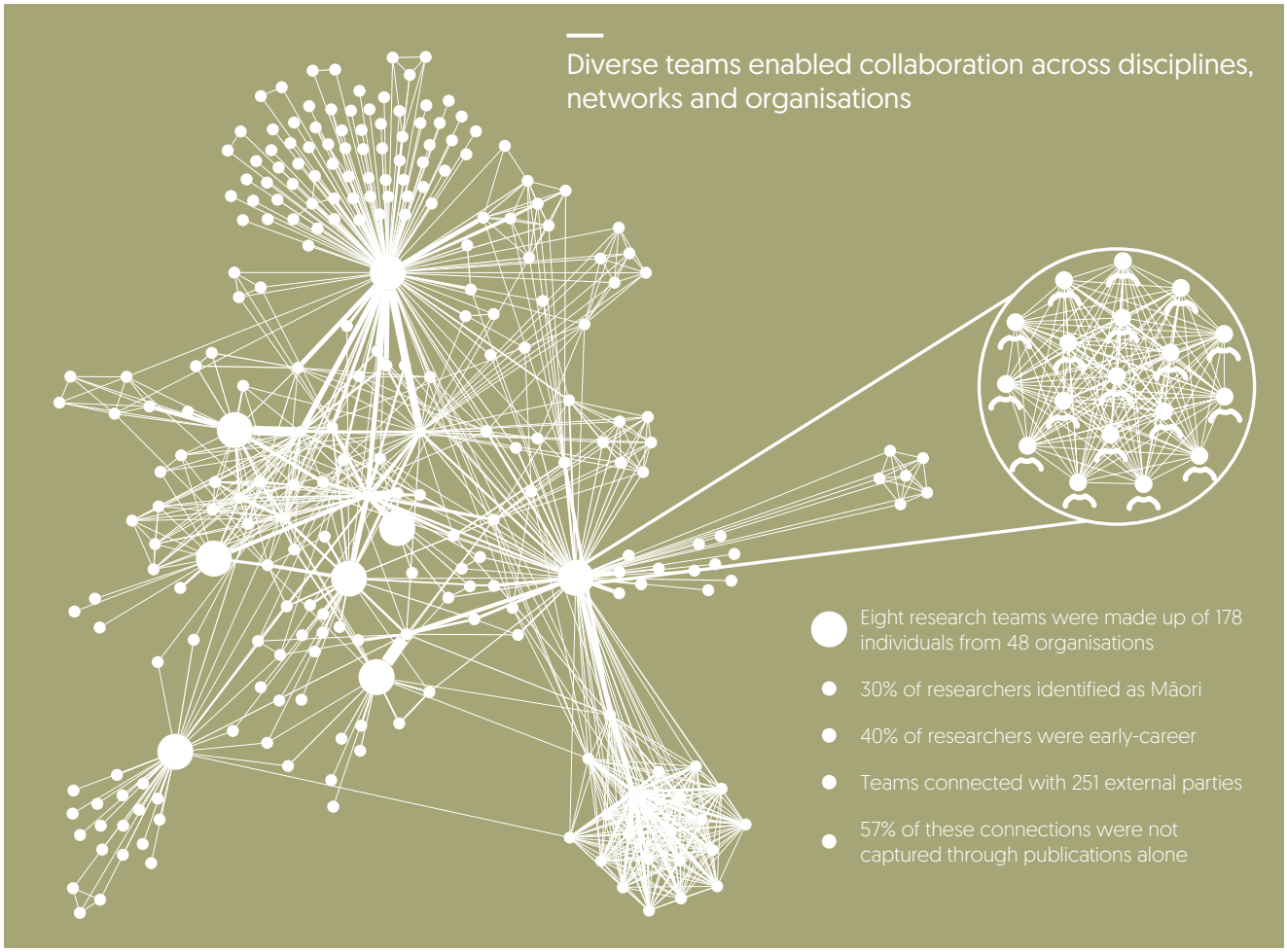
3. Embracing kaitiakitanga – established a biocultural approach to biodiversity monitoring, grounded in Te Ao Māori, reconnecting Māori to their lands, waters and taonga, and better understanding kaitiakitanga in contemporary practice.

4. Modernising biosecurity surveillance – improved surveillance for insect pests at ports, provided an app to help everyday Kiwis protect our native flora and fauna, and developed swarms of 'sensor drones' for invasive mammal predators.

5. Revealing hidden gems - developing sampling techniques for tiny invertebrates living between sand grains in aquifers as practical tools for regional councils to evaluate groundwater ecosystem health.

6. Targeting biodiversity investment – set up an accessible toolkit to guide biodiversity restoration and investment, and to upscale biodiversity restoration on farms.

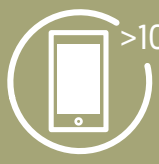
7. Interweaving knowledge systems – bringing mātauranga and science together centring Indigenous knowledge to revitalise translocations of threatened species and create new Māori-led solutions.



Impact summary


>50
Policy-ready research briefs were published


>25
Artistic works such as paintings, storymaps and motoeta were curated


>100
People delivered tools, apps and decision-making frameworks for biosecurity and pest control


4
Crazy & Ambitious conferences were hosted which were attended by more than 100 people from over 225 organisations


>75
Online webinars, videos and blogs produced


25
Tools, apps and decision-making frameworks for biosecurity and pest control were delivered


>75
Communities became part of our reseach teams


>50
Published over 50 policy-ready research briefs


>90
Students were trained


100
Open-access datasets were created


27%
Had an author who identified as Māori


> 40
Roles provided for post-doctoral students


19%
Of our publications were in the top 10% most cited


>45
Reports tabled for end users

8. Uncovering high-tech solutions for invasive mammal pests – developed new scent lures to attract stoats to predator traps, and compiled genome sequences for all three predator groups targeted under the Predator-Free 2050 goal, to help find exploitable weaknesses.

9. Taking the public with us – formed a bioethics panel to consider the social and ethical considerations needed for Predator-Free 2050, and Māori researchers investigated Māori perspectives on control methods.

10. Combating weeds in a warming world – used climate scenario modelling to predict weed spread and impacts across landscapes and potential interventions to slow or stop the spread.

Research for a flourishing Aotearoa

BioHeritage has laid a strong foundation for the future of biodiversity and biosecurity in New Zealand.

Challenge tools, practices, databases, and partnerships are discoverable in a searchable data repository (data.bioheritage.nz) including outputs, such as research briefs, reports, data, and links to papers from our research.

As National Science Challenges end, BioHeritage transitions to a national alliance – The BioHeritage Alliance – co-led and supported by Te Tira Whakamātaki and Manaaki Whenua. This Alliance will continue BioHeritage connections and ways of working to help safeguard our biological heritage into the future.

Toitū Envirocare: Scaling to meet New Zealand's growing demand

Toitū Envirocare: Responding to evolving economic and regulatory contexts

As a subsidiary of Manaaki Whenua, Toitū Envirocare has been leading positive change for over 22 years through science-based carbon and environmental programmes. Toitū's purpose is to help organisations shift their impact on the climate and environment from negative to positive, at pace. This includes enabling businesses to make strategic decisions to mitigate their greenhouse gas (GHG) emissions and adapt to climate change impacts. These business-led decisions are vital in helping Aotearoa New Zealand achieve its national emissions reduction commitments.

Despite the challenging economic landscape of FY24, Toitū achieved 8% revenue growth compared to the FY23 period, predominantly driven by strong performance in the manufacturing, professional services, construction, and public administration sectors.

A total of 134 new businesses signed up to Toitū's carbon and Enviromark programmes in FY24, with there now being 722 carbon and 118 Enviromark certifications issued. Carbonreduce continues to be Toitū's fastest growing and largest revenue contributing carbon programme, although its verification-only service is also increasing, up 50% from FY23.

The total volume of emissions certified or verified during FY24 was 46.5 million tonnes CO_2e (over twice the volume verified in FY23), and Toitū's clients cancelled (i.e. permanently removed) 201k tonnes of high-quality offsets.

Meeting market demand through continued development of Toitū's offerings

Elevate:
Work continued though FY24 on Toitū "Elevate", version four (V4) of Toitū's carbon certification programme. The public version of Toitū's Elevate standard was released in August 2023, and audits will begin against the standard in July 2025. Elevate ensures that Toitū remains at the leading edge of best practice, aligned with voluntary, regulatory and market expectations of climate action. It addresses the full scope of emissions, mandates reductions in line with scientific limits, and boosts collaborative action and ambitions. Elevate supports businesses to embed climate into their strategy, operations and risk management, align with necessary climate budgets, and leverage collaborative action.

Elevate will result in a range of benefits and opportunities for Toitū. It is being launched with a multiple year on-ramp to ensure adoption and client retention. Every client making a Toitū carbon claim from 2026 onwards will be on a trajectory aligned with 1.5°C. As Elevate pushes for collaboration and influence up and down the value chain, Toitū will be able to amplify its impact and expand its reach to shift more of Aotearoa's economy (and beyond) towards a 1.5°C pathway.

Toitū Measure:
Toitū's "Measure" product was introduced in Q1 FY24, to provide a lower cost entry point for businesses. This was a strategic move that aligns with the increasing demands for compliance and transparency in emissions reporting. By catering to businesses that are not yet ready for a full carbon reduction programme, Toitū can expand its market reach and support a broader range of organisations in their sustainability journey. This approach not only positions Toitū to capture new market segments, but also reinforces its commitment to enabling businesses to meet both regulatory and customer-driven environmental expectations.

Climate Related Disclosures product:
A significant update in FY24 was the development of a range of product offerings for organisations mandated to report as part of the recent Climate Related Disclosures (CRD) regime. The CRD regime holds significance from a sustainability standpoint, requiring approximately 200 of Aotearoa's largest organisations (Climate Reporting Entities, or CREs) to acknowledge, understand, and take action on climate change. From Toitū's viewpoint, it presents a valuable opportunity to strengthen its influence and impact in relation to climate and environmental action, by expanding its access to key decision-makers in some of the nation's largest organisations.

The CRD "product" was developed as a variation of Toitū's existing programmes for CREs, with an assurance standalone product. Its primary objective is to ensure adherence to the metrics and targets section of the XRB's Climate Standards (NZCS 1-3), specifically focusing on GHG emissions requirements encompassing measurement, reporting, and target setting. In addition, there is a new requirement for assurance practitioners (NZ SAE1), which has resulted in Toitū splitting out services provided to CREs to either be of an advisory or assurance nature, to avoid any independence issues and to maintain credibility in the market.

Toitū's tāngata / people

During FY24, Toitū decoupled its People function from Manaaki Whenua, recognising Toitū's growing employee base and enabling more focused internal support. Work was instigated across employee experience and onboarding, as well as the review of Toitū's People strategies and processes to ensure alignment with the evolving needs of the business, all of which will remain a focus for FY25. In addition, there is an increased focus on ensuring Toitū's leaders are equipped and supported in their leadership roles, with 30 of Toitū's senior people and technical leaders (including the Leadership Team and CEO) completing Toitu's Leadership Development Programme in May 2024. This involved participation in six three-hour experiential and collaborative working sessions, focused on real and immediate business issues and needs. This group of leaders will continue to be engaged and mobilised to support Toitū's ongoing commitment to the development, engagement and support of Toitū's people.

Education and outreach

In a year of significant development in domestic and international market expectations and initiatives, Toitū has responded to calls for more focused high-quality information about emissions reporting, avoiding greenwashing, and international developments. Toitū published eight explainers and delivered six webinars, presented at over 15 workshops and conferences, and delivered paid training courses on a range of related topics. Toitū's webinar uptake is strong, with an average of over 400 registrations per webinar.

Dr Belinda Mathers, Toitū's Chief Science and Advisory Officer, attended international climate conference, COP 28, in late 2023, delivering presentations in relation to Toitū's work, participating in a webinar and media interviews, and enabling Toitū to provide real-time insights throughout the event. Toitū also hosted a post-event debrief webinar to summarise outcomes.

Transformation

Toitū's transformation business case was developed in 2022 and focused on three key pillars: simplifying and automating processes (aka operational excellence), scaling through meaningful partnerships, and digitising the business to ensure simple, cost-effective access for all. FY24 saw Toitū prioritise operational excellence, recognising the impact that this would have on its service delivery model – for clients, partners, and employees alike. Following comprehensive work to map all of Toitū's client-facing service delivery systems to ensure a comprehensive understanding of operations, roles, tools, and processes, key achievements included the simplification and/or automation of over 20 material processes, and the implementation of a time-tracking tool for all client-facing team members, enabling accurate billing and providing valuable data for identifying further areas of improvement.

Partnership revenue growth focused on expanding Toitū's existing ~16 year international partnership with Achilles into new countries, while progressing Toitū's operational excellence work to ensure Toitū is 'partner fit' before entering into similar partnerships. In addition, Toitū continued to build its network with like-minded organisations to expand its influence and impact through non-revenue generating partnerships.

Toitū's digital strategy underwent significant evolution in FY24, initially focusing on a fully automated verification and certification tool. This strategy, which relied on partnerships and a unique go-to-market approach, eventually pivoted to a more direct client-focused model after efforts to validate a commercial service and define platform requirements determined that the model is not commercially viable at present. Despite these shifts, Toitū made significant progress in several key areas. One of the notable achievements was the development of intellectual property in relation to data protocols, which will be instrumental in future client services and partner activities. The establishment of a cloud infrastructure also provided a solid foundation for further developments in FY25. Toitū also made significant progress in the development of a tool to improve verification / assurance activities, including foundational connections into the current eManage platform.

The transformation business case did not contemplate the impacts of the economic, political, and regulatory context of late FY23 and FY24/25 on Toitū's business. These external drivers have resulted in forecast revenue shortfalls of ~$7m through FY24/25, vis-à-vis the transformation business case. As a result, this has had, and will continue to have, a material impact on Toitū's ability to fund and deliver the transformation as initially contemplated.

Financial performance

Toitū achieved total revenue of $18.4 million in FY24, an 8% increase on FY23 despite the recessionary environment of FY24 and the additional challenges posed by the broader political and regulatory context. Growth was materially less than anticipated, however, falling $2.60m short of the FY24 budget. Operating expenses were well-managed, coming in at $1.04m under budget, largely due to the implementation of cost control measures in response to declining revenues, and deferred roles related to the transformation programme.

Toitū incurred a net loss of $2.1m for the year, mainly due to the decision to expense $2.3m of digital transformation costs that were originally expected to be capitalised. Without this adjustment, the business would have achieved a small profit, which underscores the impact of the economic environment and strategic financial decisions on the overall result.

Looking ahead

Trading conditions continue to remain tight as businesses face challenges such as reduced consumer spending and increased borrowing costs. Toitū expects continued headwinds through to the end of the 2024 calendar year, with business confidence slowly returning in 2025. As business confidence returns, and increasing national and international regulatory requirements require businesses up and down the value chain to report their carbon emissions, Toitū expects programme membership growth to continue.

Given the current market conditions, Toitū is committed to maintaining a strong focus on financial responsibility, ensuring prudent management of resources and strategic investments to sustain its growth and stability. This includes a continued focus on client retention in response to the ongoing recessionary environment and increasing competitive landscape, as well as a heightened focus on employee engagement and retention. Revenue / funding challenges will continue to necessitate a slowing down of the delivery of Toitū's transformation programme, with a focus on ensuring that Toitū has the foundations in place to enable it to accelerate the programme at pace, once funding permits.

Toitū Envirocare-certified client Better Eggs showcasing its climate credentials at the Auckland Food Show.

Toitū Envirocare hosting a member event for the launch of its Elevate carbon certification standard.

Dr Paul Mudge analysing soil cores. Image: Dave Allen.

Action on climate change

Climate change is the major challenge of our generation and is of specific concern to Pacific island nations. Over two decades we have redirected our research to focus on understanding Aotearoa New Zealand's emissions balance, supporting mitigation, and enabling adaptation and resilience to climate change. Our research has supported Aotearoa New Zealand's international emissions reporting, and has provided an understanding of carbon stocks in our indigenous forests and in the soil. We have designed and supported pathways for carbon sequestration and for businesses and communities to take meaningful climate action. Our Toitū Envirocare subsidiary has enabled hundreds of organisations to plan and achieve certification of their emissions management, as discussed on pages 47-49. Increasingly, Toitū members are offsetting their emissions to become carbon-zero.

Selected highlights

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Manaaki Whenua Kaihautū Māori Research Impact Leader Dr Shaun Awatere (Ngāti Porou) has recently participated in workshops with other Māori advising the Climate Change Commission to develop Pae Tāwhiti Pae Tata, the te ao Māori specific chapter for the Commission's first national adaptation plan monitoring report. This report assesses progress towards meeting the emissions budgets and the 2050 target, and the adequacy and implementation of current emissions reduction plans by government.

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Dr Shaun Awatere also co-hosted the Ngā Pae International Indigenous Climate Change Research Summit in November 2023. Delegates worked on a communiqué, a statement from the summit intended for world leaders, policymakers, environmental organisations, and the global community. It underscores the pivotal role of Indigenous voices, ideas, and actionable solutions in addressing climate change.

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We found that the efficacy of nitrification inhibitors (NIs) for mitigating nitrous oxide emissions was reduced because large proportions of applied NIs were retained in the pasture canopy. Delays in application of NIs following urine deposition further reduced the proportion of nitrogen in the urine patch that was in contact with the inhibitor solution. Increasing the amount of water applied with NIs is a potential solution.

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A workshop was held at our Hamilton office to gather insights on opportunities for peatland rewetting in the Waikato region. Decomposition of drained peatlands, mostly used for dairy farming, account for up to 8% of net GHG emissions. A range of stakeholders represented farmers, Māori interests, scientists and regional and central government. This is part of a wider Waikato Regional Council funded project identifying risks associated with drained peatland management and identifying opportunities to reduce or stop subsidence and GHG emissions from drained peatlands. Intact peatlands provide important ecosystem services including carbon sequestration, water storage, and habitat provision.

—

A study involving over 200 authors and extensive satellite and on-ground data (including plot data sourced from our National Vegetation Survey Databank) suggested that restoring global forests could potentially sequester 226 gigatons of carbon, equivalent to about a third of the carbon released since the Industrial Era began.

—

We collaborated with Lincoln University to develop a national GHG inventory methodology for enhanced rock weathering (ERW) – a negative emissions technology receiving extensive attention internationally. To our knowledge, this work (for MPI) is the first time that someone has developed concrete suggestions of how to implement ERW into a national GHG inventory.

Changing our SOCs – a progress report

Soil organic carbon is critical to soil health. It's the basis of the soil food web and it plays an important role in making nutrients available for plants. It's important we know what's happening to soil carbon levels in Aotearoa New Zealand, because small decreases in soil carbon could contribute to reducing our national carbon footprint.

Although carbon sequestration is more commonly thought of in terms of plantation forestry, an international study has determined that an annual increase of just 0.4% in the soil carbon stocks in the top 30-40 cm of soil would significantly reduce the carbon concentration in the atmosphere. And because agriculture contributes significantly to our national greenhouse gas (GHG) emissions, increasing our soil organic carbon stocks (SOCs) in our soils could be a great opportunity for the agriculture sector to offset our national emissions.

The National Soil Carbon Monitoring Project, a collaboration between Manaaki Whenua and the University of Waikato, and funded by the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC), is currently assessing whether soil carbon stocks under New Zealand's agricultural land are increasing or decreasing, and how land use contributes to that change. The project will generate data that will help improve our estimates of carbon stocks and stock changes within a particular land use. Data will also improve our ability to predict how SOCs are likely to change when land use changes.

Benchmark sampling at 500 sites across New Zealand, which began in 2018, has now been completed, with return trips planned in the coming years based on a robust farm-scale measurement and monitoring protocol. This work is also feeding into improving the national GHG inventory, providing a basis for calculating farm and industry emissions.

Once SOCs are better understood, new policy or regulatory frameworks will need to be put in place to enable soil carbon to be accounted for in a robust way. Should New Zealand choose to include soil carbon in its Emissions Trading Scheme, the simplest approach might be to adapt the system already legislated for in Australia, informed by our New Zealand-specific underpinning science.

Kim Triegaardt

Dr Hamish Maule (left) and Zach Dewhurst sampling soil carbon near Ashburton, Canterbury.

How trees could turn down the heat

Like people keeping cool under beach umbrellas, cattle seek shade as the temperature rises. And for cows, even air temperatures in the low twenties can be too hot, because the animals naturally create a lot of internal heat whilst digesting food or producing milk.

Alert farmers watch carefully for signs of heat stress in their herds: faster breathing, grazing less, drinking more and moving slower. Because cows graze less and use more energy when it's hot, heat stress is known to cause billions of dollars' worth of losses to meat and milk production globally. The economic impact of heat stress on cows is projected to become more severe in the future due to climate warming.

Tree establishment to provide shade in pastoral livestock farming holds a lot of potential as a nature-based adaptation tool to reduce cattle heat stress. To establish trees in the best way to help cows, we must answer a complicated mix of questions – what type/s of tree, planted where, and in what densities? And what are the likely financial benefits of increasing on-farm shade on future milk and meat yields?

Researchers led by Dr Dan Richards at Manaaki Whenua have now developed a general model for the impact of trees on cattle heat stress, carefully piecing together the effects of various climatic

elements including air temperature, wind speed and humidity with tree characteristics such as height and leaf density. They have added high-resolution mapping of over 400,000 farm management units to estimate the amount of shade currently available to the beef and dairy herds across Aotearoa New Zealand, and used all this information to model milk and meat production under future climate scenarios at varying scales. The work neatly links to other work currently being done at Manaaki Whenua on the potential benefits of planting mosaics of trees in pastoral landscapes for carbon capture.

The modelling shows that existing tree cover already brings impressive economic benefits to Aotearoa New Zealand. The simulated current contribution of trees to national milk yields is in the order of 500 million extra litres of milk to the overall total of around 20 billion litres per year, which conservatively works out at an additional US$200 million of revenue per year based on 2017 milk prices. For meat production, the contribution of trees is around 8000 tonnes of meet to an annual national total of around 110,000 tonnes – an extra US$37 million of revenue.

Adding more shade trees to pastures could bring even bigger economic returns. The maps in the model estimated that tree shade is currently (as of 2020) not available to around 3 in 10 cows in New Zealand's dairy herd and to around 1 in 5 of the beef herd. If additional trees were established to ensure universal access to shade for cattle and minimise the risk of heat stress, the modelling showed that by 2070-2080 there could be an increase in national milk yields of an average of 350,000 litres per year and an increase in meat yields of an average 2500 tonnes per year, within a range of yields depending on the degree of future climate change.

Carbon stocks – can ryegrass be beaten?

Worldwide, soils under managed grasslands hold a lot of carbon: up to 22% of all land-based carbon stocks. How the land is managed affects whether these soils gain, lose, or keep their carbon – and historically, much carbon has been lost as natural ecosystems have been converted into grassland. Land management to maximise soil carbon stocks in grasslands could help New Zealand's overall greenhouse gas balance. With managed grasslands making up around 55% of New Zealand's land area, mostly for sheep, beef and dairy production, and with greenhouse gas emissions from the agricultural sector comprising around 50% of the nation's total, it is important to optimise pasture management to preserve or increase soil carbon stocks and avoid losses.

Best-practice grazed grassland management, which broadly aims to limit environmental impacts, relies on practices such as rotating grazing areas, maintaining plant cover year-round, irrigation, pasture renewal, periodic cropping of pastures and increasing pasture plant diversity away from conventional ryegrass and white clover. These practices, and others such as planting deeper-rooted pasture species, may also benefit soil carbon stocks, but the effects are not easy to quantify due to labour-intensive measures and lack of replication between farms.

Scientists from Manaaki Whenua and the University of Waikato recently combined the data from three dairy farms in Waikato and two in Canterbury over 68 site-years, between 2008 and 2022, to calculate how different management practices have affected soil carbon stocks. On these farms, the net CO_2 exchange of the pasture was continuously measured, and carbon removals and additions associated with grazing, harvesting, effluent and fertiliser application were monitored.

Although the data were limited to five farms and only four main soil types, the results make for interesting, and perhaps unexpected, reading.

Soil carbon stocks under grazed pastures were largely steady-state. None of the management practices assessed on these farms showed increases in soil carbon stocks over time, other than when carbon was added in the form of manure or effluent. Some practices, such as periodic feed cropping and pasture renewal, led to net soil carbon loss, although some or all of the carbon could be recovered over subsequent years. Irrigation did not seem to make a difference to soil carbon in Canterbury, while enabling large increases in grass production.

The researchers also found no evidence in their data that pastures with moderately increased diversity (5 species) increased carbon stocks compared with conventional ryegrass/white clover mixes. It appeared that use of a conventional ryegrass/white clover mix, the most common pasture mix in use in Aotearoa New Zealand over the past century, gave the best opportunity for maintaining soil carbon stocks in New Zealand's temperate climate, while also producing enough biomass to support dairy cows. However, the studied farms did not use highly diverse species mixes or altered grazing management aiming for higher standing biomass after grazing, which are practices explored by the growing regenerative agriculture movement. "Research into the carbon effects of these practices is underway" says Dr Johannes Laubach, a senior researcher in greenhouse gases at Manaaki Whenua, "including measurements of the greenhouse gases methane and nitrous oxide, to identify trade-offs or synergy effects of management practices on net greenhouse gas emissions."

Flood damage in Dartmoor Road, Puketapu, Napier, after Cyclone Gabrielle. Image: John Cowpland.

People and environment

Since 1996 Manaaki Whenua has built social, cultural, and economic research capability to understand people's decision-making in matters of the natural environment. We now have one of the largest dedicated groups in the Southern Hemisphere. The audience for results from this research is diverse – including central and local government, Māori organisations, primary industry, businesses, non-goverment organisations, and communities – because all parts of society affect natural resource management. Our research spans rural, conservation, and urban landscapes, and the full range of ecosystem services viewed from both European science and indigenous knowledge systems. It supports improved natural resource and climate change decision-making in Aotearoa New Zealand and in the Pacific. This work is integrated with our work in all impact areas where people need improved tools for decision-making, policy, governance, regulation, planning, and strategy development.

Selected highlights

The Survey of Rural Decision Makers (SRDM) is the leading source of information on New Zealand's primary sector and one of the largest and longest-running rural surveys in the world. Conducted by Manaaki Whenua every two years, thousands of farmers, foresters, growers, and lifestyle block owners from Cape Reinga to Oban complete the survey. In 2023, there were around 5,200 respondents. Each year, new questions are added to reflect pressing knowledge gaps for industry, policy makers, and scientists. In 2023, new and expanded topic areas included winter grazing practices, forestry risk, biosecurity, volatility in input and output prices, life satisfaction, disaster preparedness, trustworthiness of advice, and perceptions of the regulatory environment.

Thanks to Manaaki Whenua's annual COLOSS survey of the apiary industry, AoNZ achieves the highest participation rates and the highest engagement with beekeepers, particularly commercial beekeepers, among the 43 countries that conduct surveys of honeybee colony losses. Key findings of this year's survey were that colony losses attributed to varroa continue to increase, with beekeepers increasingly turning to alternative treatment methods, that colonies lost to Cyclone Gabrielle were 3-4 times higher than previously reported, and that commercial beekeepers experience lower well-being than other primary producers.

Senior researcher Dr Suzanne Vallance, funded by the Resilience to Nature's Challenges National Science Challenge, looked at the role of women in two disasters: the recent devastation caused by Cyclone Gabrielle and the Kaikōura earthquake. The research showed that as natural disasters become more frequent, the role of women in recovery, including the restoration of relatively invisible but vital community infrastructure, needs to be better recognised and adequately supported.

Most of our historical biological specimens have only a natural-language location description, such as '200ft above and south of main highway, 1.1 miles west of Porters Pass', and numerical coordinates are unknown. Brandon Whitehead and Dr David Medyckyj-Scott are working with Massey and Cardiff universities as part of the BioWhere project to automatically determine the geographical coordinates (geo-references) of complex location descriptions using the latest transformer-based deep learning models.

We demonstrated that farmers who experience climate worry or climate anxiety have lower well-being than those who do not. Specifically, we found that climate worry has a strong negative impact on well-being, reducing subjective well-being scores by 4.8%. These results suggest that rural mental well-being will diminish as the effects of climate change become more pronounced.

To our knowledge, this is the first time that a negative relationship between climate worry and well-being has been established for primary producers.

Innovation stories

Good farmers go SLO

In New Zealand, farmers and the largely urban general public are held to have differing views on what is meant by being a "good farmer". Anecdotally, farmers see themselves as stewards of the land for future generations, using management practices that would be considered environmentally sustainable, whereas the urban public disagrees with such a portrayal. But does a rural/urban difference of viewpoint about "good farmers" really exist? Recently, our social scientists teamed up with researchers from the University of Otago, Cawthron, AgResearch and Lincoln University and partners Dirt Road Communications, Quorum Sense and Thriving Southland to dig a little deeper into public perceptions of the "good farmer".

The research team undertook two surveys in 2023, one among farmers and one among the general public, to discover how well the public's perception of a "good farmer" and farmers' perceptions of a "good farmer" align. To do this, they used the idea of social licence to operate (SLO) – a wide-ranging concept that describes how expectations of behaviour and actions are set between a community and a business or industry, often at a local level. If a group has SLO, its actions and behaviours are accepted by the society it operates within.

SLO can extend into many aspects of what constitutes a "good farmer" – and the surveys reflected this. Participants were asked, among other things, whether they thought farmers manage their farms in an ethical way, comply with government rules and regulations, use practices that focus on animal welfare, contribute to the local community, and reduce chemical inputs where possible.

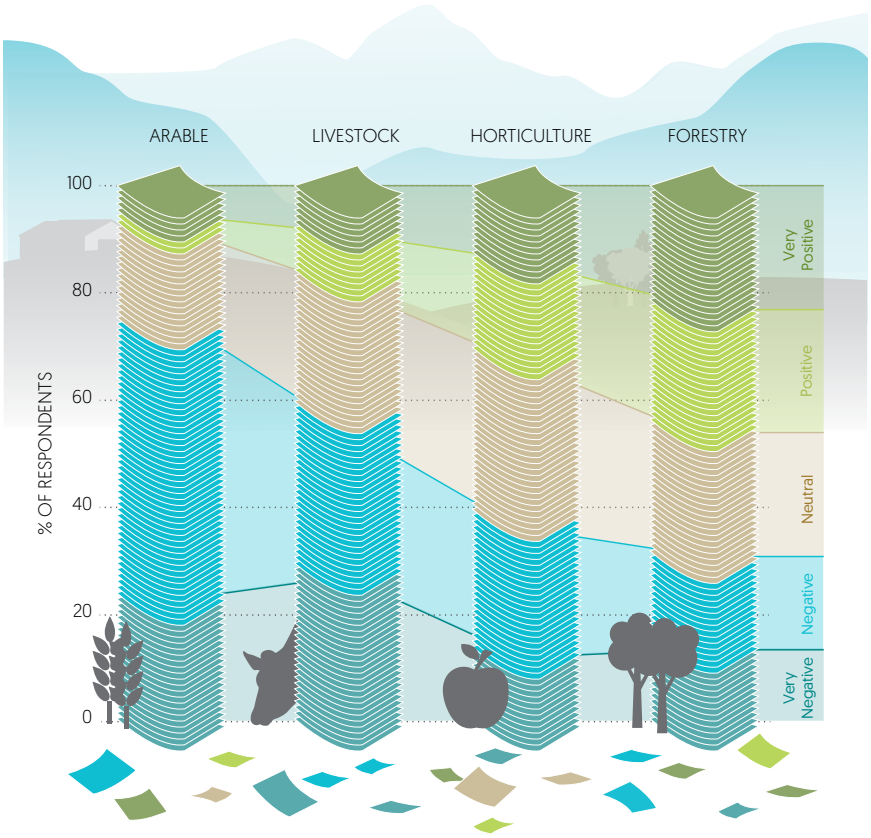
The survey results showed some differences in perceptions between the two groups – for example the public tended to mention treating staff well, keeping fences intact, minimising the use of chemical inputs, ensuring they meet environmental requirements and legislation, and that they produce a good yield during harvest as being characteristics of good farmers, whereas farmers did not.

By contrast, farmer respondents reported more often that a 'good farmer' was one who gained 'social acceptability' for their practices, and farmers expressed a belief that many members of the public do not understand what farmers do, and that this lack of understanding could affect public perception of the acceptability of farming.

Overall, however, the study showed a much closer alignment between the groups about what is meant by a "good farmer".

"Interestingly, both groups trusted farmers as a source of information more than they trusted the media," says Dr Peter Edwards, senior researcher. "These results, when taken with other work in the Our Land and Water National Science Challenge, suggest that the perceived urban/rural divide between farmers and the public may not be as large as previously believed – which is good news for farmers' continued SLO in New Zealand."

Hugh Campbell, Professor of Sociology at the University of Otago, adds: "This is an encouraging outcome in an area where there has been a lot of discouragement lately. The gap between urban and rural isn't nearly as wide as it might appear in some social media discussions. We need to build on



The Survey of Rural Decision Makers provides rich primary-sector data – in this case, about the burden of regulations faced by different types of farmer.

this to avoid any further loss of trust between many parts of New Zealand society as we go about collaborating on finding solutions to some compelling farming challenges."

The Social Licence to Operate framework developed by Manaaki Whenua is also proving valuable in a wide range of settings: social licence to farm, the significance of the urban-rural divide, the forestry sector (with reference to cyclone damage in Tarawhiti/Gisborne), in the interactions between Māori and industry, and for pest control and biocontrol projects.

Creating "cultural licence to operate" in pest control

Key to making research programmes successful is ensuring we have the social and cultural licence to operate says Kairangahau Māori Mahuru Wilcox.

Researchers at Manaaki Whenua have been working closely with four groups (Ngāti Porou, Tūhoe Tuawhenua Trust, Hokotehi Moriori Trust, and a northern Taranaki collective including Ngāti Mutunga, Ngāti Tama and Ngāti Maru), who are undertaking small and large-scale pest control projects. "A kāhui Māori process has given us the support of Māori experts and knowledge holders to co-develop approaches that are culturally acceptable to tangata whenua and draw on traditional and current knowledge of pest control strategies," says Mahuru.

Through a series of wānanga with our iwi and imi partners, mātauranga aligned with pest control has been shared, along with the aspirations of Māori and Moriori in this area. Discussion included different types of lures (some of which were used historically for snaring kiore), the influence of maramataka on animal behaviour, how to undertake pest control using local tikanga to ensure the safety and success of those in the field, as well as local environmental tohu that can be used as early warnings for mast seasons.

"All of this has helped inform a kaupapa Māori and Moriori-based pest control framework", says Mahuru. "The framework can support iwi and imi as they develop local pest control strategies and projects, and serves to monitor success beyond the number of pest animals killed. Success for many of our iwi and imi includes wider benefits to communities, traditional knowledge transmission, and ways to reconnect tangata whenua with their lands, taonga, and each other."

Data supermarket on land use open for hungry minds

An online data 'supermarket' is open to anyone hungry for information about the food and fibre we can grow in Aotearoa New Zealand – now and in the future.

The Whitwhiti Ora website hosted by Manaaki Whenua is free and stocked full of datasets that give a broad understanding of the benefits and consequences of a wide range of land use opportunities.

Dr Linda Lilburne, Principal Scientist in Spatial Data Science at Manaaki Whenua, says a large team of researchers from multiple institutes and scientific disciplines produced these datasets as part of the Land Use Opportunities: Whitiwhiti Ora research programme funded by the Our Land and Water National Science Challenge.

The datasets hosted on the website were created between 2020 and 2023 to provide information on social, environmental, and economic costs and benefits of a range of land use options.

"The datasets provide a snapshot of land-use information across Aotearoa – it is national scale data, so the purpose is to provide users with an initial picture of information they can use to undertake their own further research," says Linda. For example, the website has datasets on crop suitability and how that changes over time with the impact of climate change.

"You see that in some places where apples, cherries, or avocados grow well now will not be optimal land in the future due to the impacts of climate change – some of the datasets can be quite eye-opening," says Linda.

The researchers hope the site will be used by a range of users, such as mana whenua, regional councils, farm advisors, consultants, primary sector groups, investors or anyone keen to find out more about land use opportunities across the motu. "It is essentially a one-stop-shop for land use opportunity information in Aotearoa," says Linda.

Each dataset includes information about its limitations and how the data was produced, and most include spatial layers. The information can be downloaded for use in third-party tools such as geographical information systems (GIS). Some of the data has been published on the 'Our Environment' section of the site to allow for easier browsing of the spatial layers. The data is open-access and suitable for New Zealand use only, says Linda.

The Whitiwhiti Ora website landuseopportunities.nz is a collaboration between Manaaki Whenua, AgResearch, DairyNZ, Scion, Land Water People, NIWA and Plant & Food Research. It is funded by the Our Land and Water and Deep South Challenges.

How we work

Te āhua o tā tātou mahi

Our goal at Manaaki Whenua is to create an environment that allows the right people to come together and create high-impact research that meets Aotearoa New Zealand's needs. That means supporting our own people, but also supporting a high level of collaboration and integration across the research sector and the wider community that relies on and uses our research and solutions.

Mycologists taking part in the annual Fungal Foray, which aims to discover and record fungal species present across Aotearoa New Zealand. This year, the Foray was at the Mangapapa Conservation Area near Rotorua.

Putting people at the centre

The diagram shows four interlinked strategic aspects of how we work. Our overarching priority is development of our people and culture, which also puts our people at the centre of everything we do. We are also committed to ensuring our financial resilience, developing impact processes for our science, and continually improving our support systems and infrastructure.

A great place to work – being an employer of choice

We are proud of our ability to attract high-calibre people to Manaaki Whenua. To ensure that we retain as well as attract the best, we have extended our partnership with the New Zealand Institute of Management and Leadership (NZIM), which has implemented a Leadership Programme specific to us. The third cohort of leadership programmes ('Empowering Leaders' and 'Leadership Capability') finished in mid-October 2023. A total of 25 participants completed the Leadership Capability programme from February to May 2024. The Emerging Leaders programme for 2024 started in March with 21 participants (10 from Manaaki Whenua and 11 from ESR). Staff from previous years are continuing to meet and network with each other, and feedback on this initiative has been positive.

Our flexible working guidelines in relation to working remotely have been updated following feedback from our Employee Experience Survey. The change enables staff who can work flexibly to request to work up to 40% of their time remotely.

Employee Experience survey results

This survey helps us understand the overall experience for our people at Manaaki Whenua. We intend that our culture, values and behaviours underpin our staff's senses of belonging/connection/whanau and help to create an inclusive workplace, in which everyone can bring their whole selves to work.

At 71%, the 2024 Employee Experience Survey reported a high level of staff engagement.

Staff were asked the following questions as part of this year's survey. The figures quoted are for those who agreed or strongly agreed with the following statements:

- This organisation is a place where everyone can succeed to their full potential no matter who they are (e.g. all genders, races, cultural backgrounds, etc.): 66% (2022/23 = 69%, 2021/22 = 74%)
- I feel included at this organisation: 79% (2022/23 =74%, 2021/22 = 76%)
- Diverse perspectives are valued at this organisation: 70% (2022/23 = 65%, 2021/22 = 72%)
- I feel comfortable being myself at work/with my colleagues: 82% (2022/23 = 83%, 2021/22 = 83%).

Providing for health, safety and well-being

Our goal is that everyone is 100% committed to health, safety, and well-being. The staff survey indicates that 94% of staff agree or strongly agree that Manaaki Whenua strives towards this goal. We continuously seek to mitigate risks inherent in our work in laboratories, on our sites, and in our fieldwork in remote locations.

We regularly review processes in place to ensure we are providing a safe work environment for all people working for and with Manaaki Whenua. We ensure that our staff are supported when the unexpected happens: our business continuity and crisis management response plans are integral to this.

Our 2023 Field Forums consisted of eight online sessions and a half-day in-person session, covering field intentions and emergency management, operating emergency beacons, fleet vehicles and driving, and fieldwork competencies including creating a field risks

register. The sessions had a total of 166 attendees from across the organisation.

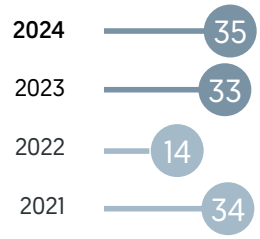
The National Laboratory Manager and HSE Manager have been working on hazardous substance training and refresher resources for our laboratory and facility users. The new materials consist of online videos, a presentation, and new spill and fire emergency response posters. We are also now working to transition the organisation to the Globally Harmonised System (GHS7) for the management of hazardous substances.

Manaaki Tangata – our well-being programme for staff – is themed monthly and linked with the Diversity & Inclusion group. The wide-ranging calendar for 2023/24 comprised months dedicated to a variety of well-being themes: financial well-being, Pasifica including language weeks and cultural intelligence, stress and burnout, heart health, bullying and harassment, neurodiversity, Matariki, mental health, and sun safety.

Staff at Manaaki Whenua in Lincoln gathered to celebrate Matariki. Image: Kim Triegaardt.

HEALTH AND SAFETY

Near misses



Lost-time injuries

Creating an equitable culture

This year we have updated our Gender and Ethnic Pay Report, incorporating data as at 30 June 2023. We are actively working towards closing our vertical median pay gap. This gap had decreased from 16.7% in June 2020 to 14%, in June 2022, but rose again to 17.3% in June 2023 and currently sits at 19.4%. Our vertical pay gap is primarily driven by a lack of women in senior roles and at Science Hay Grade 17, with only 34% representation as of 30 June 2024.

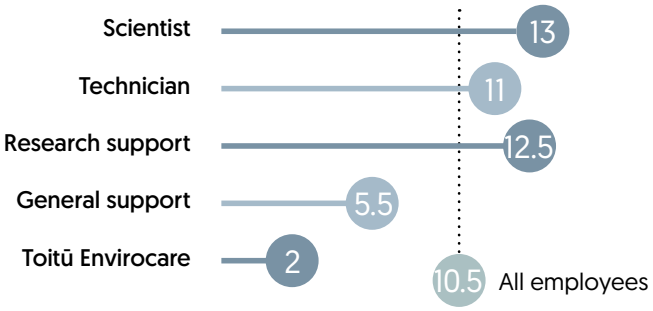
To help to address this problem, focus groups took place in February 2024 with 26 women on the science side of the organisation who are in leadership roles, or who are aspiring to be or have the potential to be in such roles. The aim of the focus groups was to understand the current leadership inclusion challenges and help build a road map to improve the representation of women in our senior roles.

Manaaki Whenua also looks at its gender pay gaps across similar pay grades (horizontal pay gap) and there is no evidence of gender pay gap across like-for-like roles.

STAFF OVERVIEW

Overall engagement (%)

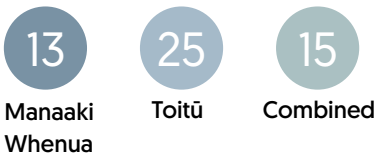
Average years' tenure



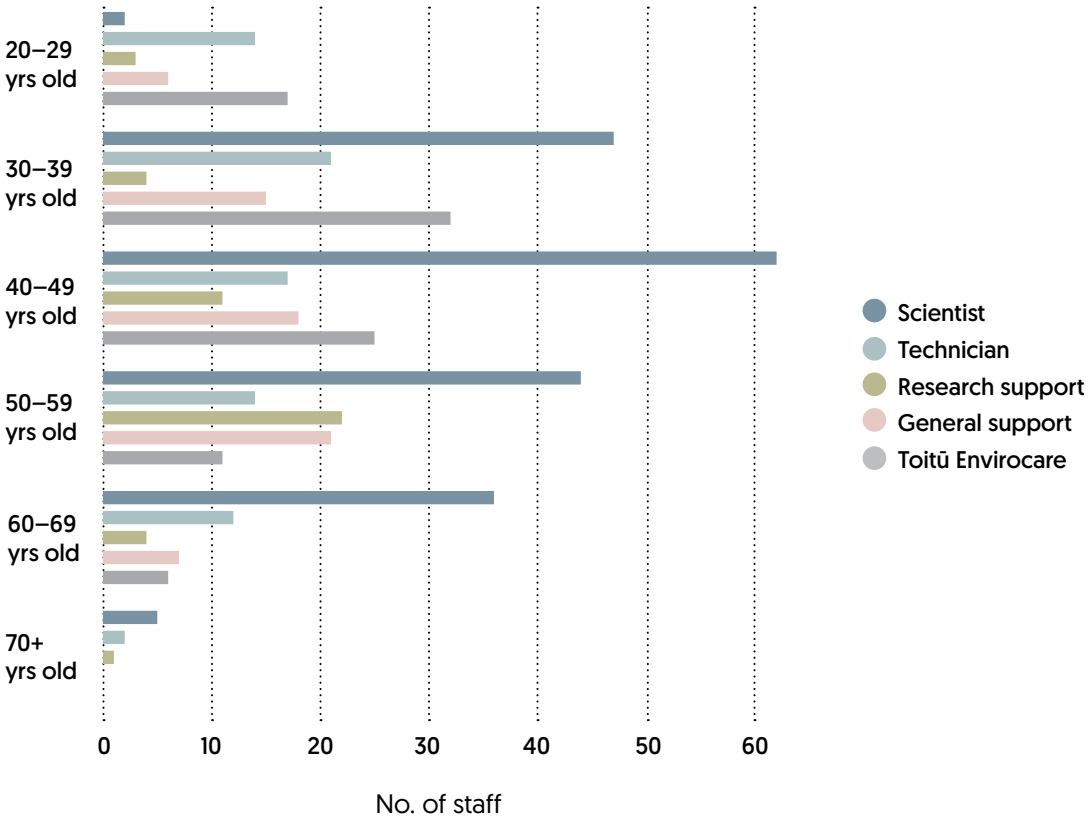
Overall gender distribution#*

None of our staff identified as genders other than male or female.
*excluding Toitū

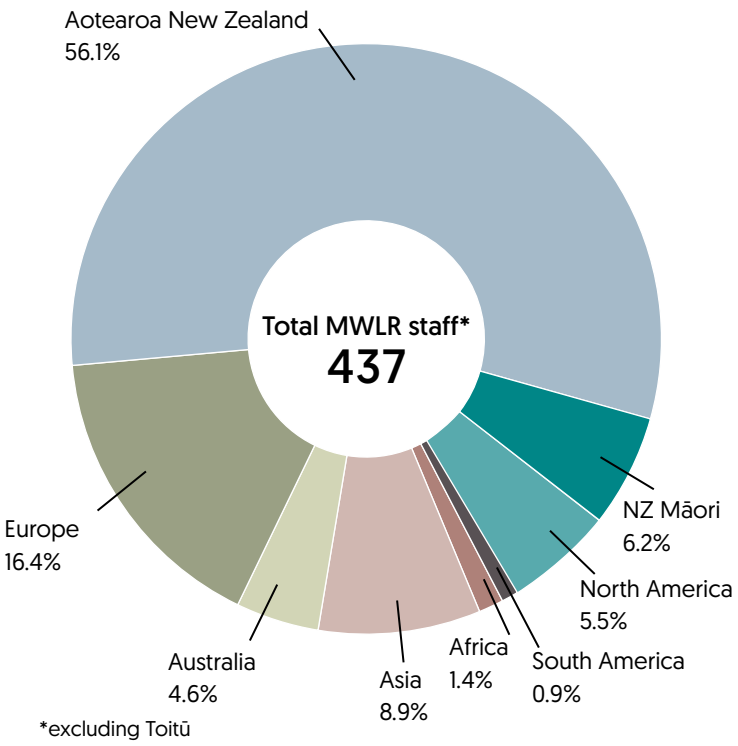
Annual turnover (%)



Age distribution



Origin of our staff



*excluding Toitū

As a result of collective bargaining in 2022, Manaaki Whenua and the Public Service Association union agreed to establish a Remuneration Review and Design Group, with the purpose of reviewing the existing remuneration and designing/recommending changes to ensure a fit-for-purpose remuneration system. One important outcome was the recommendation that science staff, as well as support staff, should have their salaries benchmarked against external all-organisation data, in line with other science organisations. The Board approved a one-off remuneration adjustment for science staff from the beginning of April 2024.

We continually review our recruitment and remuneration processes to ensure they support our diversity and inclusion aspirations. Our Māori staff currently have a median pay gap in their favour of 3.4% compared with non-Māori.

Building a diverse and inclusive work culture

Our Diversity & Inclusion group of staff is made up of representatives across our teams and sites, raising awareness and building knowledge of diversity, enabling us to better understand the needs of our stakeholders and people and respond effectively to them.

Following a survey of current and previous group members to understand how the group could have greater impact, this year the Terms of Reference for the group and Position Description for group members have been refreshed. The results of Diversity Works's Aotearoa Inclusivity Matrix maturity index assessment have been reviewed and the immediate focus is on our recruitment practices.

Our inaugural noho marae at Taumutu (Te Pā o Moki) with Ngāi Te Ruahikihiki took place in February. Open to all staff, 35 of our people attended. Feedback from participants was extremely positive, with them finding the experience both educational and inspirational. We will continue to build stronger relationships with the local rūnanga, and further noho marae are planned.

We are currently reviewing the status of Kia Māia (our bicultural capability programme) and considering what Phase 2 might look like, particularly regarding extending our baseline capability and training in Wai262 issues.

We are also exploring our Māori staff capability to understand the current environment, opportunities and constraints. A hui of our Māori researchers (the Manaaki Taiao group) in early June 2024 discussed these themes further. We also contributed to MBIE's pan-CRI project, led by NIWA and supported by MBIE's Equity, Diversity and Inclusion Capability Fund. The project's main report, T*owards a collaborative pan-CRI approach to attract and retain Māori in the science sector*, was released in May 2024. The anticipated deliverables include a high-level framework for establishing a pan-CRI graduate and mentoring programme; and implementing a pan-CRI step-change across graduate and retention programmes.

Manaaki Whenua has undertaken work in this space but there is much more to be done. Our Māori internship programme is well-established (see page 21) and the report showed that Manaaki Whenua has more scientists who identify as Māori than any other CRI, but CRIs would collectively require an additional 540 Māori staff members to reach parity with the proportion of Māori in the general population.

Our infrastructure

Our goal is that our facilities, property, equipment, and infrastructure support excellent research; and that our sites provide great working environments.

Selected highlights

A successful TELARC audit

A full reassessment of our ISO45001 (health & safety) and ISO14001 (environmental management) certification audit took place in June 2024, run by TELARC, Aotearoa New Zealand's leading business certifier. Manaaki Whenua retained the highest possible (Gold) SiteWise certification status for the 2024/25 period. This achievement reflects the collective effort of everyone at Manaaki Whenua, as it is through our record-keeping, behaviours, actions, and systems that we have successfully secured this distinction. We received commendable feedback from our external auditor, highlighting the significant strides we've made over the past 3 years. Among the key achievements noted were the continued improvement of our management systems, the enhanced orderliness of operational sites, the responsible disposal of legacy chemicals, and the robust development of our legal compliance and reporting processes. Our effective communication and consultation on environmental and Occupational Health & Safety matters have been pivotal in these advancements. The audit process not only affirmed our progress but also provided valuable insights into areas for further enhancement.

ISO 14001 certification
1998–present

Telarc. Registered
cert TM
Environment
ISO 14001

Solar panels on the roof at our Hamilton site.

Improving our dust extraction systems

With advice from an industrial hygienist, improvements to our laboratory dust extraction systems have continued with a bespoke system designed and installed in Palmerston North.

Biolab XR – Molecular Containment Lab Project

In July 2024, we commenced an exciting design & build project to extend our existing Physical Containment (PC2) Molecular Laboratory capacity at our Lincoln site. A great project team has been assembled, and the project is tracking well against all milestones, with developed design nearing completion and construction contractor procurement underway. The expanded and refurbished facilities will be in use in 2026.

Other infrastructure

Other infrastructure investments during 2024 include a modern electric boiler at Dunedin, lab fume cupboard replacement, roof safety line installation and a full lift refurbishment at Palmerston North; a new security system and HVAC at Hamilton; and in Auckland a suite of upgrades including commercial kitchen appliances, security lighting & cameras, gates and fencing, new mechanical and refrigeration plant and various sensors and controls to optimise our specialised internal environments. A new reverse osmosis water system, new paving, acoustic panelling and furniture upgrades have further improved our Auckland site.

Our impact processes

We identify groups of partners, and we formalise partnerships to bring together complementary skills, align planning, and build trust within and beyond the science sector, into government and industry.

Our emphasis is strongly on integration – across organisations, disciplines, and issues.

We have continued to support the Impact Planning and Evaluation Network (iPEN), a joint initiative between the seven CRIs that aims to create greater impact for research. Over the past year iPEN has developed resources and methods, related in part to our own work in i3 to hone the impact creation cycle and to develop a community of best practice

Partnering nationally and internationally for greater impact

Our pathway to science impact depends on working with local, regional, and central government, the New Zealand science sector (including universities and the National Science Challenges), industry and businesses, landowners and growers, and Māori entities. As in previous years, this year we have developed new partnerships across linkages in the science value chain.

Partnership with Māori

Manaaki Whenua has developed enduring partnerships with selected iwi, groups of iwi, Māori trusts/ incorporations, and Māori organisations. These partnerships support and contribute to our partners' aspirations. We engage regularly with these groups in the spirit of partnership, as expressed in the principles of the Treaty of Waitangi.

We seek to understand and respond proactively to the needs of our Māori partners, including novel approaches (e.g. through secondments and new commercial models). We increasingly co-design our science and research programmes with our Māori partners. We build on and add value to the platforms, tools, and technologies of our Māori partners to grow joint intellectual property that is beneficial to AoNZ.

Our people have the skills and characteristics to engage well, deliver value, and support our Māori partners.

CASE STUDY:

Connecting data back to tangata whenua

Connecting data back to the whenua is at the heart of a new Manaaki Whenua project. Across our collections, Manaaki Whenua holds and cares for a rich array of more than 820,000 specimen samples from invertebrates, to fungi, to flora and fauna and taonga plant species.

A new documentary produced by Local Contexts E Kore Au E Ngaro, explores Manaaki Whenua's work with Whakatōhea, an iwi in the eastern Bay of Plenty, to apply biocultural labels to some of these specimen samples through our Systematics Collections Data (SCD) website. Local Contexts is a global initiative that supports indigenous communities with tools such as Biocultural Labels and Notices to reassert cultural authority in heritage collections and data.

For Whakatōhea Māori Trust Board Council Member Local Contexts Council Member and Strategic Advisor Māui Hudson (Whakatōhea, Te Korowai Ngāruahine, and Te Māhurehure), this work is about how his community can reassert cultural authority.

"There's some plants that are unique to our rohe (territory), critically endangered like the scrub daphne – and that's something that we've found out is part of the collection at Manaaki Whenua," says Maui.

"Because indigenous knowledge has developed over a long period of time, it's not subject to the kinds of intellectual property (IP) protections that are in place. Within research domains you end up with this situation where the copyright is claimed by the researcher or the institution and so our traditional knowledge then becomes subject to someone else's IP rights."

Maui explains that the Biocultural Labels now applied across thousands of Manaaki Whenua samples are digital tags that reflect indigenous interests in scientific data.

"Now there are several things that we're trying to express through the biocultural labels. First and foremost is provenance: that the connection back to the community should be maintained and retained across records. The other things that are being reflected are what kind of protocols are being put in place, and whether consent is being associated with the material as well."

He continues, "And then the third component relates to the permissions and the sorts of activities that the community is comfortable with in terms of outreach activities, research use and giving an indication about what sort of relationship they're happy to engage with researchers going forward."

Manaaki Whenua General Manager Te Tiriti Strategy Holden Hohaia (Ngāti Maru) says this work is about recognising indigenous rights and interests in the specimens (and related data) that we hold in our collections.

"For much of Aotearoa's post-colonial history the scientific endeavour of collecting specimens and data has been carried out usually with little recognition of Māori rights or interests in what was collected. In effect we have tended to collect without first seeking permission from local iwi/hapū interests."

The labels seek to address this imbalance by putting the research community on notice that these specimens have a provenance, explains Holden. They also serve as a reminder that iwi/hapū may wish to have some say over, or involvement in, how that material and data are used in the future.

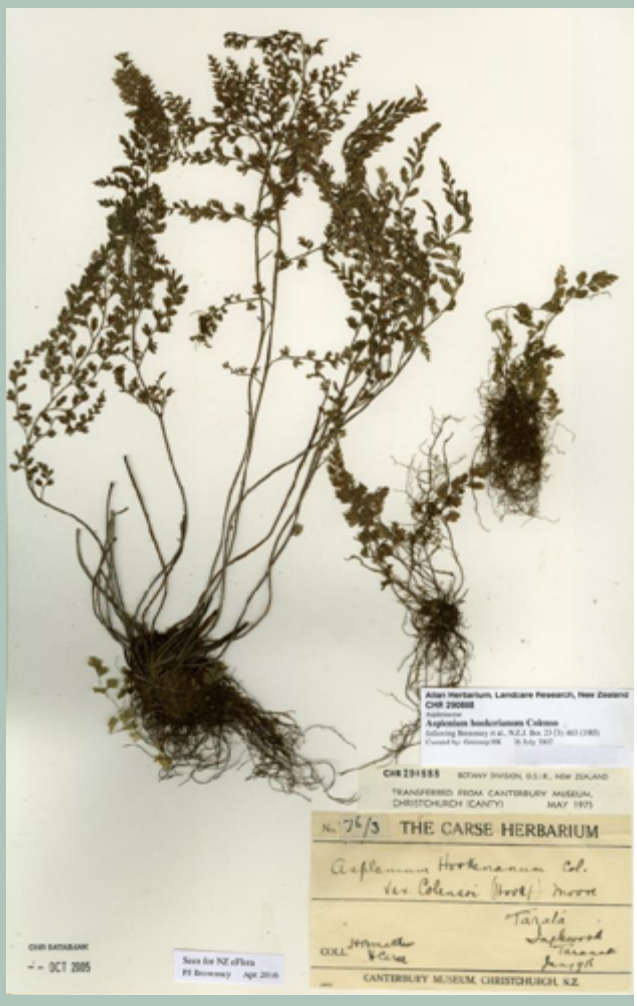
"They offer an ethical framework for us to recognise indigenous rights and interests in indigenous data without needing a comprehensive legal framework– which may be a long way off yet," he says.

Manaaki Whenua Allan Herbarium database manager Dr Aaron Wilton, who has managed the project, says about 60 to 70% of the collections data are georeferenced. "This means we can pin down, based on a coordinate, to a particular rohe such as Whakatōhea," says Aaron.

"There is significant work that happens under the hood to support how we deliver information out for use – the labels are critical as a tool as we start that journey – just to raise awareness among the scientists but also as a signal to iwi and hapū that we want to collaborate."

[c] Jon Sullivan, some rights reserved (CC BY)

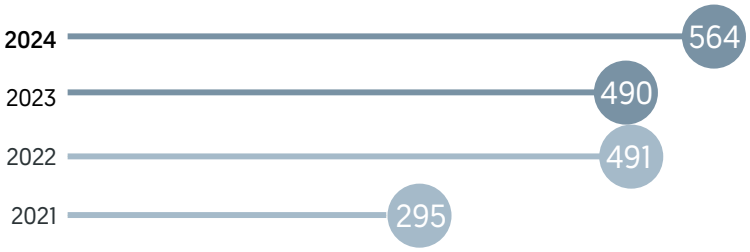
The critically endangered scrub daphne.



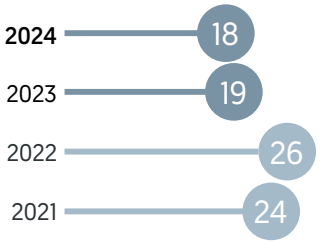
Asplenium hookerianum *has a biocultural notice attached online at scd@landcareresearch.co.nz*

VISION MĀTAURANGA PROJECTS

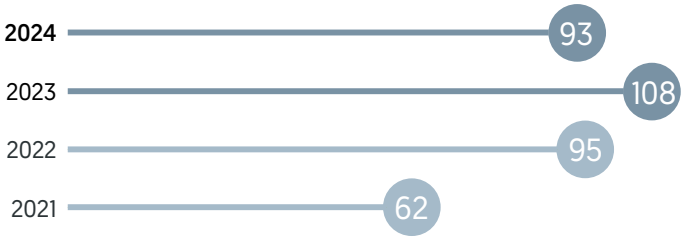
Research specifically relevant to Māori



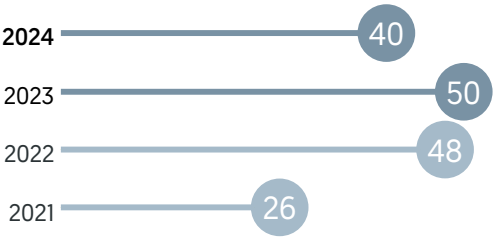
Kaupapa Māori



Research involving Māori



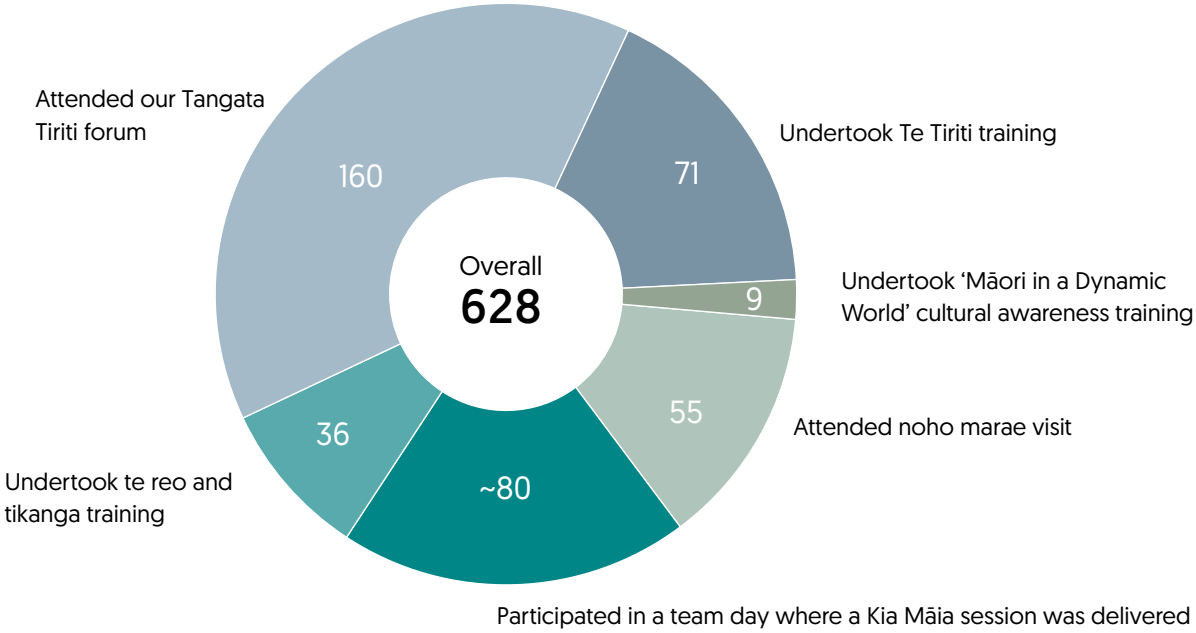
Māori-centred research



NUMBER OF WORKSHOPS

The total for 2023/24 comprises 628 Kia Māia training sessions

Kia Māia



National partnerships

Our pathway to science impact depends on working with local, regional, and national government, the New Zealand science sector (including universities and the National Science Challenges), the primary sector, and Māori entities. As in previous years, this year we have developed new partnerships across linkages in the science value chain.

National partnerships
This year we have strengthened our engagement strategy and planning, to ensure we have the capacity and capability to develop and continue rich, productive partnerships and provide value to Aotearoa New Zealand. We have advanced the cross-CRI regional sector alliance to provide greater impact through shared research programmes, and strengthened our relationships at all levels of the government to provide research that has impact and end-user uptake. We have continued to develop closer links with the primary sector and with primary sector-focused CRIs to enable integrated solutions for the farming sector, such as provisioning for climate-smart landscapes, as well as with other sectors that are concerned with environmental management.

Local and regional partnerships
We have continued to support Cyclone Gabrielle recovery and response. The emergency platform on Extreme Weather Ecological Impact Assessment (funded by the Strategic Science Investment Fund) is continuing to work well with the Cyclone Recovery Advisory Group, including research leads (from NIWA and MWLR) and representatives from Hawke's Bay Regional Council, Auckland Council, DOC, and the Ministry for the Environment. Delivery of the following objectives will be completed early in the 2024/25 financial year:

- identify changes in the extent and condition of vegetation cover
- assess impacts on naturally uncommon ecosystems
- examine the impacts on, and recovery of, freshwater fish and macroinvertebrates (led by NIWA)
- determine damage to conservation infrastructure (ecosanctuaries)
- assess impacts on threatened and taonga species populations.

Work is progressing well on all these objectives.

Other examples of close work with regional authorities this year include S-map fieldwork for Northland Regional Council, monitoring of volcanic frost-flat ecosystems for the Bay of Plenty Regional Council, and a study of land-use sustainability for Taranaki Regional Council.

Ministry for the Environment (MfE)
We are working with MfE on the sixth version of the Land Cover Database, an online classification of the 33 main land cover classes used extensively by land-use planners and policy makers. Version 6 includes significant updates and intersects with a range of other projects / research including wetlands mapping and characterisation. We are also currently collaborating on the next Our Land environmental report due in late 2024.

Ministry of Foreign Affairs and Trade (MFAT)
A wide range of existing work with MFAT includes food security (Pacific Seeds), biosecurity in agriculture (investigating weeds in beef pasture in Vanuatu), biosecurity in agriculture and conservation (MISCCAP: Managing Invasive Species for Climate Change Adaptation in the Pacific), and soils assessment in post volcano/tsunami Tonga. We are also working with MFAT to shape future research into climate-smart agriculture and sustainable land use practices in the Pacific region.

Department of Conservation (DOC)
Our long-standing close work with DOC harmonises our research interests in biodiversity and likely predator changes. We are hosting the data and platform for DOC's Tier 1 Biodiversity Monitoring Services 2024-25, and we are continuing to work with DOC across terrestrial biodiversity priorities, including National Vegetation Survey biodiversity monitoring and a scenario modelling tool for Phase 2 of Predator Free 2050. This year we have also joined the Working Group for the Native Carbon Initiative (led by Zero Invasive Predators).

Ministry for Primary Industries (MPI)
Wallaby control and beehive colony loss are current important topics, both of which we have significant expertise in. We successfully

JOURNAL PUBLICATIONS

Average journal citation score of MWLR articles[1]

Papers published[2]

[1] Scimago journal ranking.
[2] Web of Science 2011–2024, for the financial year 2023/24, 61% (177) of these 289 papers were collaborations with international institutes.

responded to last year's call for GHG reductions proposals (via NZAGRC) for research on Proximal Sensing for Near Real-Time Monitoring of Soil Organic Carbon Pools for Climate Smart Management. We are also working with MPI on passion vine hopper, and on climate action incentives for private landowners.

Te Uru Rākau
We have begun new projects this year with Te Uru Rākau - the New Zealand Forest Service. We are contributing to their research programme 'Maximising carbon sequestration' to measure carbon in permanent study plots in Rakiura / Stewart Island and calculate the carbon stocks. We are also working with them on the management of ungulate browsers such as deer across public conservation lands.

Food and fibre sector
We work closely with the food and fibre sector to develop pathways for our work programmes. Examples of our work include:

- Following on from Fieldays in June 2024 in Kirikiriroa / Hamilton we are investigating approaches to forest and tree changes within farmscapes over the past decade using remote imagery analysis.
- We are working with DairyNZ and AgResearch on the Ngāi Tahu regenerative agriculture SFFF project, Te Whenua Hou (see page 31).
- We are also working with DairyNZ (and AgResearch) on an MPI project 'Integrative GHG evaluation of forages', for which we are contributing expertise on soil carbon and modelling.

International partnerships

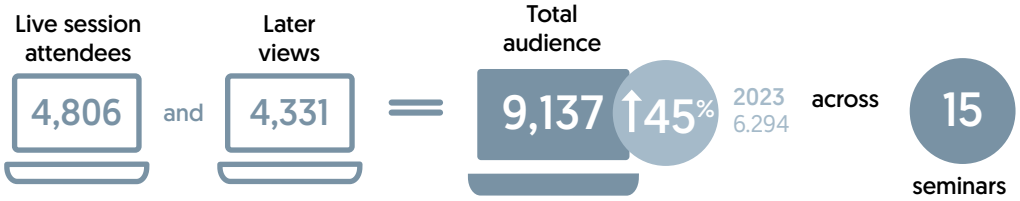
We have signed contracts with the US Department of Agriculture to provide advice on the rat eradication programme on Wake Island, a coral atoll in the northwestern Pacific. Our researchers have visited Wake to undertake preliminary assessments.

We are currently reviewing and renewing partnerships with Pacific Island countries, including those with regional agencies the Pacific Regional Environment Programme (SPREP), the international development organisation The Pacific Community (SPC), and the Scientific Research Organisation of Samoa (SROS). Our emphasis in these relationships is on on-the-ground capability building for resilience.

In 2023/24, 61% (177) of our 289 scientific papers published via the Web of Science were collaborations with international institutes.

ONLINE ENGAGEMENT

LinkOnline seminars



Manaaki Whenua social media

Facebook likes[1]
11,314 ↑ 2023 10,839

11.5% ↑ 2023 15%
Increase in audience (all social media channels)

NZ Garden Bird Survey

Facebook Group members[1]
13,200 ↑ 2023 11,426

Instagram followers[1]
1,798 ↑ 2023 1,475

New Zealand GARDEN BIRD SURVEY

[1] Meta Business Suite and Buffer social media management tool.

Matawhānui | Visionary Science
New for 2023/24 and led by our Principal Researchers, the Matawhānui | Visionary Science programme, internal to Manaaki Whenua, facilitates idea development and funding opportunities for leading-edge, potentially high-reward strategic science. It is funded via SSIF. It aims to be of interest to researchers at all career stages.The initiative supports researchers' scientific aspirations through three funding opportunities.

1. Māramatanga te kupu | Outside Thinking, Brilliant Writing
Purpose: To develop new thinking and novel ideas through internal and external collaboration

Untangling the functional response of ground and aerial hunters towards deer and other invasive ungulate prey (to be undertaken in 2024/25) — Dr Graham Hickling

2. Whakarau whakaaro | Germinating Ideas
Purpose: To deepen an existing idea and/or foster collaboration.

Several research proposals were funded under this initiative in 2023/24.

Researcher in Palaeoecology Dr Alex Boast used ancient environmental DNA to reconstruct New Zealand's prehistoric invertebrate communities.

Dr Kieren Mitchell, also a researcher in Palaeoecology, was able to determine species and origin of historical wood using DNA, with the endangered native plant *Dactylanthus taylorii* (known as wood rose) as a case study.

Kim Triegaardt

The parasitic Dactylanthus taylorii, *commonly known as the wood rose.*

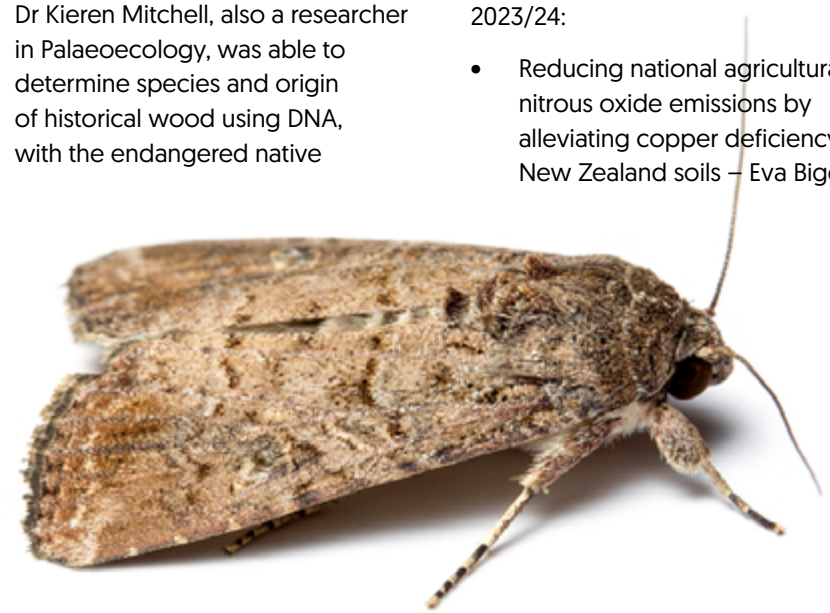
Dr Alexander Amies applied a deep learning model to identify fence lines and paddock boundaries in satellite imagery, to help assess land-use change.

Dr Amy Vaughan developed genome-informed management strategies for emerging pests, using the increasingly economically important crop pest fall armyworm as a case study.

3. Purapura taiao | Seed Funding
Purpose: To invest in early thinking for high-risk, potentially high-reward new science ideas.

Four projects were funded in 2023/24:

- Reducing national agricultural nitrous oxide emissions by alleviating copper deficiency in New Zealand soils – Eva Biggs.
- A simpler, more cost-effective laboratory tool as a proxy measurement tool to measure soil microporosity, a measurement important in regional and national environmental monitoring — Dr John Drewry.
- Does an introduced prey species elevate predation of a similar native prey species? – Dr Jo Peace.
- "Does natural and wildfire increase the persistence of soil organic carbon?" – Dr Hadee Thompson-Morrison, using the Christchurch fires of 2017 and 2024 as a case study.



Adult fall armyworm moth, Spodoptera frugiperda. Image: Matt Bertone

Is our research being used by other scientists?

Yes – without a doubt!

Our science adds to global knowledge and understanding of the natural world. Scientific knowledge is advanced by researchers building on each other's knowledge. A measure of this process is scientists citing other scientists' work in their publications in journals. The journals themselves are ranked by the level of citation of the articles they publish. Both are measures of scientific excellence.

Manaaki Whenua aspires to be in the top 15% of research institutes globally for citation impact of publications, thereby maintaining and building on our internationally and domestically recognised excellence in science.

According to the InCites database, a tool based on the Clarivate Web of Science, overall publications from New Zealand between 2019-2023 have a citation impact of 1.44. Over this time period, we had 24,357 citations with an overall citation impact of 1.45, which continues to be slightly behind Auckland University of Technology, the University of Auckland and ESR, but ahead of all the other CRIs and universities. The work of our researchers was most often cited in papers on mycology, ecology, environmental science and biodiversity/conservation. In 2023/24, 61% (177) of our 289 published papers had international collaborators. Our average SCImago journal ranking (citations per document over 2 years) is currently 4.2, down from 4.6 in 2022/23 and 5.2 in 2021/22, although still higher than 4.0 in 2020/21.

Is our research valued and trusted by all?

Engaging government, industry, Māori, other scientists, and the public with our research supports new partnerships for impact, helps develop social licence, educates, and helps shape our approach to these problems as we understand and incorporate the values of New Zealanders into our research. Our Brand and Communications team supports the wider organisation to engage through marketing, communication, and digital platforms.

This year we continued to build on the success of our online seminars. Over the past year, we have held 15 LinkOnline webinars seen by more than 9,100 people – an increase of 45% on the previous year.

Registrations for these webinars come from a wide variety of our key stakeholders, particularly in local government, central government ministries such as DOC, MPI and MfE, Māori organisations, the primary sector, and other CRIs. The most popular for the year was held in July 2023 - *Māori frameworks for disaster recovery and climate change* - which had 1,307 registrations including 132 from DOC and 296 from councils. A close second was the webinar *Agents of change for the adoption of sustainable land management practices*, with 1,107 registrations including 178 from primary industry and 329 from councils – illustrating an impressive reach among our key stakeholder groups.

We had a very successful presence at the annual primary sector Fieldays in Kirikiriroa/Hamilton in June 2024 on two stands – one in MPI's Science for Farmers tent, highlighting the work done on S-map Online, the Trees in the Landscape programme, and soil carbon work, and the other alongside AgResearch that highlighted our research into weed biocontrol, soil resilience and the MBIE-funded Moving the Middle research project. Moving the Middle researchers were aiming to survey 50 farmers daily about their environmental performance: in total, 690 surveys were done, vastly exceeding expectations for stakeholder engagement.

Across our social media channels (includes Facebook, LinkedIn, Twitter/X, Instagram, YouTube, BlueSky, Threads) our audience grew to 38,354, an increase of 3,944 (11.5%). The biggest increase was seen on Linked In (2,020 new followers, an increase of 20%).

This year's New Zealand Garden Bird Survey, Aotearoa New Zealand's longest-running citizen science project, had a record number of surveys submitted – 7,933. Data from the survey are increasingly used to inform measures of biodiversity on the ground, for example to illustrate unequal access to green space in post-quake Christchurch.

Kim Triegaardt

At Fieldays, visitors to Manaaki Whenua's stand could play a Serious Game developed by our social scientists in collaboration with NIWA. The game involves application of farm management and decision-making skills. Players navigate the consequences of their decisions on the environment, the community, the local economy and their farm profit.

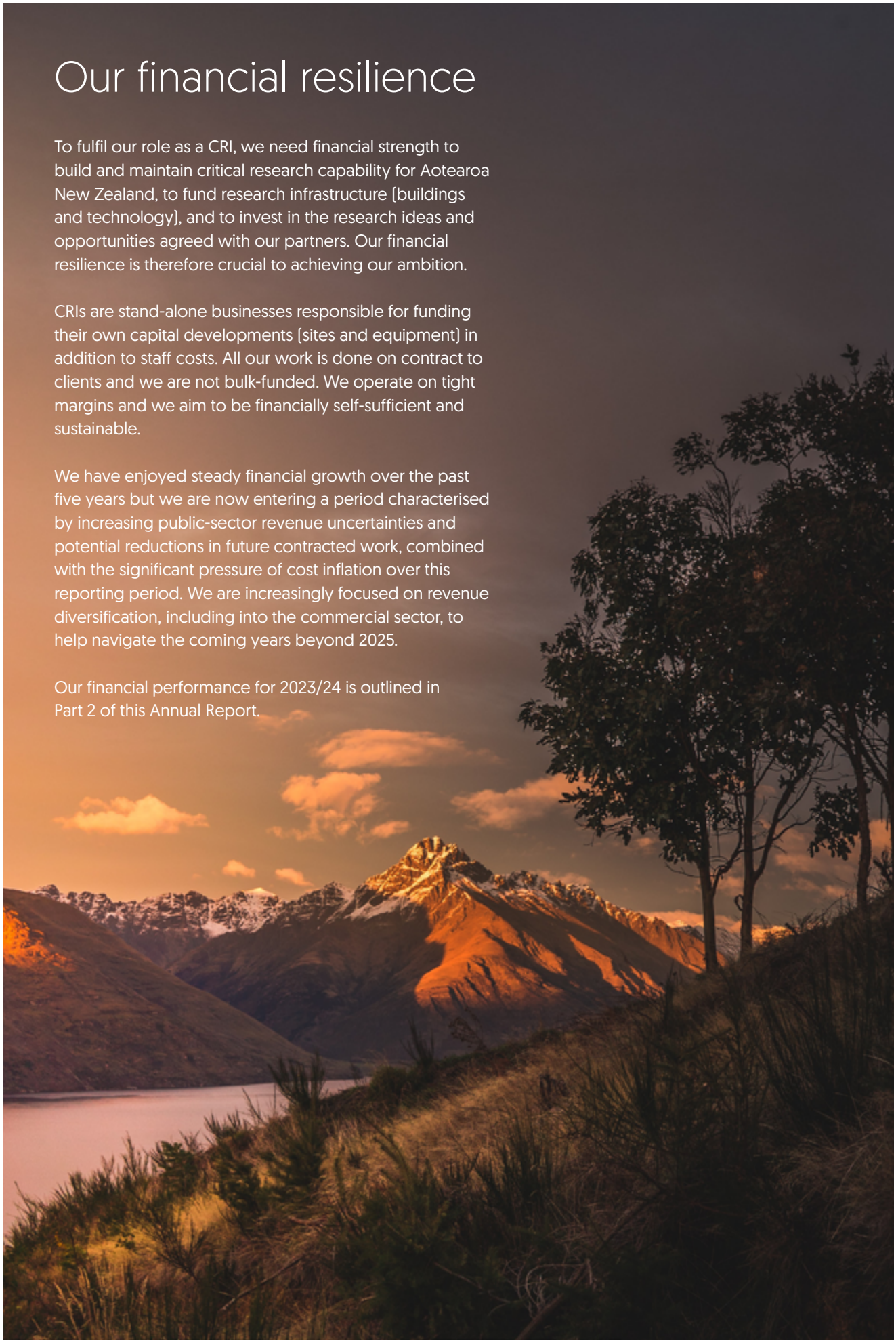
Our financial resilience

To fulfil our role as a CRI, we need financial strength to build and maintain critical research capability for Aotearoa New Zealand, to fund research infrastructure (buildings and technology), and to invest in the research ideas and opportunities agreed with our partners. Our financial resilience is therefore crucial to achieving our ambition.

CRIs are stand-alone businesses responsible for funding their own capital developments (sites and equipment) in addition to staff costs. All our work is done on contract to clients and we are not bulk-funded. We operate on tight margins and we aim to be financially self-sufficient and sustainable.

We have enjoyed steady financial growth over the past five years but we are now entering a period characterised by increasing public-sector revenue uncertainties and potential reductions in future contracted work, combined with the significant pressure of cost inflation over this reporting period. We are increasingly focused on revenue diversification, including into the commercial sector, to help navigate the coming years beyond 2025.

Our financial performance for 2023/24 is outlined in Part 2 of this Annual Report.



Our commitment to sustainable development

Our contribution to the future of Aotearoa New Zealand is underpinned by a sustainable business model that balances social, economic, and environmental impacts. As a Crown Research Institute, we are expected to be self-sufficient and financially sustainable. With the permission of our shareholding Ministers, our surplus is reinvested in our science and infrastructure.

Sustainable procurement
We access several All of Government (AoG) and syndicated contracts. Several of these have sustainable procurement practices, as required by the Government's Broader outcomes, which are built into them. Our own Procurement Policy notes we 'Require sustainably produced goods and services wherever possible having regard to economic, environmental and social impacts over their life cycle'. We work to ISO 20400 standards for sustainable procurement wherever possible.

Taking action to combat climate change
Given the focus of our business on the sustainable use of natural resources, it is especially important that we manage our operational activities to minimise any adverse impacts on the environment and our communities. The scope of these activities include moving our car fleet to electric vehicles, sustainable procurement with focus on whole of life impacts of goods and services to support our operations, and making progress towards sustainable energy use in our buildings.

We have been certified to the ISO14001 standard since 1998. Our successful TELARC audit in June 2024 (see also page 64) requires that we maintain systems to document and manage our environmental impacts.

We have been certified carbon-neutral since 2011, meaning that we measure and manage our greenhouse gas emissions and pay to offset those emissions that we have not been able to eliminate. We maintain carbonzero certification through our subsidiary, Toitū Envirocare, which purchases certified carbon credits on our behalf.

In alignment with our fleet optimisation plan, we've replaced three of our older diesel utility vehicles with new hybrid utes, and removed the last hybrid SUV's replacing these with full electric cars. Our investment in vehicle charging infrastructure across our sites continues with installations at Hamilton, Palmerston North and Dunedin to support the electrification of our fleet.

We have installed photovoltaic solar panels on our Hamilton building to help meet baseload requirements, and continue to benefit from the photovoltaic solar array at our largest Lincoln site. Much focus has been given to optimising our energy use and efficiency nationally, including investment in replacement plant, with EECA-funded audits at our two largest sites affirming our good practices whilst identifying some further opportunities.

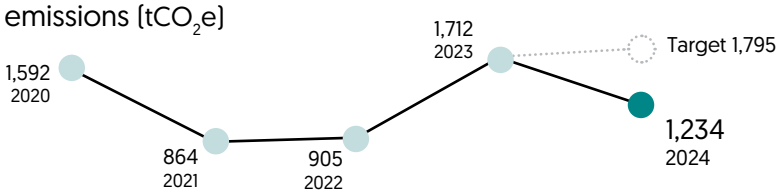
Our tCO_2e emissions
Manaaki Whenua's greenhouse gas emissions for 2023/24 were 31% below target. This is an outstanding result attributable to a significant focus on energy and refrigerant management, including investment in mechanical upgrades, improved monitoring/scheduling initiatives, and improved rigour in data entry, offsetting increased business travel.

In 2023/24 our total emissions were 1,234 t CO_2e – subject to an audit by Toitū in August 2024. It is proposed budgeted funds are used to purchase carbon offsets to neutralise these emissions, achieving carbon neutral certification for Manaaki Whenua for our 14th consecutive year.

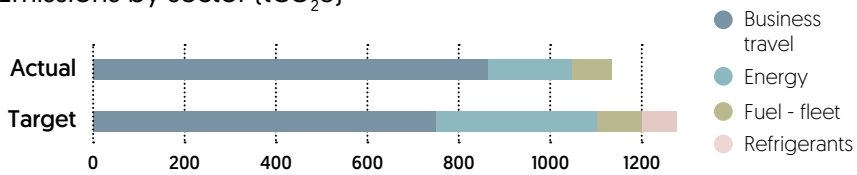
Carbon zero certification
2011–present

TOITŪ
NET CARBON ZERO
ISO 14064-1 ORGANISATION

Total emissions (tCO_2e)



Emissions by sector (tCO_2e)



Non-financial KPIs

Here we provide an overview of selected non-financial performance metrics. Our full audited financial statements and other performance information are detailed in Part 2 of our Annual Report.

KPI	FY19	FY20	FY21	FY22	FY23	FY24
How we work						
1. Employee engagement index	88%	81%	75%	76%	78%	72%
2. Employee turnover	6.9%	4.5%	7.05%	8.33%	10.02%	13%
3. Health & safety (near misses)	46	31	34	14	33	35
4. Health & safety (lost-time injuries)	2	1	5	3	2	2
5. Average tenure (years)	11	8	8.48	11	10	10.5
Science working with mātauranga Māori						
1. Research with no specific Māori component	570	490	233	64	18	19
2. Research relevant to Māori	89	93	295	491	490	564
3. Research involving Māori	49	50	62	95	108	93
4. Māori-centred research	24	31	26	48	50	40
5. Kaupapa Māori	23	23	24	26	19	18
Our sustainability						
1. Tonnes CO_2 per $m revenue*	25.2	19.0	10.1	10.8	17.5	10.43
2. Total tonnes CO_2e*	2,052	1,593	896	905	1,712	1,234.0
Our impact processes						
1. Impact of scientific publications (mean citation score)	3.9	4.2	4.0	5.2	4.2	4.2
2. Facebook likes	8,758	9,206	9,182	9,679	10,839	13,497
3. Participants in Garden Bird Survey	3,082	7,800	6,632	6,234	6,237	7,933
4. Interactions per social media post	126	143	119	187	93	**64

*This row shows provisional amounts for 2023/24. Full audited amounts are shown in Part 2 of the Annual Report.
**Facebook only.

Directory

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toitu.co.nz

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Christchurch 8024

WELLINGTON
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Wellington 6011

BANKERS
ANZ Bank New Zealand Limited

AUDITORS
Deloitte Limited on behalf of the Auditor-General

SOLICITORS
Buddle Findlay

DIRECTORS

Colin Dawson (Chair)
Dr Paul Reynolds (Deputy Chair)
John Rodwell
Justine Gilliland
Marje Russ
Dr Warren Williams
Dr Andrea Byrom
Prof Caroline Saunders*
*to 30 September 2023
Gray Baldwin*
*from 17 July 2024

SENIOR LEADERSHIP

James Stevenson-Wallace
Chief Executive Officer

Dr Fiona Carswell
General Manager, Science

Dr Fraser Morgan
Chief Scientist

Kylie Hansen
General Manager, People & Culture

Holden Hohaia
Chief Advisor, Te Tiriti Strategy

Dr Nancy Garrity
General Manager, Māori Partnerships

Chris McDermott
Chief Information Officer

Andy Doube, GM Development (Acting)

Graham Sevicke-Jones
General Manager, Science & Knowledge Translation

Richard Eglinton
General Manager, Corporate Services

Teressa Betty
Chief Executive, Toitū Envirocare

Daniel Patrick
Director, NZ Biological Heritage National Science Challenge

Melanie Mark-Shadbolt
Kaihautū Ngātahi, NZ Biological Heritage National Science Challenge

Science New Zealand

SCIENCE WORKING FOR AOTEAROA NEW ZEALAND

The Crown Research Institutes (CRIs) proudly work, individually and collectively, to create a more prosperous, sustainable and innovative Aotearoa New Zealand.

agresearch
āta mātai, mātai whetū

ESR
Science for Communities
He Pūtaiao, He Tāngata

GNS SCIENCE
TE PŪ AO

Manaaki Whenua
Landcare Research

NIWA
Taihoro Nukurangi

Plant & Food™ Research
Rangahau Ahumāra Kai

SCION™
FORESTS ▪ PRODUCTS ▪ INNOVATION

4,400
SMART AND PASSIONATE PEOPLE

54
SITES ACROSS AOTEAROA NEW ZEALAND

6,000
SCIENCE PROJECTS EACH YEAR

40
NATIONALLY SIGNIFICANT DATABASES & COLLECTIONS

WWW.SCIENCENEWZEALAND.ORG