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

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Cover image: The threatened owlet moth *Meterana exquisita*, endemic to New Zealand, whose caterpillars are specialist herbivores on small-leaved *Olearia* species. Manaaki Whenua staff have been working with DOC to assess the vulnerability to climate change of this and other threatened species. Image: Samuel Purdie.

Contents

A word from our Chair and CEO

Welcome to Manaaki Whenua's Annual Report for 2022/23, the second of our Annual Reports sharing progress on "Te Āpōpōtanga", our organisational strategy for the coming years.

Te Āpōpōtanga established our ambition: Kia mauriora te whenua me tōna taiao – the life-force and vitality of the land is strong. This ambition builds on a rich history of land environment and biodiversity research at Manaaki Whenua, and challenges us to continue to strengthen the partnership between Manaaki Whenua and iwi and hapū.

Our strategy was developed at a time when we as a Research Science and Innovation (RSI) system are exploring how we can more effectively deliver impact for Aotearoa New Zealand (AoNZ). *Te Ara Paerangi – Future Pathways* sets a direction for the RSI system focused on: 1) creating new futures through high impact research linked to national priorities, 2) embedding Te Tiriti to advance Māori aspirations for research and innovation, 3) valuing our people to ensure the RSI system is supported with the talent needed to deliver on our national priorities, and 4) building RSI system agility so we can better respond to the emerging needs of AoNZ. Our strategy and work over the past year is well aligned with these goals.

Manaaki Whenua has continued to drive research impact with our partners across AoNZ and beyond. Partners across local and regional government, the primary sector, and iwi and hapū partners, shape Manaaki Whenua research priorities. For example, this year our researchers have begun a new research programme designed both to contribute to Aotearoa reaching its zero-carbon targets by 2050 and to add value to rural landscapes through the careful placement of small clusters of trees. This work, which aims to quantify the effects and co-benefits of these plantings compared with plantation forestry, has very strong primary-sector and Māori involvement and commitment, as well as national and international science-sector collaboration.

Our science continues to be a highly collaborative undertaking – nearly 60% of all our research papers are published not just with other AoNZ co-authors, but with international researchers as well, contributing to the reach and uptake of the knowledge we generate. For example, our expertise in developing the Ozflux sensor network for greenhouse gas modelling (see page 48) has recently helped scientists from Ireland develop a similar network there – our science has global worth and applicability.

Manaaki Whenua is also uniquely cross-disciplinary, as shown by the innovations we highlight in the pages that follow. 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.

To ensure that all our research remains relevant and high impact, we are currently investing in our approach to eResearch and research data management, in line with sector investments in this space. For example, we have partnered with Microsoft's 'AI for Good' data science team to explore the use of AI and machine learning to map small wetlands using satellite data. Our researchers have also mapped wetland drainage using LiDAR, created AI tools to monitor and map predator behaviour in conjunction with Predator Free 2050 and MBIE's Kiwi Rescue programme, traced Adelie penguin migration in Antarctica using GPS – the list goes on.

During the year, our online S-map resource passed the halfway mark in mapping the farmable soils of AoNZ, with 10 million hectares now covered as part of a partnership with MPI and 12 regional councils. Our researchers plugged a major knowledge gap by creating the first master list of all plants being grown in cultivation in AoNZ – some 225,000 records – and have significantly updated the BiotaNZ database with this vital information. Manaaki Whenua researchers partnered with a group, 'Te Roopu for Russell State Forest,' made up of nine hapū and marae surrounding Russell Forest, to map the vegetation and bird life for a better understanding of where to focus their key kaitiakitanga efforts.

This year we also played an integral role in the pan-CRI response to Cyclone Gabrielle, where our long-established expertise in land management, soil erosion, remote sensing, data mapping, and social science, built up over many years and through many successful research programmes, has enabled us to contribute both to the immediate recovery and the long-term regeneration of affected areas. For example, the development of New Zealand's Emergency Event Data Catalogue (EEDC), built on the foundations of the National Environmental Data Centre (NEDC),

was rapidly developed as a pan-CRI project to ensure critical data could be provided to support emergency responses.

We are now extending our work ever further into the Pacific, working strategically with MFAT to share our knowledge and build biosecurity capabilities within equivalent organisations across the region, including via our Natural Enemies, Natural Solutions programme.

Within Te Āpōpōtanga we made a commitment to partnership with iwi and hapū consistent with the principles of Te Tiriti o Waitangi. In the past year we have focused on the co-development of a new strategy for the biological collections and databases Manaaki Whenua holds on behalf of Aotearoa. Our Te Tiriti Partnership Group (TTPG) identified the collections as a priority for Māori and a logical place to start as we begin to embed Te Tiriti into our organisation. This strategy focuses on a transition from simply 'collecting, curating, and classifying' to 'connecting, creating, and collaborating' with our Te Tiriti partners.

Our Kaihautū (Māori Research leaders) have received dedicated SSIF funding to advance research priorities that are defined by Māori for Māori. We also appointed a new kaitūhonohono role (connector) to facilitate building connections with iwi and hapu. All Manaaki Whenua staff are on their own personal journey, exploring their biculturalism supported by our Kia Maia programme. Our Māori internship programme continues to open the door to research careers for Māori, with some 25 interns coming through our doors this past year, and with two of the previous intake joining our research staff.

Of course, all of this work would not be possible without our people. Our people are our finest asset, and we are proud of all that they have accomplished this year at Manaaki Whenua. This sits alongside a positive uplift in staff engagement in this past year. Work has now begun to simplify the processes and systems that support our people to deliver research. The goal is focused on giving researchers more time to focus on research.

Manaaki Whenua ends this year in a strong, financially sustainable position. Part 2 of our Annual Report details our audited financial results. Our continued ability to deliver a modest profit within what is an increasingly difficult research funding environment is something we are proud of. Critically, this enables us to continue to invest in key research infrastructure, and underpinning public good research that powers future impact for New Zealand. In the next year we will be tabling a business case for a significant investment in a shared research facility with Plant and Food Research on their Mt Albert campus. This facility will underpin New Zealand's biosecurity readiness.

We are also pleased to report that our subsidiary Toitū Envirocare has had another very successful year, with consumer demand for our international best-practice science-based carbon certification programmes up 45% on last year. To support this growth, Toitū is actively reviewing its business model to ensure that the enterprise continues to be fit-for-purpose in a highly competitive market.

The National Science Challenges are beginning preparations to wrap up at the end of June 2024. Manaaki Whenua has made significant research contributions to many of these Challenges, and has hosted the NZ Bioheritage Challenge throughout. In their last year, each Challenge will focus on communicating research results to the communities who need them the most. We will work with other CRIs to ensure that the important research, data and relationships created by 'our' Challenge and others continue to have impact into the future.

Ngā mihi nui.

Colin Dawson – Chair

James Stevenson-Wallace – CEO

29 September 2023

He kupu nā tō mātou Heamana me te Tumu Whakahaere

Nau mai ki te Pūrongo ā-Tau a Manaaki Whenua mō te tau pūtea 2022/23, te tuarua o ā mātou Pūrongo ā-Tau e tuari ana i te kaunekehanga o "Te Āpōpōtanga", tā mātou rautaki ā-whakahaere mō ngā tau e heke mai nei.

Nā Te Āpōpōtanga i whakapūmau ai tō mātou awhero: Kia mauriora te whenua me tōna taiao. He mea tipu mai tēnei awhero i ngā tāhuhu kōrero haumako o te rangahau o te taiao whenua me te kanorau koiora i Manaaki Whenua, e whakapātari ana i a mātou ki te whakapakari tonu i te mahitahi i waenga i a Manaaki Whenua, te iwi me te hapū.

I whakawhanaketia tā mātou rautaki i te wā e tūhura ana mātou hei pūnaha Rangahau, Pūtaiao me te Auaha me pēhea ā mātou mahi e whai hua ake ai kia nui ake ngā hua mō Aotearoa. *Te Ara Paerangi* – he whakarite i te ahunga mō te pūnaha RSI e arotahi ana ki: 1) te waihanga i ngā ānamata hou mā te rangahau nui te hua kua honoa ki ngā kaupapa mātāmua ā-motu, 2) te tāmauatanga o Te Tiriti hei neke whakamaua i ngā wawata o te iwi Māori mō te rangahau me te auaha te take, 3) kia ngākaunuitia ai ā mātou kaimahi e mātua whakarite kua tokona te pūnaha RSI e ngā pūkenga e tika ana ki te whakatutuki i ā mātou kaupapa mātāmua ā-motu, 4) e whakapakari ana i te kakama o te pūnaha RSI kia pai ake tā mātou urupare ki ngā hiahia o Aotearoa. Kua tino pai te hāngaitanga o tō mātou rautaki, mahi hoki i te tau kua pahure ki ēnei whāinga.

He kaha tonu te kōkiritanga a Manaaki Whenua i te rangahau kia whai hua i te taha o ō mātou hoa mahi tahi puta noa i Aotearoa, ki tua atu hoki. Kei te tārai ngā hoa pātui puta noa i te kāwanatanga ā-rohe, ā-takiwā hoki, te rāngai matua, ngā hoa pātui o ngā iwi me ngā hapū i ngā kaupapa mātāmua rangahau o Manaaki Whenua. Hei tauira, i tēnei tau kua tīmata ā mātou kairangahau i te kaupapa rangahau hou kua hoahoatia ngātahitia ki te tautoko i a Aotearoa ki te whakatutuki i ōna whāinga waro-kore hei te tau 2050 me te whakapiki i te uara ki ngā taiwhenua mā te āta whakatakotoranga o ngā pūrei iti o ngā rākau. Ko tēnei mahi e whai ana ki te ine i te nui o ngā whaipainga me ngā whaihua anō o ēnei tipuranga, he mahi rerekē ki te whakatipu ngahere, he nui te whai wāhi mai a te rāngai matua pakari rawa, te whai wāhitanga me te ngākau nui o te iwi Māori, tae atu ki te mahi tahi o te rāngai pūtaiao ā-motu, ā-ao rānei.

He nui tonu te mahi tahi i tō tātou taiao pūtaiao – tata ki 60% o ā mātou pepa rangahau ka whakaputaina kaua ki te taha anake o ngā kaitito o Aotearoa, engari ki te taha hoki o ngā kairangahau o te ao, e whakawhānui ana i te toro whānui me te hiahia ki te whai me te whakamahi i te mātauranga e whakaputaina ana e mātou. Hei tauira, nō nā noa nei nā tō mātou tohungatanga i te whakawhanaketanga o te whatunga pūoko Ozflux mō te whakatauiratanga haurehu kati mahana (tirohia te whārangi 48) i āwhina i ngā kaipūtaiao nō Airana ki te whakawhanake i te whatunga āhua ōrite anō ki reira – ko ā tātou mahi pūtaiao he whai painga, he whai mana huri noa te ao.

Ka mutu ko tētahi āhuatanga ahurei o Manaaki Whenua he nui ōna pekanga mātauranga whakawhitiwhiti, kua whakaaturia ake e ngā auahatanga ka whakatairangahia e mātou i ngā whārangi e whai ake nei. Ko te hua, 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.

Kia mātua whakarite he mea whaitake tonu me ōna hua katoa ā mātou rangahau, e whakapau rauemi ana i tō mātou huarahi ki te Rangahau-i me te whakahaere raraunga rangahau e hāngai ana ki ngā whakapaunga ā-rāngai i tēnei wāhi. Hei tauira, kua whai hoa pātui mātou ki te taha o te kāhui pūtaiao raraunga o te AI for Good o Microsoft ki te tūhura i te whakamahinga o te hangarau AI me te ako ā-pūrere ki te whakamahere i ngā repo pakupaku mā te raraunga amiorangi. Kua whakamaheretia te manga repo e ā mātou kairangahau mā te LiDAR, kua waihangaia ngā taputapu AI ki te aroturuki me te whakamahere i te whanonga o ngā konohi ki te taha o te Predator Free 2050 me te kaupapa Kiwi Rescue o MBIE, i arumia hoki i te heke o te kororā Adelie i te Whenua-a-Tio mā te GPS - haere tonu ana te rārangi.

I te roanga o te tau, i hipa kau atu i te rauemi S-map te pae wehe i te whakamaheretanga o ngā oneone e taea ana te whakamahi hei pāmu i Aotearoa, kua oti te 10 miriona heketea ināianei hei wāhanga o tētahi pātuinga ki te taha o MPI me ngā kaunihera ā-rohe 12. I whāngaihia te puna mātauranga e ā mātou kairangahau nā rātou i waihanga te rārangi matua tuatahi o ngā tipu e whakatipuria ana ā-ngakinga

i Aotearoa - 225,000 ngā pūkete – ā, kua tino whakahoutia te pātengi raraunga BiotaNZ ki tēnei tino mōhiohio. I mahi tahi ngā kairangahau o Manaaki Whenua ki 'Te Roopu for Russell State Forest' he huinga o ngā hapū me ngā marae e iwa e karapoi ana i Russell Forest ki te whakamahere i te taiao hua whenua, manu hoki kia whai māramatanga o ngā wāhi hei aronga nui mō ngā mahi kaitiakitanga matua.

I tēnei tau i whai tūranga nui hoki mātou i te urupare CRI peke katoa ki te Cyclone Gabrielle, nā tō mātou tohungatanga tuaukiuki i te whakahaere whenua, te horo whenua, te rongohiko mamao, te whakamahere raraunga, me te mātauranga pāpori, i whakatipuria ai i roto i ngā tini tau, i roto anō i ngā tini kaupapa rangahau angitū, kua āhei mātou ki te tautoko tahi i te whakaoranga kau ake me te whakarauoranga i roto i te wā roa o ngā wāhi i pāngia ai. Hei tauira, i tere te whakawhanaketanga o te Rārangi Raraunga Mahi Whawhatitata o Aotearoa (EEDC), i hangaia mai ai i te tūāpapa o te Pokapū Raraunga Taiao ā-Motu (NEDC), hei kaupapa CRI peke katoa kia mātua whakarite e taea ai te whakaratonga o te raraunga kaikini hei tautoko i ngā urupare whawhatitata.

Kei te whakawhānui ake anō mātou i ā mātou mahi i roto i te Moana-nui-a-Kiwa, e mahi ā-rautaki ana ki te taha o te Manatū Aorere ki te tuari i tō mātou mātauranga me te whakapiki i ngā āheinga haumaru koiora i roto i ngā whakahaere ōrite puta noa i te rohe, tae atu rā hoki ki tō mātou kaupapa Natural Enemies, Natural Solutions.

I roto i Te Āpōpōtanga i paihere mātou ki te mahitahi ki te taha o ngā iwi me ngā hapū i runga i ngā mātāpono o Te Tiriti o Waitangi. I te tau kua pahure kua aro mātou ki te whakawhanaketanga ngātahi o te rautaki hou mō ngā kohikohinga me ngā pātengi raraunga koiora e pupuritia ana e Manaaki Whenua mā Aotearoa. I tautohua e tō mātou Rōpū Mahitahi o Te Tiriti (TTPG) ngā kohikohinga hei kaupapa mātāmua mō te iwi Māori me te wāhi tika hei tīmata i a mātou e tāmaua ana i Te Tiriti ki roto i tō mātou whakahaere. E aro ana tēnei rautaki ki te whakawhitinga mai i te kohinga, te whakaritenga, te whakaaturanga me te whakarōpū ki te honohono, te waihanga me te mahitahi ki te taha o ō mātou hoa pātuinga o Te Tiriti.

Kua whiwhi ā mātou Kaihautū i te pūtea SSIF tāpae hei kōkiri i ngā kaupapa mātāmua rangahau kua tautuhia e te Māori mā te Māori. I kopounga hoki mātou i te tūranga kaitūhonohono hou hei whakahaere i te hanganga o ngā tūhonohono ki ngā iwi me ngā hapū. Kei runga hoki ngā kaimahi katoa o Manaaki Whenua i ō rātou ake haerenga, e tūhura ana i tō rātou kākanoruatanga e tautokotia ana e tō mātou kaupapa Kia Māia. Kei te tuwhera tonu tō mātou kaupapa tauira Māori i ngā ara mahi pūmau mō te Māori, me te 25 ngā tauira i eke mai ana i ō mātou tatau i te tau kua hipa, me te rua anō hoki mai i te rōpū o mua ake i whai mahi ana ki te taha o ngā kaimahi rangahau.

Heoi anō, e kore rawa ēnei mahi katoa e tutuki mei kore ake ā mātou tāngata. Kāore he taonga i tua atu i ā mātou tāngata, ka mutu, kua poho kererū katoa mātou i ngā mahi kua oti i a rātou i tēnei tau i Manaaki Whenua. Kei te noho tēnei ki te taha o te hikinga whaihua i te whakawhitiwhitinga i waenga i ngā pae whakahaere me ngā kaimahi. Kua tīmata ngā mahi ki te whakangāwari i ngā tukanga me ngā pūnaha e tautoko ana i ā mātou tāngata ki te whakatutuki i ngā mahi rangahau. E tino aro ana te whāinga ki te whakarite kia nui ake te wā mō ngā kairangahau ki te arotahi ki ngā mahi rangahau.

He pakari te tūnga ā-pūtea a Manaaki Whenua i te mutunga o te tau pūtea. Kei te wāhanga 2 o ngā taipitopito Pūrongo ā-Tau ā mātou hua ā-pūtea kua oti te tātari. He tū whakahihi hoki mātou i tā mātou āhei ki te whakaputa i te huahoko whakaiti i roto i te taiao pūtea rangahau e uaua haere ana. Ko te mea nui, e āhei tonu ana mātou ki te hāpai ā-pūtea i te hanganga rangahau matua me te tautoko i rangahau pai mō te iwi whānui e whakaputa tonu ana i ngā hua mō ngā rā e tū mai nei mō Aotearoa. Ā te tau e tū mai nei ka whakatakotoria e mātou te take pakihi mō te whakapau pūtea ki te tautoko i te whare rangahau ngātahi me Rangahau Ahumāra Kai i tō rātou whare i Ōwairaka. Ka noho matua tēnei whare ki te whakaritenga haumaru koiora o Aotearoa.

E koa ana hoki mātou ki te pānui atu i tino angitū anō hoki te tau mō Toitū Envirocare, me te pikinga o te hiahia ki ā mātou kaupapa tiwhiketetanga waro e ahu mai ana i te pūtaiao, i te mahinga pai mutunga hoki ā-ao, arā, he 45% te pikinga ake i te tau pūtea o mua. Hei tautoko i te whakatipu, kei te āta arotake a Toitū i tā rātou tauira pakihi ki te mātua whakarite he hāngai mō te take i hangaia ai te hinonga i te mākete tino uaua rawa atu.

E whakarite ana Ngā Koiora Tuku Iho ki te whakaoti i ngā mahi hei te mutunga o Pipiri 2024. He nui ngā tautoko ā-pūtea mō ngā rangahau tāpua ki ēnei Wero, ā, kua manaakitia ai hoki te Wero Koiora Tuku Iho o Aotearoa mai i te tīmatanga. Ā tō rātou tau whakamutunga e aro ake ia Wero, ia Wero ki te kauhau i ngā hua o te rangahau ki ngā hapori e mate nuitia ana. Ka mahi mātou ki te taha o ētahi atu CRI ki te mātua whakarite ko te rangahau, te raraunga me ngā hononga i waihangaia e tō mātou Wero me ētahi atu e haere tonu kia whai hua ai ā haere ake nei, haere ake nei.

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

Overview

Tirohanga whānui

We are the Crown Research Institute (CRI) for our land environment and biodiversity – an organisation of 464 scientists, researchers, and experts supporting science who are dedicated to helping the people of Aotearoa New Zealand (AoNZ) understand and live well with our land.

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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.

Mauriora is the Māori concept of life-force and vitality. In Māori thinking mauriora requires the people to be connected with their ancestral lands. Māori trace their origins (whakapapa) 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 the relationship. In non-Māori thinking the close relationship between the land and its people has a long history and we believe our ambition statement speaks for all ethnicities.

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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 AoNZ'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 AoNZ 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.

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Our research impacts and outcomes

We focus on four areas of research impact:

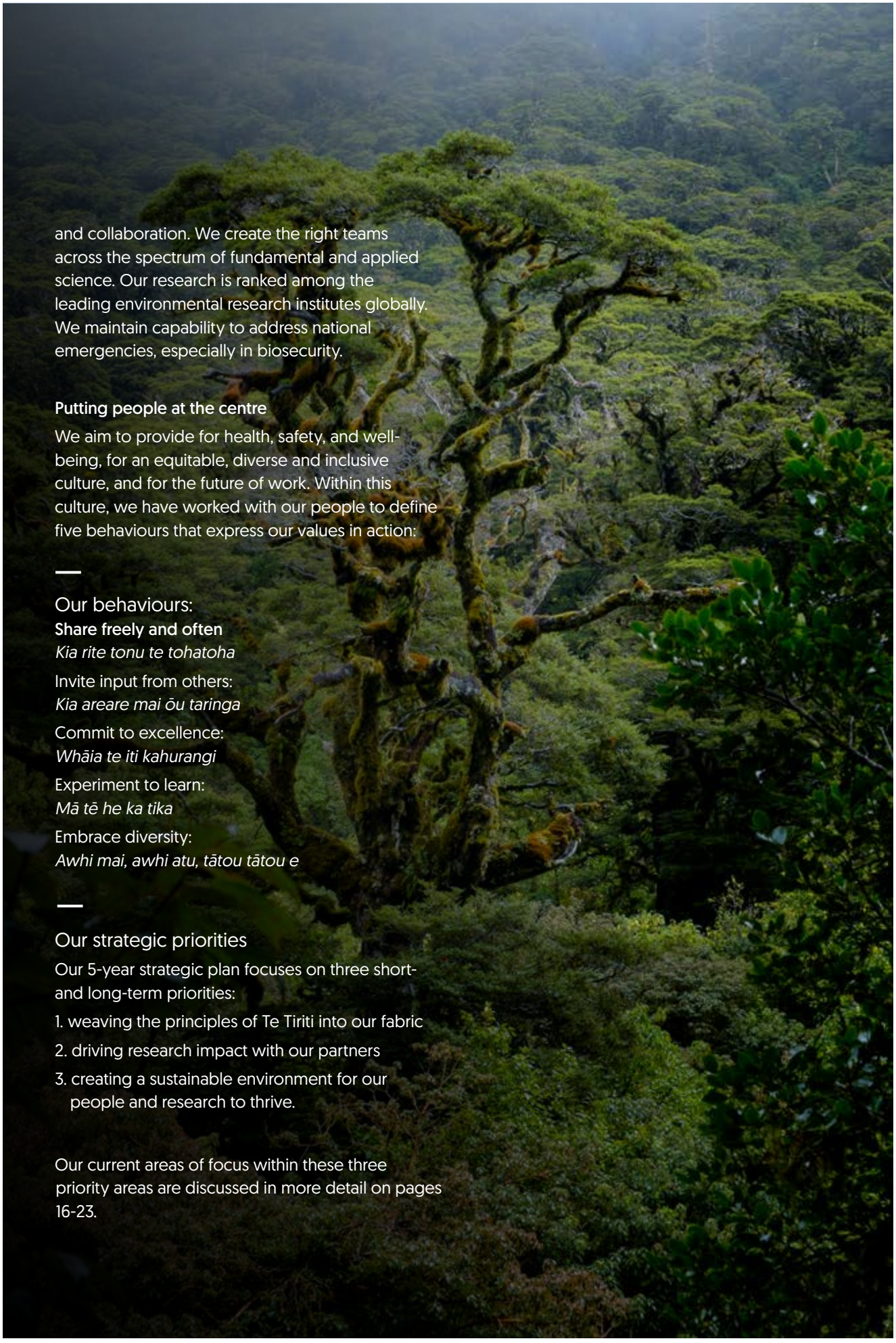
- enhancing soils, water and land
- restoring biodiversity
  beating invasive species
- action on climate change
- people and environment.

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:

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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. weaving the principles of Te Tiriti into our fabric
2. driving research impact with our partners
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.

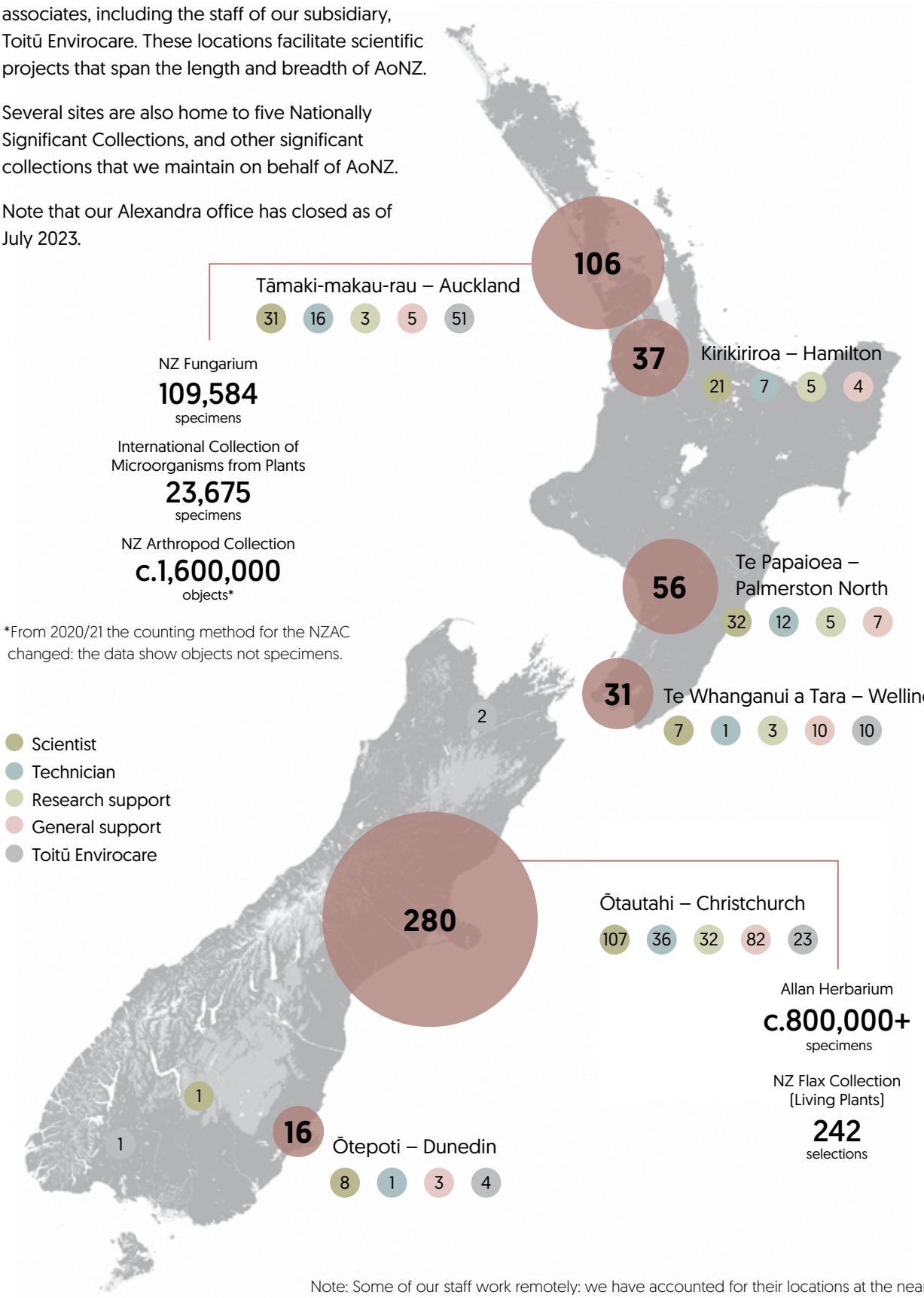
Craig Robertson

Our locations

Our sites across AoNZ house 529 staff and research associates, including the staff of our subsidiary, Toitū Envirocare. These locations facilitate scientific projects that span the length and breadth of AoNZ.

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

Note that our Alexandra office has closed as of July 2023.



NZ Fungarium
109,584
specimens

International Collection of Microorganisms from Plants
23,675
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.

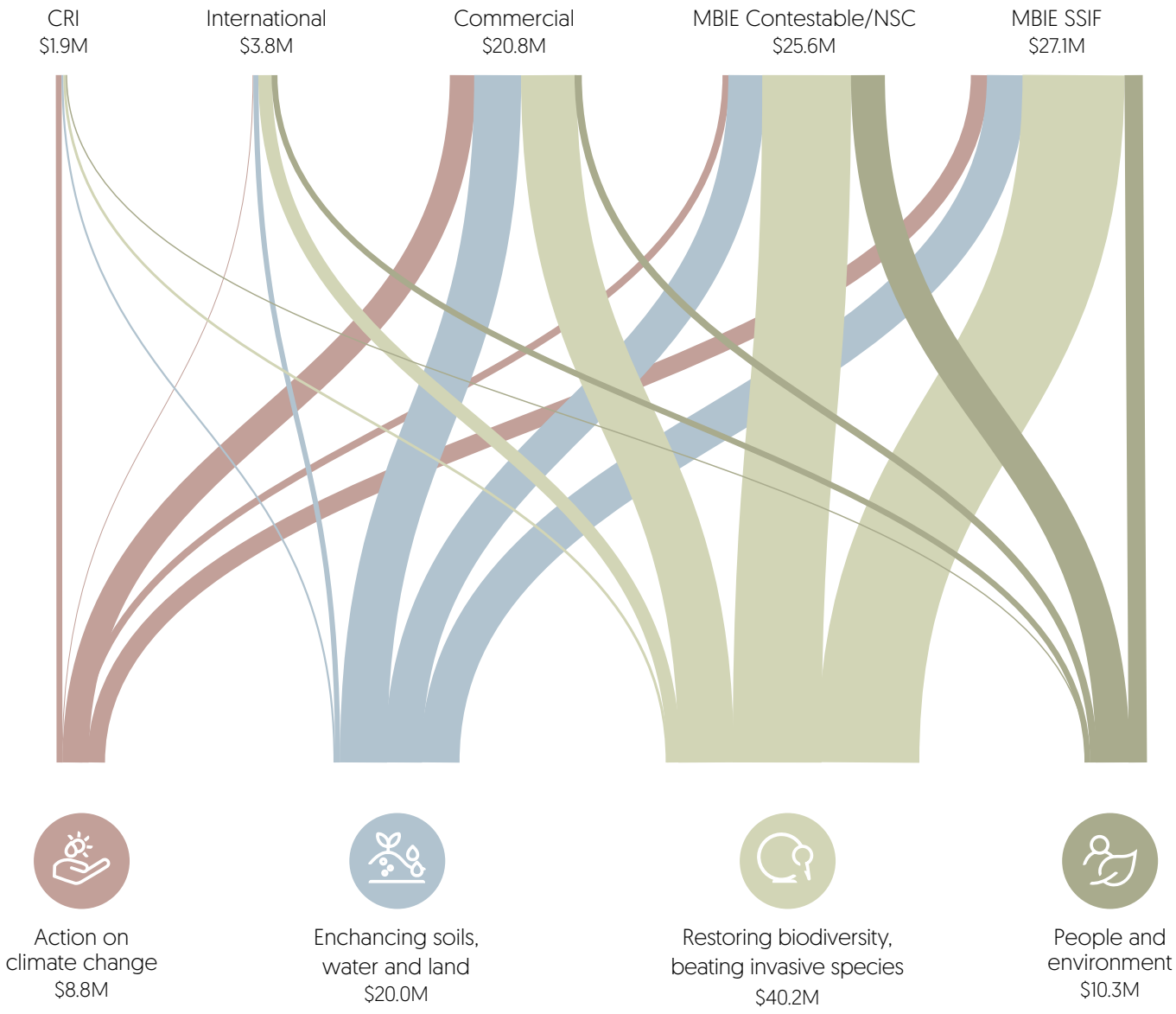
Allan Herbarium
c.800,000+
specimens

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 AoNZ, industry, and international science collaborations. These investments power programmes across our four research impact areas. The following diagram is based on science revenue information for 2022/23 rather than on audited information.



Note: as explained above, this diagram shows provisional revenue amounts for 2022/23. 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.

Tangata whenua also have an important connection to Manaaki Whenua's collections and databases. 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.

Accordingly, and as specified in the SSIF Platform Contract, Vision Mātauranga continues to be a core focus in 2022/23, and Te Tiriti o Waitangi is increasingly influencing our behaviour on 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 2 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). 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.

During the past year we held two workshops with the TTPG to develop a strategic plan for increasing the value (to Māori) of our biological collections and databases and to start changing the way we manage our collections on their behalf in accordance with our Tiriti obligations. Implementation of the agreed plan has started and includes accelerating the rate at which we digitise our collections.

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

—
Over 400 refereed publications in 2022/23 used our collections and/or databases in their research.

—
Soil laboratory data were used in a collaborative project with Plant & Food Research and AgResearch to provide a wide range of parameters for the APSIM (Agricultural Production Systems sIMulator) agroecosystem model. APSIM is the modelling platform used in New Zealand and Australia for crop production and nutrient-use efficiency simulations.

—
The ICMP culture collection was used by MPI to investigate the presence of soft rot bacteria in New Zealand. This information enables better targeting of border biosecurity efforts when importing seed and plant material, and enables ease of trade with other countries through establishing that New Zealand is free from certain diseases.

—
The data we hold underpinned the National Policy Statement for Highly Productive Land (NPS-HPL), which became operative in October 2022.

—
Using the NZAC, we received 41 critical nematode samples from MPI for identification; 23 of the samples were from *Pinus radiata*. These identifications have assisted MPI biosecurity responses and helped to protect New Zealand's pine industry.

COLLECTIONS

New Zealand Fungarium (PDD)

landcareresearch.co.nz/pdd

109,584	Specimens
979	Accessions
753	Objects sent or received in 44 transactions

New Zealand Flax Collection

landcareresearch.co.nz/harakeke

242	Selections
186	Plants sent in 17 orders
224	Visitors

International Collection of Microorganisms from Plants (ICMP)

landcareresearch.co.nz/icmp

23,675	Cultures
165	Orders sent
1,096	Cultures sent

New Zealand Arthropod Collection (NZAC)

landcareresearch.co.nz/nzac

c. 1.6M	Objects
56	Loans
1,627	Identification & enquiries

Allan Herbarium (CHR)

landcareresearch.co.nz/allanherbarium

c. 800,000	Specimens
781	Specimens sent
423	Identification & enquiries
322	Visitors

DATABASES

National Vegetation Survey Databank (NVS)

nvs.landcareresearch.co.nz

48	New datasets
310	Plots added
4,405	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)

lris.scinfo.org.nz

400,450	Page views
156,509	Website visits
87,087	Visits/sessions

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 AoNZ 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, industry, and the primary sector.

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

Manaaki Whenua's Duckchul Park and Dr Amy Martin, Fungal Foray, Rakiura Stewart Island. Image: Kim Triegaardt.

Aotearoa's science priorities

As this Annual Report shows, in 2022/23 we significantly contributed to priorities for the Government that were expressed in our shareholding Minister's Letter of Expectation.

We have continued to build AoNZ's strategic, integrated science capability across our areas of research impact, helping to build sector resilience. We have helped to foster a culture of collaboration, nationally and internationally, including with the Government, iwi and hapū, industry and community stakeholders, while building a diverse and inclusive workplace with a focus on te ao Māori and our organisation's important commitment to Te Tiriti o Waitangi.

We have constructively engaged in the developing process around sector reform as expressed in MBIE's White Paper *Te Ara Paerangi / Future Pathways*, and have continued to explore the opportunities for co-location of facilities with Plant & Food Research, ESR and MPI at a future science centre at Mt Albert, Auckland. We are making good progress on transforming our data and digital science capabilities, including making them more widely available to end-users including Māori.

We have also been in the vanguard of the CRIs' collective response to Cyclone Gabrielle (see page 28), offering our expertise and experience to collaborate across the sector both in the immediate response and the longer-term recovery.

Dr John Hunt and Dr Phil Novis at Canyon Lake in the Southern Alps, setting up equipment for a Marsden project to measure the effects of bushfire dust on glacier albedo (reflectance). Image: Kim Triegaardt.

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 an annual co-innovation workshop with primary sector and government partners, an annual iwi co-innovation workshop, 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. 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, the food and fibre industry, tourism and energy.

The Panel meets bimonthly with representatives of our Senior Leadership Team (SLT) and annually with the whole SLT to explore and clarify the needs of the natural resources sector, 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 also explored the challenges that are being faced from their sectors under climate change, the many legislative reforms taking place and how they may be navigating them. Specifically, they explored an understanding of the impediments that they may be facing that may impact on the ability of science information to be taken up, applied, and progress made towards their environmental goals. Future OAP sessions will explore how pathways to impact can be facilitated through senior leadership interaction with the panel. The OAP provides a valuable connection with the Board on contributing to broader iwi, government and industry direction.

Our Science Advisory Panel brings an international scientific perspective, helping us evaluate our scientific excellence, explore emerging science needs, and develop research areas. During the year we did not undertake a science excellence review, because instead we established the TTPG and worked with them on our collections and databases. Next year our Science Advisory Panel will be reviewing our biodiversity and biosecurity-related research.

Our strategic goals

O mātou whakaarotau rautaki

Our main strategic goals, current focus and ongoing priorities for the next 2–3 years, both within and external to Manaaki Whenua, are summarised below and explained in the following pages.

Strategic goal 1.
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 goal 2.
Drive research impact with our partners

Together with our partners we will prioritise AoNZ'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 goal 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 goals, our current focus as an organisation is as follows:

Strategic goal 1

- Kia Maia: achieving our bicultural competency baseline.
- Te Tiriti Partnership: working with Te Tiriti Partnership Group to define the future strategy for our biological collections and databases.

Strategic goal 2

- Leveraging data science and digital technology to increase the impact of our research.
- Investing in a centre for biological security at Mt Albert with Plant & Food Research, ESR and MPI.

Strategic goal 3

- Mahi Tahi: Working Together – an internal change management programme.
  Helping our people to find the combination of environment, tools, and approaches to best achieve their daily goals.

Pīwauwau / rock wren, Southern Alps. Image: Jeremy Sanson.

Strategic goal 1

Weave the principles of Te Tiriti into our fabric

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

Our commitment is as follows:

"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 priorities are:

1.1 Bring external Māori into our leadership processes as partners, helping to shape our strategies.

Progress in 2022/23
In 2021/22 we established an independent Te Tiriti Partnership Group (TTPG), see also page 10), comprising senior Māori from across a range of areas of expertise, to provide input and advice as we undertake a Te Tiriti-informed review of our collections and databases. This work is gathering pace.

We have appointed a Kaitūhonohono or "Connector" position whose focus is on engaging with iwi and hapū and helping to connect them to the taonga that we hold from their whenua. It is envisaged that, through better connections between iwi/hapū, we will leverage more opportunity to collaborate with them on science and research that creates value and impact from the collections.

This was a key recommendation of our Rōpū Māori which was reflected in the recent Science Advisory Panel report. Specifically, the report recommended that we expand our approach from one where we simply 'collect, curate, and classify' to one where we also 'connect, create, and collaborate' with our Te Tiriti partners.

This role has initially focused on developing relationships internally and externally, centred around the collections and assisting Lincoln staff in particular to develop protocols for engaging early with tangata whenua on research projects. With the support of the Kaitūhonohono, researchers have started to form working groups to explore kaupapa Māori and Māori-informed themes in their research and strengthen Māori engagement in Vision Mātauranga across our research agenda.

1.2 Support iwi as kaitiaki through internal Māori leadership and co-leadership of our research.

Progress in 2022/23
We have established new senior roles for this purpose, and increased the proportion of MBIE SSIF-funded projects that are co-designed with Māori and under the leadership of the members of our Manaaki Taiao research group, based in Hamilton.

In February 2023, we appointed a GM Māori Partnerships to support the GM Te Tiriti Strategy and strategic leadership in Manaaki Whenua for engagement and business growth with the Māori sector. The GM will actively foster Manaaki Whenua's role as a preferred partner for Māori and grow our relationship with related primary sector stakeholders. The role will also ensure Manaaki Whenua has the right internal capability and culture to meet these objectives as well as meet its obligations under our commitment to Te Tiriti.

The previous year, in February 2022 we appointed three Kaihautū – Tier 3 senior Māori research leaders with a unique combination of highly regarded science expertise alongside enviable iwi, hapū, Māori networks and experience across the three science impact areas (i.e. land, biodiversity and climate action). The Kaihautū have been working across our existing research portfolios to support Manaaki Whenua to deliver its Tiriti commitment across these domains. The Kaihautū responsibilities include the strategic allocation of SSIF funding that allows kaupapa Māori led research projects within the portfolios.

It is expected that each Portfolio Leader co-develops their three yearly Portfolio Strategy, Annual Portfolio Plan and overall SSIF allocations with at least one Kaihautū. This is in keeping with the principle of increased Māori co-design and co-leadership of our research agenda as signalled in our strategic document *Te Āpōpōtanga* and our Statement of Commitment.

The three Kaihautū are functioning as a team and operate effectively as integrators, from a te ao Māori perspective, of the research occurring across each of the portfolios.

1.3 Enhance participation of Māori in Manaaki Whenua through supporting new kairangahau (Māori researchers) into a research career with pathways to senior roles.

Progress in 2022/23
We continually seek to grow our pool of senior, mid and early career kairangahau Māori, actively working to build the capability of our early career kairangahau in particular by providing both cultural and technical supervision and support in their areas of expertise. We are also using SSIF funding under a Kaihautū allocation to support our kairangahau to apply their science skills to projects that have a specific te ao Māori focus. Additionally, two kairangahau have been supported to complete their PhD and their Masters research. What we have realised is that the current science pathways might not suit kairangahau Māori for any number of reasons and so we are currently exploring alternative pathways that reflect and address Māori aspirations and priorities rather than the conventional science excellence route.

This year we hosted eight Māori students through our summer internship programme Poipoia Kia Rere, and the campaign is already underway to host a similar or larger cohort for our 2023/24 summer programme.

As part of our MBIE Endeavour programme Te Weu o te Kaitiaki we have approximately 25 Māori interns, taiohi, and young kaitiaki being supported as part of our research each year. This research programme funds and supports Trusts and Kaitiaki Authorities (e.g. Rangatahi Tumeke; Ko Moehau Ki Tai) to deliver these capacity building support services. We have a marine and terrestrial programme with Pare Hauraki and a Whare Maire programme being set up with Tūhoe.

Strategic goal 2

Drive research impact with our partners

Our research has impact when it is valued and used by our partners and benefits 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 priorities are:

2.1 Prioritise AoNZ's needs from research (now and in the future) together with our partners, and develop strategic investment pathways.

Progress in 2022/23
This year we have made significant progress in our partnerships including a major shift in gear around the nation's predator-free goals, through partnering with Ngāi Tahu and DOC to provide the research needed to underpin a predator-free Rakiura (Stewart Island) the most ambitious island pest eradication ever attempted globally.

We have continued to work with partners to make our tools and resources more usable, for example partnering at a regional scale with Waikato Regional Council in the Hauraki and Hawke's Bay Regional Council on improving the use of LiDAR remote sensing technologies, and continuing to refine our S-map soil mapping capabilities.

2.2 Invest in our research and innovation in ways that accelerate its impact.

Progress in 2022/23
We have continued to provide leadership to iPEN, a pan-CRI group developing tools and approaches to increase the impact from CRI research. This has involved a programme of seminar and workshops across the CRIs to roll out new tools and approaches, as well as discussions with MBIE to inform their thinking about science sector reforms as part of *Te Ara Paerangi*.

2.3 Leverage data science and digital technologies to increase value for our users and customers.

Rapid changes in technologies have made data more accessible, but our focus will be on creating value rather than simply more information and tools.

Progress in 2022/23
Today almost all research that Manaaki Whenua does is eResearch. Researchers may use new remote sensing technologies to collect data, they invariably use digital technology to store data they collect, and new and emerging analytical tools, like artificial intelligence, are providing them new ways to leverage that data to create new insights.

In the past year, we have been laying the groundwork for a data and digital transformation at Manaaki Whenua. We see the potential for Manaaki Whenua to better leverage the disruptive power of digital technology to advance high impact research for AoNZ.

Our Data and Digital programme is focused on three key use-cases for technology at Manaaki Whenua: 1) Connecting and Collaborating, 2) Undertaking eResearch, and 3) Building Digital Products and Services that put our research in the hands of end-users.

We have four workstreams underway that underpin delivery across these three use-cases.

The first workstream is developing a Digital Strategy for Manaaki Whenua. This will establish our vision and principles, setting the direction for investment over the next 5 years. This work is closely connected with other strategic work in this space within the science system, including MBIE's Data and Digital Research Institute Business Case.

A Data and Information workstream is focused on maturing our approach to Research Data Management. As a science sector we are all grappling with the very real challenges of research data management. The potential of making our data Findable, Accessible, Interoperable, and Reusable (FAIR) is significant. Our commitment to Te Tiriti, discussed earlier in this report, also requires that we consider our obligations to iwi and hapu as a Treaty Partner, given we hold significant data that we know is of relevance and interest to iwi and hapū.

A Research Technology operations stream is exploring how we can better connect our various technology support teams, across the operational parts of the organisation, and our science teams, to ensure we are delivering a seamless service to researchers and our customers.

Finally our Cyber Security stream is working to improve our overall information security, ensuring that we can be trusted kaitiaki of all of the research and data we hold for New Zealand.

While this work is in its early phases, Manaaki Whenua continues to deliver some exciting, leading edge eResearch and digital services to AoNZ.

For example, Manaaki Whenua's collaboration with Microsoft's AI for Good data science team based in the US continues to yield benefits both locally in AoNZ and on a global scale.
By harnessing the swift model training capabilities of Microsoft's Planetary Computer and combining them with the expertise of the US team, Manaaki Whenua's data science unit has accelerated the development of advanced AI/machine learning techniques for identifying small (<500m^2) wetlands using satellite data. Recent trials in the Waikato and Northland regions have shown heightened accuracy in detecting these compact wetland areas. This advancement in detecting various land surface features through existing remote sensing technologies not only enhances our understanding of changes in the world's land environments but also benefits AoNZ and the broader global user community of the Planetary Computer.

Strategic goal 3

Create a sustainable environment for our research and people to thrive

Manaaki Whenua achieves impact through its research. Critical enablers of that research are our people and culture, our infrastructure, our process for creating impact, and our financial resilience.

Our current priorities are:

3.1. Adapt global trends in the Future of Work to meet our needs in Manaaki Whenua.

Progress in 2022/23
We are embracing changes in technology, globalisation, generational and social shifts as part of the Future of Work. We are adapting to, and adopting, new technologies and continuously looking at ways to improve the way we work with the support of technology.

Hybrid and flexible working are embedded in our way of working and valued by our people. We are working smarter and more inclusively online, but also using opportunities to connect and collaborate with our peers and partners in person at our sites.

In line with the goals of *Te Ara Paerangi*, we aim to attract, retain and develop an excellent and diverse workforce at all levels. For us, this strategic shift includes diversity and equity initiatives to improve under-representation and support for expanded career pathways and improved career mobility across the science system. The reopening of international borders post-COVID has increased our ability to attract overseas talent and also strengthened our ability to partner and collaborate, especially across the Pacific region.

Our longer-term focus on creating and expanding science career pathways, especially for early career researchers, is beginning to bear fruit including for Māori (see page 19). For more on our bicultural and diversity commitments see page 61.

3.2 Be proactive in 'making our future' through the science system reset.

Progress in 2022/23
As an organisation and as an integral part of the science sector, Manaaki Whenua has welcomed *Te Ara Paerangi* and the opportunities it opens for creating a fit-for-purpose science system. We have already contributed the thinking of our wider staff and our leadership teams to *Te Ara Paerangi*, and look forward to ongoing discussions with MBIE throughout the next stages of the system reset. We support sector reforms being focused on creating impact for AoNZ, and will contribute to the development and deployment of AoNZ's new National Research Priorities. This will require a co-development approach with mana whenua, with the other Crown Research Institutes and with our stakeholders, partners and clients with whom we have invested 30 years of relationship development.

3.3 Enhance our project lifecycle systems and processes using human-centred design and effective change management.

Progress in 2022/23

Over recent years the pressure has grown on our researchers to manage much more than simply their research. Our project lifecycle systems and processes (linking design to delivery of research contracts) should be reset to ensure we have the right people doing the right things with the right skills and tools.

In the past year we have completed the first phase of our Mahi Tahi – Working Together programme. 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.

The programme mapped 73 Manaaki Whenua processes associated with delivering research projects, with the goal of identifying pain points and opportunities to simplify or improve delivery. A key goal was to understand the role that systems played within these processes, compared with the process design, behaviour and policies. We found that while our systems were contributing to some of the pain experienced by our research leaders and other staff, a more significant contributor was processes that had evolved over many years.

The outcome of this phase of the project is to deliver a Mahi Tahi Phase 2 investment case to the Manaaki Whenua Board that considers: 1) the opportunity to undertake process simplification, 2) the opportunity for some system improvements, and 3) the opportunity to adjust roles and responsibilities relating to project delivery to ensure we have the best person doing the task. If approved, we expect to commence Phase 2 during 2023/24.

Our science
Tō tātou pūtaiao

Delivering on our core purpose, to fix the complex environmental problems facing AoNZ, 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/publications/innovation-stories

Senior Researcher Dr James McCarthy counts leaves on a ramarama tree (Lophomyrtus bullata) *in Egmont National Park as part of a disease assessment for myrtle rust. Image: Kim Triegaardt.*

Our four research impacts

Our four research impacts are designed to present our science and research in an approachable and meaningful way, for all people in AoNZ to engage with.

Much of our research work is focused where these four research impacts 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 AoNZ'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 AoNZ. 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 AoNZ 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 AoNZ 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 AoNZ 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 2022/23

The following pages showcase the innovative science we undertook in 2022/23, taking each research impact area in turn. We begin, however, by profiling our cross-disciplinary, integrated responses to Cyclone Gabrielle, to demonstrate how Manaaki Whenua's unique combination of science expertise and skills positions us at the forefront of the local, regional and national responses to the recovery efforts.

Science with immediate impact: integrated research for cyclone recovery

For around 4 days from 12 February 2023, Severe Tropical Cyclone Gabrielle caused significant flooding and damage across northern and eastern regions of the North Island. Gabrielle's effects were felt over a very wide area, including Northland, Auckland, Coromandel, Waikato, Bay of Plenty, Gisborne, and Hawke's Bay.

With soils across much of the North Island already saturated from an unusually wet summer, including Cyclone Hale a few weeks earlier, the rapid, unrelenting rainfall of Gabrielle could not be absorbed. The saturated soils triggered shallow landslides in the steep, erodible hill country, displacing millions of tonnes of sediment across a range of land uses – pastoral farming, plantation forestry, native forest, and native scrub. The worst-hit areas were the Hawke's Bay and Gisborne regions.

As the clean-up has continued it is clear that much of the landscape in the worst-affected areas has effectively been 'reset' by Gabrielle. It has affected substantial areas of natural and regenerating ecosystems, productive land (including farm, orchard, forestry, and vineyard operations), much vital infrastructure, and many rural and urban settlements.

Manaaki Whenua has significant immediate and long-term contributions to make to the recovery from the cyclone. Initially, we contributed our capabilities to the Ministerial Inquiry into Land Use run by MfE. The panel for this inquiry issued its initial report in May 2023. The report focused on woody debris and sedimentation associated with the cyclone; two areas of specific long-term expertise within Manaaki Whenua.

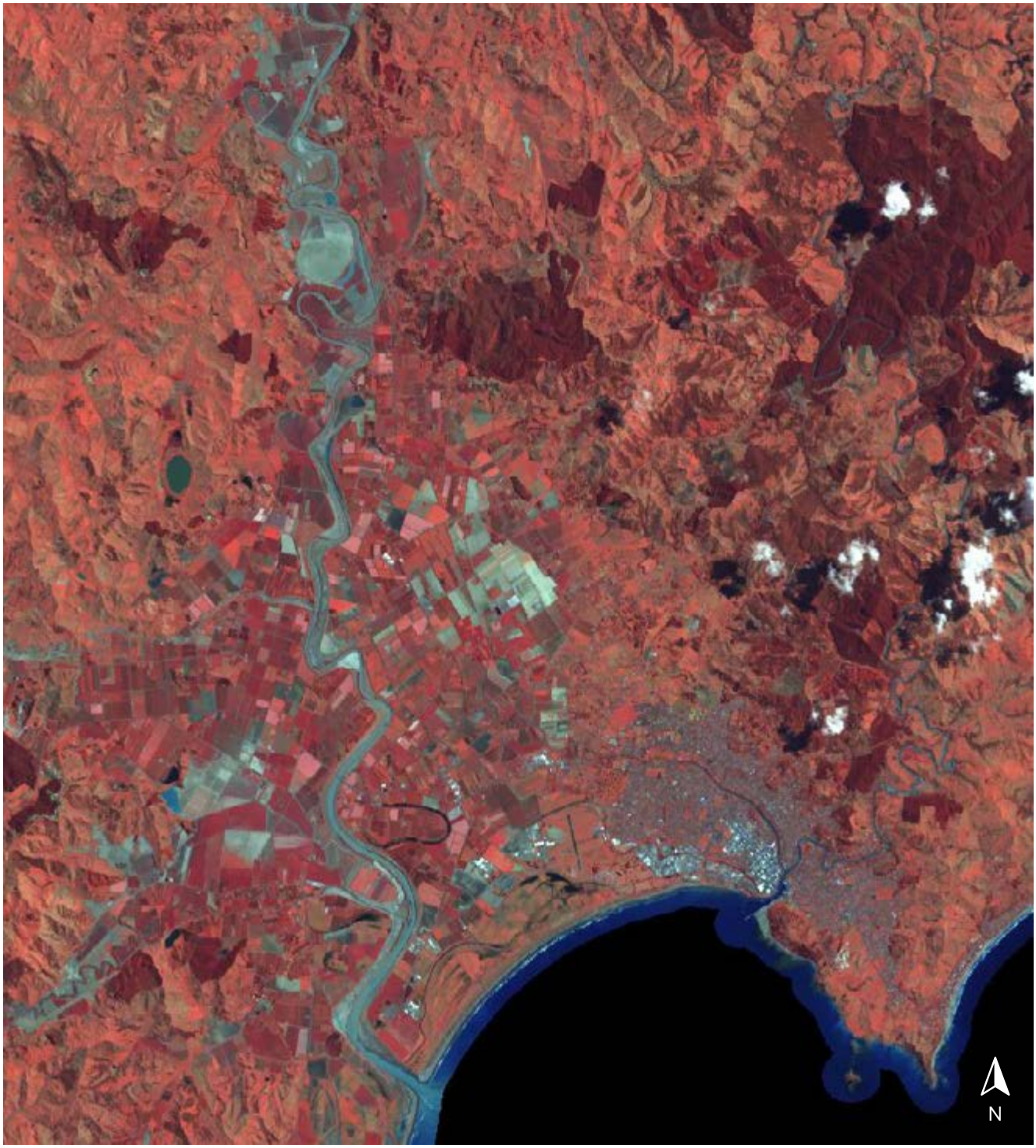
Whilst the inquiry was underway, one of the most urgent early research responses was to update vital satellite, LiDAR, and optical imagery to discover exactly how landscapes and catchments have changed. We made available our expertise in big data analysis and interpretation to support ministries and agencies such as regional and local councils that have an immediate role to play. This work included assisting GNS Science's response to the cyclone focused on mapping landslides from high-resolution satellite imagery. Having already been involved with a project with Hawke's Bay Regional Council to map landslides following a heavy rainfall event in March 2022, the new regional LiDAR has been used to update our data on landslide susceptibility, landslide-debris mapping, erosion mapping, land characterisation, cultural mapping, and vegetation cover mapping.

As initial response gives way to longer-term recovery, Manaaki Whenua's scientists will draw on a large body of integrated research knowledge and data that encompass economic, social, environmental, cultural, and policymaking aspects to ensure relevant, resilience-building research.

We have a current MBIE Endeavour research programme of direct relevance to the devastating soil loss and silt deposition caused by Gabrielle. 'Smarter Targeting of Erosion Control' (STEC), now in its final year, is a pivotal research programme that has significantly improved understanding of spatial and temporal patterns of soil erosion, sediment-related water quality, sediment mitigation, and modelling. The most recent STEC outputs include high-resolution geospatial modelling of shallow landslide susceptibility to better inform targeting of mitigation measures, catchment-based sediment 'fingerprinting' (determining where eroded sediments originated), understanding the sediment contributions of large, slow-moving landslides, and modelling the likely patterns of soil erosion and sediment transport under future climate change.

Led by Manaaki Whenua researchers Dr Chris Phillips and Dr Hugh Smith, STEC includes researchers from NIWA, Massey and Canterbury Universities, and international collaborators from KU Leuven, INRAE, University of Salzburg, and Bern University of Applied Sciences in Switzerland. Our partners include Whanganui iwi (Tamaūpoko Community Led Trust) and Rangitāne o Manawatū. STEC has been supported throughout by Northland, Waikato, Horizons, and Hawke's Bay Regional Councils, Auckland Council, Environment Southland, the Ministry for the Environment, the Ministry for Primary Industries, Our Land & Water National Science Challenge, and Federated Farmers.

We also offer research expertise in forestry slash management, weed management (weeds may spread onto newly exposed soils), and in wildlife, plant population, and disease modelling as the affected areas recover. Our mapping capabilities will be needed



Near-infrared satellite image of Gisborne after Cyclone Gabrielle.

to assess changes in the landscape's carbon stocks through loss of woody vegetation and carbon-rich soil.

In another relevant Endeavour research programme, we are already working to understand whether biomass and soil carbon stocks in rural landscapes can be enhanced by the planting or natural regeneration of small clusters of trees, matched with soil and climate conditions.

Our social scientists are also well positioned to help build back better after Gabrielle. We will help to analyse the social and economic impacts of the cyclone, including how change is managed and the inter-related, intergenerational resilience of communities, economies, and biodiversity. This knowledge creation has a head-start thanks to our existing Endeavour-funded social research programmes, in which we are unlocking effective decision-making for land managers, and seeking to identify and demonstrate how kaitiakitanga practices (which might include economic opportunities) achieve biodiversity regeneration, cultural revitalisation, and community well-being.

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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Senior Researcher Dr Surinder Saggar contributed to a study of dairy pasture that includes the perennial plant plantain, finding that nitrate leaching and nitrous oxide emissions from cow urine patches could be significantly reduced in a pasture that included plantain without decreasing milk yield. Farmers can have increased confidence to incorporate plantain into pasture, and the practice is being promoted by DairyNZ.

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A study using forest company imagery, LiDAR and satellite information revised the understanding of the period when commercially harvested pine plantations are most susceptible to landslides. This "window of vulnerability" has been refined from 0-8 years to 1-4 years. This refinement is likely to be incorporated into the National Environmental Standard for Plantation Forestry.

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Our scientists supported the development of the 2022 *National Policy Statement on Highly Productive Land*, a significant policy to protect AoNZ's most versatile soils and land from ongoing urban sprawl and rural residential developments. The NPS-HPL is based on the Land Use Capability classification, part of Manaaki Whenua's LRIS database. As a result, the LUC website saw a significant increase in daily usage after the NPS was released, from around 45 daily users to around 170.

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We evaluated the feasibility and potential value of wireless sensor networks to monitor and map soil temperature and moisture in hill country farms for Beef+Lamb. Networks were established on six hill-country farms between 660 and 11,400 hectares in size. Results over 2 years showed that sensor networks are increasingly reliable over distance, and that soil temperature was easily monitored and mapped, whereas soil moisture was only moderately easy to map.

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We gave significant support to the Parliamentary Commissioner for the Environment's report on mapping urban green spaces: *Are we building harder, hotter cities?* We used a range of automated and manual processes including machine learning to extract green space from aerial photography of Auckland, Hamilton and Wellington, including from poor-quality black-and-white photography, which was a particular challenge. We also provided information on green infrastructure in cities, and reviewed the final report.

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Our LRIS portal had a major refresh to improve the user's experience in finding and downloading geospatial datasets on AoNZ's land environment, including enhanced map viewers and the ability to mark 'favourite' map layers.

Urban tree mapping in Wellington [see page 34].

Our remote sensing scientists expanded upon work begun in 2021 using satellite imagery to delineate intensive winter grazing and forage, paddock by paddock. The new work expanded the scope of the project from the regional to the national scale.

Our SedNetNZ erosion modelling tool has improved understanding of the likely effects of climate change on future river sediment loads in the Taranaki region. Without soil conservation efforts, the amount of sediment transported to the coast could increase by over 100% by late-century, the model predicts.

Innovation stories

S-map reaches 10 million

S-map has reached the halfway mark for mapping the farmable land area of Aotearoa New Zealand.

Over the past 4 years, and thanks to a partnership between the Ministry for Primary Industries, Manaaki Whenua, and 12 regional councils, 2 million hectares were added to the database.

A further 1.5 million hectares are expected to be completed by 2025.

Manaaki Whenua soil scientist leader Dr Sam Carrick says that within the farmable land area, the land that has the potential for multiple types of use now has 68% of its soils mapped.

S-map is more than a soil map, it's a soil information system, with a comprehensive database and modelling research platform (led by Dr Linda Lilburne), delivering data and information across a number of platforms and tools (led by Dr David Medyckyj-Scott).

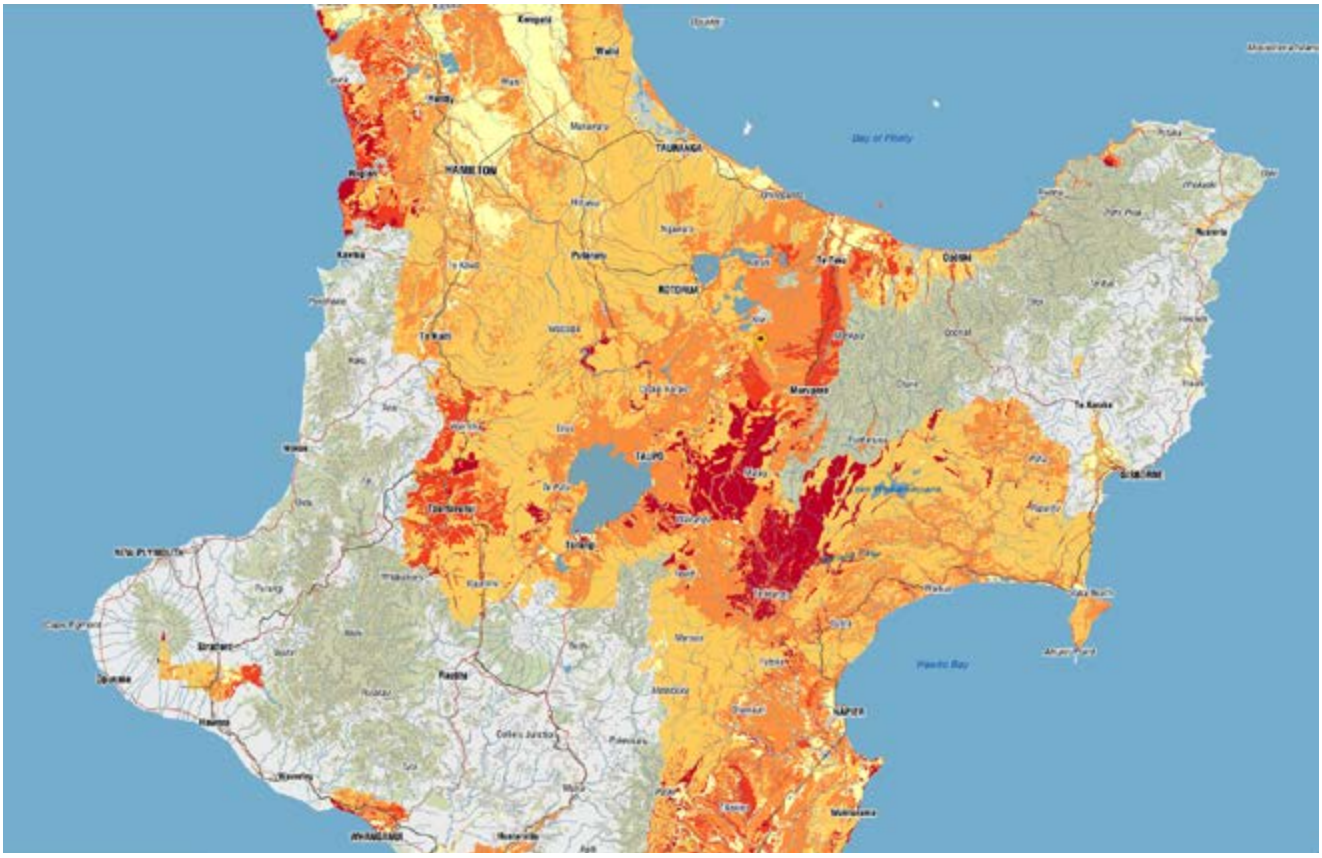
Alongside the soil scientists and laboratory staff, who do the mapping and soil attribute characterisation, the modern soil information system includes staff across a range of disciplines, such as spatial and data science modellers, database informatics, software and website developers.

Linda says more than 5,500 different soil types have been mapped so far, with information on each soil type freely available on the popular S-map Online website.

S-map information is extensively used across a range of sectors to enable more informed decisions to manage our land within environmental limits. In the past year alone, users downloaded 54,000 soil information sheets.

In this latest update 680,000 hectares of new soil mapping was released. Newly mapped areas are located in Northland (near Moerewa), Manawatu (Horowhenua), Wellington (Wairarapa) and Canterbury (upper Rakaia) regions.

A new improved map was also published to replace five separate legacy maps, completed at different times by different people. The new map covers an area across



An image of nitrogen-leaching susceptible soils.

the Hauraki Plains, Coromandel Peninsula, and the west side of the Kaimai ranges and Mamaku Plateau.

Other S-map Online updates include three new layers of soil attribute information. A new soil carbon concentration layer is available for all of New Zealand, replacing the existing soil carbon stocks layer. This layer is only suitable for viewing the spatial pattern at a regional scale; it is not accurate at the farm scale. Two layers of soil susceptibility or vulnerability are also available: nitrate leaching and by-pass flow susceptibility.

River catchment planning for future climate change

To develop effective management plans for river catchments, policymakers and catchment managers need to account for how climate change might affect soil erosion and river sediment loads. However, there has been no published, quantitative assessment of national-scale changes in erosion or suspended sediment loads anticipated under future climate for Aotearoa New Zealand.

To address this gap, Manaaki Whenua's Dr Andrew Neverman and colleagues, in collaboration with AgResearch and NIWA and with funding from the Our Land and Water National Science Challenge's Whitiwhiti Ora programme, have produced AoNZ's first national assessment of the potential impact of climate change on erosion and suspended sediment loads.

As part of the project, future erosion and sediment loads were estimated for mid-century (2040) and late century (2090) based on projected changes in climate and hydrology. Changes in suspended sediment loads were modelled under four potential future atmospheric CO_2 concentrations, with associated changes in rainfall intensities and amounts.

Researcher Dr Balin Robertson logging data in the field. Image Kristin Deuss.

The results of this modelling, published in the international journal *Geomorphology*, show that up to 28% of the North Island and 8% of the South Island are estimated to experience a two-fold or greater increase in average annual sediment supplied to the channel network by late century.

Can mosaics of trees help to reach Aotearoa's carbon targets?

Increasing carbon stocks in woody vegetation will be a major contribution to AoNZ reaching its zero-carbon emissions target by 2050. Plantation forestry has previously been promoted as the best way to achieve large-scale carbon sequestration, but a new MBIE Endeavour research programme now underway and led by Manaaki Whenua is investigating an ingenious alternative with additional co-benefits.

The research programme, Integrating trees to target zero carbon and add value to rural landscapes, led by principal researcher Dr David Whitehead and researcher Dr Sam McNally, aims to quantify the enhanced biomass and soil carbon stocks associated with edge effects from small clusters of trees, and additional co-benefits, compared with continuous plantation forestry.

Field measurements at sites across the country will be combined with innovative metagenomic approaches, isolating and analysing DNA from environmental samples, to provide new insights into the role of specific microbial processes that regulate ecosystem carbon cycling at the edges of tree clusters. Combining the field measurements with modelling will show how the optimal spatial arrangement of trees in grasslands matched with soil and climatic conditions can increase carbon stocks and lead to additional co-benefits including increasing diversity of products (e.g. nuts, honey), alternative animal fodder, shelter for animals, improving water quality and enabling of kaitiakitanga in rural landscapes.

Compared with plantation forestry, over 30 years, the researchers

initially estimate that establishing mosaics of tree clusters on low-productivity grasslands on 25% of the land area currently recommended for forestry could result in additional biomass and soil carbon stocks equivalent to offsetting 1.5 years of the country's current gross greenhouse gas emissions, or 3 years of agricultural emissions – a very significant contribution to emissions reduction.

First steps have been to co-develop the research plan with end-users and identify selection criteria for 32 sites for field measurements across the country: there has been considerable sector interest in getting involved. The research will involve national partners from AgResearch, Scion, NIWA, Lincoln University, University of Canterbury, Māori organisations including an ahuwhenua Māori Trust at Te Whaiti, existing Māori special interest groups (e.g. the Kānuka Entity, Ngā Pou a Tāne / National Māori Forestry Association) and Māori agents of change in the agribusiness sector, plus international collaborators from France, the Netherlands, the USA and Australia.

Interactive urban tree mapping in Wellington

"Bridging the gap between remote sensing and tree modelling with data science" – an exciting collaboration between New Zealand and Singapore – has achieved an important milestone with the launch of an interactive urban tree map of New Zealand's capital city.

The Wellington Urban Tree Explorer contains a map layer of individual tree crowns across Wellington. The data were produced by a deep learning model called Mask R-CNN (Region-based Convolutional Neural Network), which identifies individual tree objects from top-view aerial imagery.

Dr Jan Schindler leads a joint AoNZ-Singapore Data Science research programme that uses data science, remote sensing and 3D modelling for extracting tree species information from multi-resolution, remotely sensed data.

The aims of the programme are to advance our current methods for measuring individual trees by developing and applying novel deep learning algorithms and to model their interactions with the human and physical environment.

"As the world becomes increasingly urbanised, urban trees and forests become increasingly important for overall human well-being," says Jan. "There are plenty of studies showing the benefits of urban trees and forests from a number of perspectives – health, climate and ecology."

However, sustaining and enhancing biodiversity and healthy living environments requires careful management of trees in urban areas and forests. But these decisions are currently limited by the quality of available data, tools, and techniques.

"With the information we gather using these new deep-learning techniques, we can detect trees and identify species in greater detail than ever before, moving towards analysing the socio-economic impacts of trees in cities," says Jan. "The methods are transferable to non-urban areas and are already being successfully applied to a number of tree mapping projects in pastoral hill country and native forests."

Features of the website include sliders for layer transparency, coloured maps showing tree heights and diameters, selecting data based on attribute ranges, and being able to zoom in to get information on individual trees, such as their crown dimensions and height.

The project team includes researchers from Manaaki Whenua, Scion, the University of Canterbury, Victoria University of Wellington, the Institute of High Performance Computing Singapore and Nanyang Technological University.

LiDAR reveals real risk to wetlands

For the first time in AoNZ, research has shown how remote sensing, using LiDAR, could improve conservation management of wetlands through better drain detection.

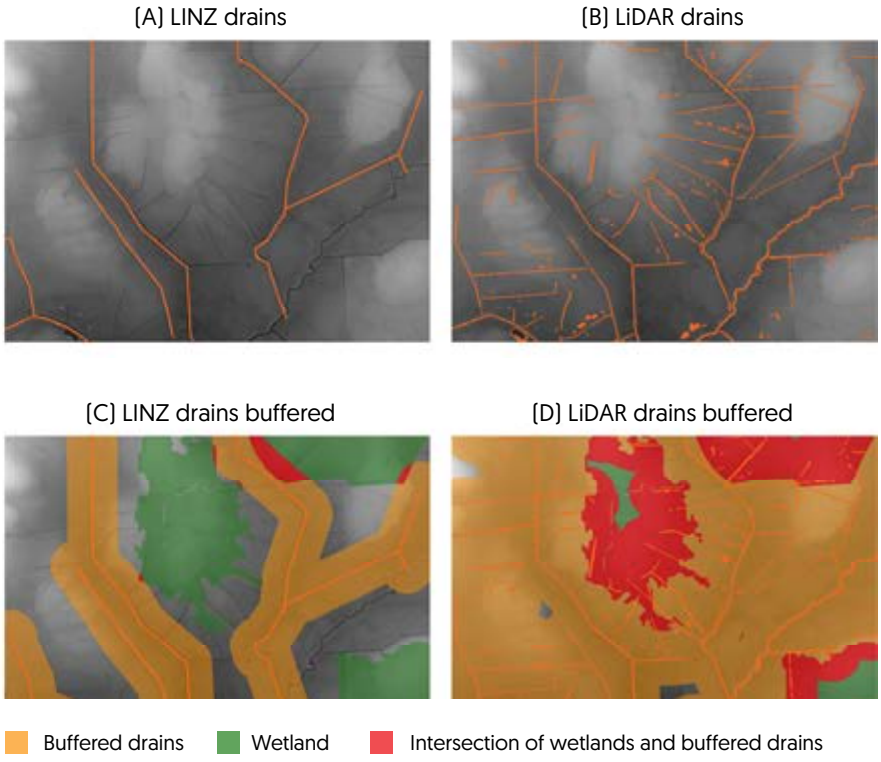
Historically seen as an intrinsic component of land management in AoNZ, drainage of wetlands has seen their natural extent decrease by around 90% since human arrival here.

Recent work led by Manaaki Whenua ecologist Dr Olivia Burge shows that while recent efforts have been made to restrict new drainage close to existing wetlands, the extent of existing drainage in or near wetlands nationally is unclear.

"Wetlands on peat are particularly sensitive to lowered water tables and can effectively subside and shrink when drained," says Dr Burge. "Drainage systems can cause the loss of key wetland species, an increase in weediness, declines of native wetland species diversity, and further wetland loss and degradation."

There is a national drains map layer, but it has never been used to explore where drains occur near wetlands. Dr Burge and her team are the first to look at the area of wetlands within 100m of drains using LiDAR. Co-author Dr Hugh Robertson, a wetland ecologist from the DOC, says they developed a model to identify drains using LiDAR which they then compared with the national drains spatial layer for the Waituna catchment of Southland.

Tutaki West Branch Headwaters Wetland, Murchison area. Image: Olivia Burge.



(A) LINZ drain coverage, clearly showing many drains missing. (B) LiDAR drain coverage with some drains missing, but also a river channel mapped as a drain. (C) LINZ drain coverage buffered by 100 m, showing a small overlap between drains and wetlands. (D) LiDAR drain coverage buffered by 100 m, showing substantial overlap (red) between areas mapped as wetland by FENZ, and the buffered drains.

"As LiDAR is more sensitive to detecting drains in the landscape, it showed the area of wetlands potentially affected by drains is larger than the national layer might suggest," says Dr Robertson.

Dr Burge says, "not only does this work help us to better detect drains around wetlands and identify where the potential risks from drainage exist, it also has the potential to be scaled up nationally to complement the mapping of wetlands down to 0.05ha, which is required to be completed by 2030 under the NPS Freshwater Management".

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

Restoring biodiversity, beating invasive species

AoNZ'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

We delivered a genotyping workshop to staff at the Centre for Pacific Crops and Trees (CePaCT) in Fiji to help them characterise the diversity of crops such as yam, cassava and breadfruit in their collection, to improve food security.

Changes to alpine vegetation are monitored closely by scientists around the world studying the effects of the climate crisis. This year we compiled the first global dataset of alpine vegetation plot data, which lays the groundwork for better global understanding of climate-change trends in alpine ecosystems.

We made the first report of a tropical fungal disease of macadamia nut, caused by the pathogen *Calonectria pseudoreteaudii*, in Laos. This is important knowledge to safeguard the AoNZ macadamia industry. Macadamia is also related to the native plant rewarewa, which could be a potential host of the pathogen here, especially in a warming climate.

Our researchers have plugged a major knowledge gap by creating a master list of all plants being grown in cultivation in AoNZ – some 225,000 records – and have significantly updated the BiotaNZ database with this information. This is vital knowledge to assist in the importation of plant germplasm into the country under the Environmental Protection and Hazardous Substances Acts.

We have worked with Scion to investigate the role of fungal pathogens in the decline of taraire forests in Auckland and Northland, which have been additionally stressed by recent droughts.

We developed a new, practical method to screen soils and substrates used in enclosures for kiwi conservation to identify the pathogen *Aspergillus fumigatus*, which can cause serious respiratory illness and death in birds. We have also improved our knowledge of the gut biome of captive kiwis vs wild kiwis, and how the gut develops and responds to microbes it is exposed to.

Research is underway to see if the pico beetle (Leptinotarsa undecimlineata)*, native to Jamaica, could help to stop the spread of the prickly pico shrub* (Solanum torvum) *in Vanuatu.*

In other *Aspergillus* work, working with a national and international team of experts we determined that the 2019 deaths of six kākāpō were caused by that fungal disease. Unusually the deaths were caused by a single strain, suggesting that the spores were inadvertently distributed by people rather than naturally occurring. This information is vital to future management of the birds.

We have developed an AI-based biosecurity tool for wasp identification – capable of identifying 57 genera of parasitoid wasps with 96% accuracy. This tool can be used by biosecurity managers to quickly identify wasps from photos so that appropriate action can be taken.

Until 2014, two species of kānuka (*Kunzea* spp.) were accepted as present in AoNZ. Then, kānuka was thought to comprise 10 closely related species. However, a new DNA microsatellite study done by our researchers has definitively shown *Kunzea ericoides* to be a single species in Aotearoa, albeit one with considerable regional variation – which will have important implications for conservation.

Our researchers have challenged received wisdom on the ecosourcing of tree seeds. Advice developed in the 1980s suggested that seeds should be sourced very locally, but this may lead to reduced genetic diversity, vulnerability to disease and other threats. The new recommendations have considerably widened acceptable sourcing areas, and will change the approach to ecosourcing seed for biodiversity restoration projects.

We provided mast seeding advice to DOC about chionochloa (snow tussock) flowering and likely predator increase, based on long-term monitoring. Takahē are more likely to breed in mast years and so this information is of interest to the Takahē Recovery Programme.

Our continuing work in possum control included modelling the required density of traps for Hawke's Bay Regional Countil to achieve predator freedom at the 370-hectare Mahia peninsula, and and monitoring of TB in possums in the Wanganui Valley, West Coast.

We uncovered national-scale long-term change patterns in forest bird populations and, with DOC characterised rodent dynamics across AoNZ forests. Together with new information on stoat management, this information fed into a redesign of DOC's Tiakina Ngā Manu predator control programme.

The native plant *Craspedia diversicolor*, known only from two wild specimens, has been saved from extinction through cross-pollination and growing of the resulting seedlings at our Lincoln site, before replanting at two reserves near Ashburton.

Myrtle rust, caused by the fungal pathogen *Austropuccinia psidii*, infects plants in the myrtle (Myrtaceae) family. In AoNZ, Myrtaceae include some of our most iconic trees, pōhutukawa, mānuka, kānuka, swamp maire, ramarama, and rōhutu. Through monitoring efforts, myrtle rust infections were found on pōhutukawa trees in Auckland at unprecedented levels in summer 2022/23, as well as on Rangitoto Island for the first time. At the inaugural Australasian Myrtle Rust Conference, researchers from AoNZ and Australia, where the disease has been established for several years, shared information on the pathogen's genome and long-term management strategies including germplasm conservation of affected species.

At the beginning of July 2022 Manaaki Whenua and Predator Free Rakiura signed a significant research partnership agreement worth a joint $2.8 million over 4 years to work together towards ridding Rakiura/Stewart Island of all major predators – possums, rats, feral cats and hedgehogs. In October 2022, research priority-setting began between Manaaki Whenua and Te Puka Rakiura Trust. Manaaki Whenua will provide $350K per year over the next 4 years of the project to undertake the fundamental underpinning science. This funding will be matched by Te Puka Rakiura Trust.

Innovation stories

Natural enemies, natural solutions

Eight countries in the Pacific will introduce natural enemies in order to reduce the impacts of key weeds in the island nations under the umbrella of Manaaki Whenua's 'Natural Enemies – Natural Solutions' (NENS) programme.

The Cook Islands were the site of the first major release of biocontrol agents, specifically for the African tulip tree (*Spathodea campanulata*). Introduced to many Pacific islands as an ornamental plant, the trees pose a huge threat to island biodiversity across the region. Native to tropical Africa, this fast-growing, evergreen tree infests rainforests, out-competes native vegetation, and affects agricultural production.

Biocontrol agents include African tulip tree flea beetles (*Paradibolia coerulea*) and gall mites (*Colomerus spathodeae*),

which are both specialist natural enemies of the African tulip tree. The beetles feed on the leaves and the mites form leaf galls, known as erinea, which stunt new growth. Working together, these two natural enemies will reduce this invasive tree's competitive ability. This work is being undertaken with assistance from the National Environment Service, the Ministry of Agriculture, and members of the Te Ipukarea Society and the Natural Heritage Trust. The mites have also been supplied to Tonga and Vanuatu.

African tulip tree was also determined to be the top priority for Fiji, where the NENS team of Lynley Hayes, Dr Quentin Paynter, and Temo Talie ran a weed prioritisation workshop with representatives from a range of government and regional institutions, including Fiji's Biosecurity Authority, the Department of the Environment, The Pacific Community, the University of the South Pacific, and Fiji National University. Staff at the Ministry of Agriculture at Koronivia Research Station, in Suva, will support the work needed to import, mass rear, and release the African tulip tree mite and beetle.

While delivering the African tulip mites to Vanuatu, Manaaki Whenua researchers also visited the Vanuatu Agricultural Research and Technical Centre to view trials of conventional control of wild peanut (*Senna tora*) and to provide training on photo analysis software. This work will help farmers while natural enemies are being sought for this key pasture weed.

The NENS team has also begun research and risk assessments into the shrub S*olanum torvum* (sometimes known as pico), a prickly, impenetrable shrub which is having a major impact on the beef industry in Vanuatu.

Our molecular study has shown that populations of *S. torvum* in the Pacific are genetically very similar and originate from the Antilles, confirming the Caribbean to be the best place to look for natural enemies. Testing of a pico beetle (*Leptinotarsa undecimlineata*) obtained from Jamaica has been successful, and an import risk assessment is now being prepared for Vanuatu.

Arnaud Cartier checking African tulip trees reared in the insect quarantine facility. Image: Johannes Van Kan.

The right tree in the right place? A major economic tree species poses major ecological threats

Radiata pine (*Pinus radiata*, or Monterey pine) is native to North America but is one of the most widely planted tree species in the southern hemisphere. It had naturalised in AoNZ by 1904.

At present, radiata pine is by far the largest contributor to AoNZ's forestry industry, comprising 90% of the total plantation area. It supplies most domestic wood products, and is the third largest export earner, contributing around 3% of GDP.

Dr Peter Bellingham of Manaaki Whenua and colleagues have reassessed the prevailing view, stemming from the late 1980s, that radiata pine is only a minor invasive species in New Zealand. Thirty years on, the researchers undertook the first comprehensive review of where invasive radiata pine occurs in AoNZ, and evaluated whether climatic conditions are suitable for radiata pine to invade nationally.

The modelling showed that up to 76% of the land area of AoNZ is climatically capable of supporting radiata populations – only the very coldest and wettest areas are unsuitable. Plot and site data from the National Vegetation Survey database showed that radiata pine occurs far more widely across AoNZ than previously appreciated. It has invaded grasslands and shrublands, but also some forests. It has invaded

ecosystems mostly below 1000 m altitude, including revegetating landslides, down to sea level, where it was historically planted to stabilise sand dunes. Notably, it has often invaded areas of lower-statured vegetation, and at least three classes of naturally uncommon ecosystems: geothermal; gumlands; and inland cliffs, scarps, and tors. Because of its rapid growth rates and its flammability, it is likely to alter naturally uncommon ecosystems, and it is likely to drastically alter forest regeneration. Abandonment of grazing near plantations also results in more land likely to be invaded.

The researchers suggest that the risk of spread of radiata pine seeds on the wind from existing and new plantations is almost certainly underestimated. They conclude that greater emphasis is needed both on managing current radiata pine invasions and proactively preventing future invasions. They suggest that a levy on economic uses of invasive species to offset costs of managing invasions, alongside stricter regulations to protect vulnerable ecosystems, could help to prevent or avert the future negative impacts of those invasions.

Using artificial intelligence to monitor wildlife

Camera traps (motion-triggered cameras) are used for monitoring a range of wildlife species in AoNZ, including native and invasive animals. These cameras provide essential information on animal abundance, distribution, and behaviour, but they have one major drawback: they can produce thousands of images, many of which are empty, and which are time-consuming and costly to process.

With funding from Predator Free 2050 and the Ministry of Business, Innovation and Employment (MBIE)'s Kiwi Rescue programme, Manaaki Whenua researchers Dr Brent Martin and Dr Al Glen have developed a free online tool, CamTrapNZ, which allows users to manage their images quickly and easily.

The tool uses artificial intelligence (AI) to identify images of 15 taxa commonly detected by camera traps in AoNZ: kiwi, other birds, cats, deer, dogs, ferrets, goats, stoats/weasels, possums, rodents, hedgehogs, rabbits/hares, wallabies, pigs, and livestock. The model could be trained to recognise more taxa in the future. The software is hosted on TrapNZ, a free online platform widely used for recording pest control, monitoring, and biodiversity outcome data in AoNZ.

The accuracy of species identification depends on the species, and also whether the image is colour (daytime) or black and white (night), says Al. "For example, the AI will detect wallabies around 98 percent of the time, but has much lower accuracy for mice. This is mainly because mice are so small that they often appear as little more than a dot in the images. Accuracy is generally higher with colour images than with black and white ones."

Some species are grouped together because the images captured by camera traps don't always show distinguishing features. Rats and mice are particularly difficult to separate.

The online tool allows users to produce maps, graphs, and other reports of their results. Further improvements to CamTrapNZ are planned, including improved accuracy of species identification, more species, and new software that runs on the user's own computer, without the need to upload images to a server.

Camera trap images showing that accurate species identification can be difficult. From top: ferret, ferret, cat, stoat with rabbit prey, rosella, stoat.

Local extinctions of kākāpō

Kākāpō (*Strigops habroptilus*), found only in AoNZ, are critically endangered, flightless, nocturnal, and the heaviest parrots in the world. Kākāpō quickly disappeared from most of AoNZ after the introduction of predatory mammals, and now comprise approximately 250 individuals on three small, predator-free islands.

Kākāpō once ranged throughout the forests of AoNZ. However, early European observers noted the bird population declining rapidly within their own lifetimes and speculated this was due to packs of feral European dogs and other mammal predators.

A new study designed to better understand the dynamic processes of extinction, has shed new light on what led up to the near-terminal decline of kākāpō. Dr Jo Carpenter and her co-authors Dr Janet Wilmshurst (Manaaki Whenua) and Prof George Perry (University of Auckland) used a unique combination of fossil and recent (post-1769) historical records to examine how kākāpō distributions changed through time.

These data were used to predict the kākāpō's likely local extinction dates, which were between 1936 and 1959 in the North Island, and between 1990 and 2006 in the South Island – a time lag of around 31-70 years. The researchers explain this time lag as resulting from different prehistoric hunting and predation pressures, and extents of habitat transformation on the North and South Islands.

In the historic era, packs of feral dogs appeared to be a less important driver of kākāpō decline. "Our analysis of more than 100 geo-referenced newspaper and scientific reports shows the distribution of kākāpō and feral dog packs did not overlap strongly anywhere, suggesting they did not frequently interact," says Jo. "Kākāpō also persisted in the South Island for up to 70 years after the last noted observation there of feral dogs in 1913."

Conversely, the explorers were right about the European-introduced stoats, possums, cats, Norway and ship rats, which have been a much more important contributor to kākāpō decline since European arrival. "These animals would certainly have been the coup de grâce for this species if the birds hadn't been rescued from the wild," says Dr Wilmshurst.

Ancient diets revealed by kākāpō scats

Our researchers have also revealed the most comprehensive analysis of prehistoric kākāpō diet ever performed.

Kākāpō now depend on the production of rimu fruit to breed, which only happens every two to five years. This breeding cycle creates problems for kākāpō conservation, especially since rimu don't occur in all of AoNZ's forests. However, fossils show that in the past, kākāpō were abundant and lived throughout AoNZ. The kākāpō niche must have therefore been much broader in the past than today.

A collaborative effort between Manaaki Whenua, the University of Auckland, and the University of Adelaide, used cutting-edge ancient DNA techniques and microscopic techniques to investigate what plants kākāpō were eating in ancient AoNZ. They did this by looking at kākāpō coprolites (preserved droppings), which have been found in caves across the South Island.

Surprisingly, the research showed that kakapo lived and bred in beech forests and were not purely reliant on rimu masting to survive and breed. The birds ate a wide variety of plants including mistletoes and fungi that are not in their diet today, a direct result of their heavily contracted population now restricted to a handful of managed populations on offshore islands.

"This work has come at a critical time for kākāpō conservation" says Dr Janet Wilmshurst. "The kākāpō population is increasing, and their islands can't sustain them for much

Principal Scientist Dr Janet Wilmshurst searches a cave near Lake Wakatipu, Otago, for ancient DNA samples. Image: Brad White.

longer. Our work suggests that southern beech leaves and seeds were major kākāpō foods in the past, which is a big surprise since kākāpō hardly ever eat beech today. This means that beech forests are probably ideal habitats for kākāpō."

Do native birds have enough to eat in mountain forests?

With native forest bird species in AoNZ under threat from introduced mammal predators such as possums, rats, and stoats, the ranges of many native forest bird species have contracted to cooler, higher-elevation tracts of forest that support fewer introduced mammals. However, while the birds are escaping predators, higher, cooler elevations have less food available, potentially leading to lower survival or breeding success.

Dr Anne Schlesselmann and her Manaaki Whenua colleagues recently undertook the first study to look for an elevational gradient in reproductive success for AoNZ birds, as part of the MBIE Endeavour research programme 'More Birds in the Bush'.

Being able to determine the factors that limit populations in this way is fundamental for effective conservation management of AoNZ's threatened bird species. If places with optimal conditions can be identified, these can be targeted for predator control and lead to faster recovery of dwindling bird populations.

In spring and summer 2020/21, working at six sites at each of three different elevations on the sides of Pirongia Mountain, the researchers sampled invertebrate prey while simultaneously monitoring the fate of 55 tītitipounamu/rifleman (*Acanthisitta chloris*) nests and 33 miromiro/tomtit (*Petroica macrocephala*) nests, and the number of fledglings produced by each. Camera traps and tracking tunnels were used to monitor predator numbers.

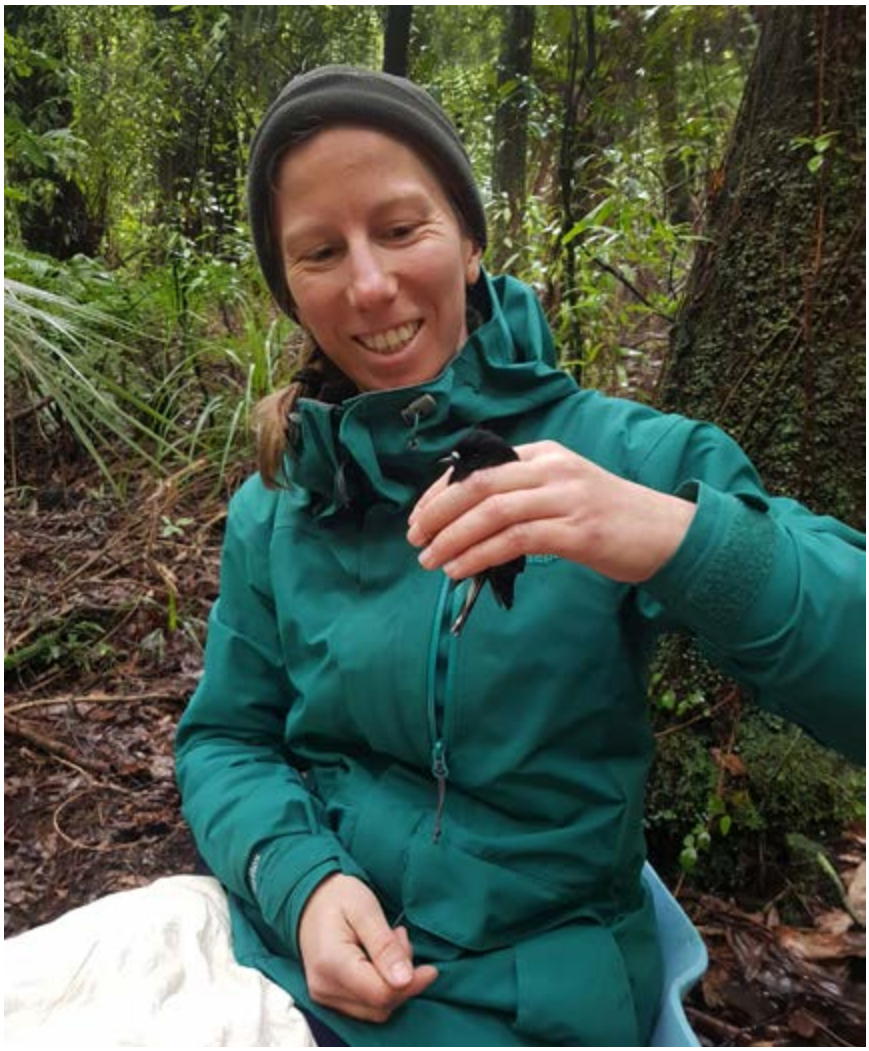
Mammal predators are routinely suppressed on Pirongia Mountain. Rats and possums do not only eat birds, but also the same food as native birds. Hence, only when rats and possums are at low numbers is it possible to investigate whether there are environments that are intrinsically more productive for birds, such as low-elevation forests.

The results from the 18 sites somewhat supported the theory that there would be less invertebrate food available for the birds at higher elevations and that their reproductive success would be lower as a result. In general, though, nest survival and number of fledglings produced by tītitipounamu and miromiro were not strongly related to elevation or food availability. Understanding differences in survival will be the next step to better understand food limitations.

Core blimey: how an old Hoover revealed the secrets of a wetland

East Coast farmer Tim Brownlie and QEII National Trust regional representative for Gisborne Malcolm Rutherford have become fascinated by the world of palaeoecology – the ecology of the past.

Malcolm approached researcher Dr Janet Wilmshurst from Manaaki Whenua's Long Term Ecology Laboratory about a wetland area on Tim's farm. The lab specialises in reconstructing past ecosystems and former species interactions using microfossil and molecular analyses.



Dr Anne Schlesselmann with a kakaruia / black robin, Petrioca traversi.
Image: Archie Macfarlane.

Janet suggested Malcolm collect a few samples of peat from the wetland to get the research started. He and Tim hammered an old vacuum cleaner tube into the ground on the edge of a newly fenced and covenanted wetland.

Janet received a nicely 'vacuum-sealed' core she could analyse under the microscope. "Pollen analysis provided us with a list of at least 43 pollen and fern spore types," she says. "This included podocarp trees such as rimu, miro and tōtara, as well as numerous broadleaf trees and shrubs that made up the canopy, including maire, pōkākā, māhoe, akeake, rewarewa, kohekohe, and nīkau."

She also recorded the presence of tree ferns, climbers, perching plants, parasitic plants, and ground ferns. "It's a huge increase from the 11 known native species from the wetland today."

Janet says one of the most exciting finds was pollen of te pua o te rēinga (*Dactylanthus taylorii*), or the wood rose, a semi-parasitic and now nationally threatened plant that grows as a root-like stem attached to the root of a host tree. "Its distinctive pollen is rarely found in the pollen record, but I have recorded it before in pre-human sediments from Lake Tūtira."

Janet's analysis suggested the site was formerly a shallow lake surrounded by tall forest rather than a wetland. Because there were no signs of charcoal in the samples, the sediments probably started accumulating in the pre-human era between 3,000 and 1,000 years ago.

Janet compared the pollen spores from Tim's Frasertown farm with records from other regions in Gisborne and the Hawke's Bay. "Pollen records show us what the vegetation was like across New Zealand long before people arrived," she says. "Understanding what plant species survived and flourished in an area in the past is a good reference point for informing current land-management decisions."

Dactylanthus taylorii*, or the wood rose. Image: Marti, CC BY-NC, via iNaturalist.*

Northland ngāhere mapped to help kaitiakitanga efforts

Russell Forest on the east coast of Te Tai Tokerau/Northland is a diverse native ngāhere (forest). Researchers say it is an important example of a warm temperate rainforest in the region as it contains kauri, taraire, tawa, and tōtara along with threatened bird species, including the North Island brown kiwi.

The ngāhere covers over 11,000 hectares between the Bay of Islands and Whangārei, and comprises mostly forest and small areas of shrubland and mangroves with highly dissected topography and steep valley slopes.

Māori have been working on a kaitiakitanga plan for safeguarding and restoring this ngāhere after years of disturbance from logging, fire, and invasive pests following European colonisation.

Manaaki Whenua researchers including Dr James McCarthy and Dr Peter Bellingham partnered with a group, 'Te Roopu for Russell State Forest,' made up of nine hapū and marae surrounding Russell Forest to map the vegetation and bird life for a better understanding of where to focus their key kaitiakitanga efforts.

In the project, funded by MBIE Vision Mātauranga and SSIF, researchers mapped over 5,000 hectares of the ngāhere. To do this, teams including Te Roopu kaimahi (staff) conducted field surveys of vegetation and birds in key areas surveying 106 plots. At each plot, the vegetation was measured by determining the canopy cover of all plant species present in fixed-height tiers. Birds were tallied in two 5-minute bird counts per plot (to allow comparison with earlier surveys of the ngāhere from 1979 and 1993). Birds were also measured using acoustic recorders and camera traps at 11 locations along with detecting pest mammals.

These data were then modelled across the area to create a baseline map of vegetation and biodiversity within the ngāhere. The results and maps were shared with Te Roopu at a recent wānanga alongside a report to contribute to the 20-year Russell Forest Health Plan for long-term kaitiakitanga to maintain and enhance the ngāhere. The project was supported by Northland Regional Council, Massey University and DOC.

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

A system-wide collaboration to address the challenges of protecting our nation's unique biodiversity

National Science Challenges take a collaborative approach to solving some of AoNZ's biggest societal issues. They are mission-led, collaborative and connected across sectors to create impact from research and provide new approaches to tackling national science priorities.

Manaaki Whenua is proud to host New Zealand's Biological Heritage National Science Challenge (BioHeritage Challenge), one of New Zealand's 11 National Science Challenges (NSCs). We also contribute to Our Land & Water; Deep South; Resilience to Nature's Challenges; Science for Technological Innovation; Building Better Buildings, Towns and Cities; and Sustainable Seas. Working with the NSCs allows us to increase the impact of our research across our four ambitions through effective collaboration and adding value – solving national-scale problems for the benefit of Aotearoa.

The mission of the BioHeritage Challenge is to reverse the decline of our biological heritage by protecting and managing biodiversity, improving biosecurity and enhancing resilience to harmful organisms.

To do this, they facilitate national collaborative approaches and have a strong commitment to partnerships, including honouring Te Tiriti o Waitangi and working with local communities. Working across the science system enables better outcomes for AoNZ's precious environment and taonga species.

BioHeritage is strategically focused on three impact areas:

- Whakamana – Empower
- Tiaki – Protect
- Whakahou – Restore

In addition to their seven original research programmes, the BioHeritage Challenge also leads Ngā Rākau Taketake (NRT) – a four-year research platform finding new solutions for the management of kauri dieback and myrtle rust. They have also launched an additional three strategic investment areas, with the aim of filling current gaps in the science system.

Recent BioHeritage Challenge successes:

- The launch of Me Tū ā-Uru: an action plan that presents a vision for a healthier natural environment, and for healthier long-term human and environmental relationships.
- Ngā Rākau Taketake research theme 'Mobilising for Action' had a special issue of the journal *Knowledge Cultures* dedicated to their work – featuring 14 open access, peer-reviewed articles.
- The production of nine e-learning modules from the Farming with Native Biodiversity pilot project. These modules provide free advice to farmers about how best to protect and enhance the native biodiversity on their land. This was a collaborative project between NZ Landcare Trust, Silver Fern Farms, the Living Water Partnership (Fonterra and DOC) and the BioHeritage Challenge.

- Researchers found both sexual and asexual methods to successfully propagate maire tawake (swamp maire; *Syzygium maire*) – a notoriously difficult plant to propagate and one that is at risk of extinction.

- The 'Eco-index' research programme became the first in AoNZ to gain international Digital Public Good certification.

- The publication of '*When the Crown controls mātauranga*' – a report on a survey of Crown policies, programmes, legislation, funding, and impact assessment relating to mātauranga Māori. This was followed by a webinar that attracted 410 registrations from 92 different organisations, with 190 people joining live and 270 people watching the recorded session.

Partnering for impact: our support for the BioHeritage Challenge

As host to the BioHeritage Challenge, Manaaki Whenua provides premises and administrative support such as IT, human resources, legal and finance. We also align significant amounts of our research effort, which contributes to the collective success of the Challenge mission.

Finishing well: the last year of the National Science Challenges

The National Science Challenges are preparing to wrap up at the end of June 2024. In doing so they can reflect on, and celebrate, everything they have achieved over the past decade. The Challenge is in awe of what their teams have accomplished by collaborating far and wide across the motu and putting Te Tiriti o Waitangi first at every level.

The last year will focus on communicating research results to the communities who need them the most. By giving these communities the tools to utilise this knowledge, BioHeritage will maximise the impact of their research, which has been the end goal from day one.

BioHeritage Challenge parties

Including Manaaki Whenua as host, 18 organisations formally partner to create the BioHeritage Challenge. They are: AgResearch, Auckland University of Technology, 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, Te Herenga Waka – Victoria University of Wellington.

Craig Robertson

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 AoNZ's emissions balance, supporting mitigation, and enabling adaptation and resilience to climate change. Our research has supported AoNZ'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. Increasingly, Toitū members are offsetting their emissions to become carbon-zero.

Selected highlights

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Primary industry stakeholders have been interested in our finding that whilst diverse pastures emit 39% less nitrogen oxide (NO_x) than standard ryegrass-clover pastures, there's a catch – the ryegrass-clover is a net CO_2 sink whereas diverse pastures are CO_2 neutral, meaning that net emissions are higher from the diverse pastures when the CO_2 and NO_x results are combined, the opposite to what many had previously assumed.

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Surveying climate beliefs in AoNZ's primary sector, we discovered that 88% of respondents believe in climate change, but only around half of them have views on future drought and future temperatures that match IPCC projections. Nonetheless, belief in climate change is positively associated with proenvironmental action in the primary sector.

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Our recommendations on the risks and opportunities associated with including soil carbon in a farmlevel greenhouse gas pricing system, based on a summary of decades of research, were provided to He Waka Eke Noa. We also provided economic analysis of a range of policy scenarios to MfE and MPI for the pricing of agricultural greenhouse gas emissions.

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We worked with Environment Canterbury and DOC to explore spatially explicit pathways to achieve climate adaptation in the Mackenzie Basin and passive afforestation on Banks Peninsula.

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Our social scientists surveyed the diversity of organic waste management in Auckland, Wellington and Christchurch in relation to reducing and managing organic waste to help meet climate change mitigation targets.

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Dr Andre Eger and others analysed rates of chemical weathering of rock in the Southern Alps as part of current attempts to understand and to harness this natural process to mitigate global warming.

Flooding on Awatoto Road and Erikson Road in Awatoto, Napier, March 2023. Image: John Cowpland.

Innovation stories

Towards local-parallel scenarios for climate change adaptation

We live in an already complex world, to which climate change is rapidly adding an extra layer of complexity. Communities and societies are increasingly having to adapt to climate change, but the unpredictability of change makes it very difficult to plan for future responses at any scale.

To address this problem, scenario planning is commonly used to explore potential impacts, assess vulnerability of populations, and identify their adaptation options. The 'global-parallel' method, as used by the Intergovernmental Panel on Climate Change (IPCC), is one example. It creates projections of the effects of climate change for specific regions, using consistent global datasets of, for example, greenhouse gas emissions and population growth, set within a variety of policy options.

In developing such scenarios, however, there is a challenge in moving from the global scale to the national and local scales in a way that connects and explains complex systems in meaningful, trusted ways for stakeholders such as farmers and other rural business people.

In response, using the West Coast as a testbed, Dr Nick Cradock-Henry and Dr Gradon Diprose of Manaaki Whenua worked with former Manaaki Whenua colleague Dr Bob Frame to develop a novel 'local-parallel' method that might be applied across other regions.

At the heart of the approach was the co-creation of contemporary, locally specific yet globally connected knowledge about the likely effects of climate change on farm management on the West Coast. This was achieved by interviewing a wide range of local business people and thought leaders – from doctors and clergy to writers and artists – both formally and informally, to discover their lived experiences, and researching easily relatable documents and visual cues such as local photographs, maps, and opinion pieces from local newspapers.

At a pair of workshops attended by West Coast farmers, the team then presented global and national trends in climate adaptation for two scenarios, a low emissions scenario and a high emissions scenario, alongside the local stakeholder knowledge.

The researchers showed that the local-parallel approach, with its additional components of locally specific knowledge, helped make the climate change scenarios appear as accessible and credible representations of plausible local futures.

Is my paddock carbon-neutral? How our scientists contribute to understanding global climate change

Measuring fluxes, the uptake or release of gases from a surface, is a crucial part of climate science. A method known as eddy covariance, first developed in the early 1950s, is today used by scientists worldwide to measure the carbon, water and energy flows between ecosystems and the atmosphere.

This science is becoming more and more sophisticated. As gas gets exchanged at plant or soil surfaces, it is transported vertically by turbulent eddies. Instruments placed on towers above the surface can measure these eddies, which then allows the fluxes of carbon dioxide, water vapour and other gases to be calculated.

Improvements in technology and data processing power have allowed these flows to be measured and modelled in ever-increasing detail and has led to the development of a global network of about 1000 flux towers known as FluxNet.

Fluxes of nitrous oxide and methane can also be measured, which is important to help New Zealand's agricultural sector to assess the effect of different management options on total greenhouse gas emissions.

OzFlux, which counts Manaaki Whenua as a partner organisation, is part of FluxNet. The OzFlux network was set up in 2001 to provide Australian, AoNZ and global researchers with consistent flux data for Australia's and AoNZ's unique ecosystems. Since then, it has matured into a network that provides relevant and robust data and information on ecosystems for researchers, resource managers and policy makers, with an important emphasis on data sharing and integration.

This underpinning science is vital to enable climate-smart future land management. It demands continuity of data collection over many decades.

Some OzFlux sites, particularly in AoNZ, have been dedicated to investigating the net carbon gains or losses (including carbon dioxide as well as imports and exports) of pastoral agriculture and from conversion of pasture to forest. Two teams participating in OzFlux, at Manaaki Whenua in Lincoln (including Dr Johannes Laubach) and at the University of Waikato, operate sites to determine net greenhouse gas balances of grazing systems and to test mitigation approaches. Manaaki Whenua scientists in Palmerston North (including Dr Miko Kirschbaum) use these data to model the underlying processes.

Adélie penguins on ice near Cape Bird, Antarctica. Image: Susanne Anderson.

Future development of the network will include further integration of the tower stations with remote sensing technologies; more research about how soil processes contribute to the fluxes, including how soil moisture affects plant transpiration; and exploration of how changes in land use or management impact net greenhouse gas emissions.

Adélie penguins, climate change and fisheries management

As a harbinger of change, Antarctica's Adélie penguins make the perfect subjects. They are an ice obligate species and are highly sensitive to the abundance and distribution of their primary prey – krill and fish.

Manaaki Whenua researcher Dr Dean Anderson says Adélie are a sentinel species because changes in their behaviour or population dynamics are indicative of changes in climate (which can be seen in the ice) or fishery management. At Cape Bird, where Dean and his team do their research, about 80,000 birds return every year to nest and breed, from around the start of summer in late October.

During the Antarctic summer Dean and the team attach GPS telemetry units to the backs of breeding adult penguins. The data show how far and where the birds are travelling to feed relative to ice and prey abundance.

Following the breeding season, adult penguins and newly fledged chicks migrate north over a period of about 8 months. During this period, the penguins need to fatten up and gain strength to prepare for the following breeding season. To do this they need to find 'primo Adélie luxury spots', where they have access to water, high prey abundance, ice, and daylight (they need to see to forage). This can require a round trip of 14,000 km.

To learn where the penguins migrate, Dean and the team deploy small light-reading devices on the ankles of breeding adults. The information gained provides an understanding on how climate change and fisheries may impact survival and behaviour during this critical time.

The next steps in the project are to start using remote sensing to start monitoring the size of penguin breeding colonies across the Ross Sea. The data feed into a model that can show whether population changes are natural fluctuations or due to deviations in sea ice or prey abundance, which would be indicative of the effects of climate change or fisheries management.

Dean says 3 years of data so far have given a good baseline of relationships between ice conditions and fisheries practices. "The Ross Sea is in a marine protected environment, but it's only set in place for 35 years. We really need a scientific basis for making decisions on what happens to it after that."

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

Toitū's purpose is to help organisations shift their impact on the climate and environment from negative to positive at pace, thereby supporting AoNZ's commitment to achieve net carbonzero by 2050. As a subsidiary of Manaaki Whenua, Toitū is truly purpose led and genuinely driven by impact, not profit, by collaboration, not competition. Our roots are, and always will be firmly based in climate science – which is a true differentiator for Toitū, and our standards-based programmes and services reinforce our status as market leading experts. We have over 20 years of experience working with a wide variety of organisations to help them measure, manage, and reduce their emissions and impact on the environment, in accordance with international standards and best practice science. We intend to leverage this expertise, experience and mana as we deliver our strategic and transformation goals.

This has been another year of strong growth for Toitū, with total revenue up 42% on 2021/22 and most of the growth driven out of the agriculture, manufacturing, professional and scientific services, and public administration sectors.

A total of 707 carbon programme certifications were issued in 2022/23, up 45% from 2021/22. An additional 118 Enviromark certifications were also issued. Carbonreduce continues to be our fastest growing, and largest revenue contributing carbon programme. The total volume of emissions certified or verified during 2022/23 was 17.6 million tonnes CO_2e (an increase of 87 percent on 2021/22), and our clients cancelled 262k tonnes of high-quality offsets.

Our people

As a result of growth in our underlying business, and the ramping up of our three-year transformation programme, total workforce numbers continue to increase. Current headcount, at 105, is up 59% on 2021/22. Our new CEO, Teressa Betty, joined Toitū in January 2023, and moved quickly to make significant changes to the organisational structure, ensuring that both the current business strategy and the transformation programme are sufficiently resourced to achieve their respective objectives. Under Teressa's leadership there has also been significant mahi in growing the levels of staff engagement, including rearticulating Toitū's Purpose and Values, development of a comprehensive Wellbeing|Toiora Strategy, the implementation of OKRs (Objectives and Key Results) to measure business performance, and a focused programme of internal communications.

Operational and product development

Toitū continues to monitor international lead practice relating to its areas of focus. Over the past year Toitū has contributed to a number of AoNZ-based consultation requests, covering a range of subjects including the Emissions Trading Scheme (ETS), Climate Related Disclosures (CRD) regime, Beyond Value Chain Mitigation, and AoNZ's second Emissions Reduction Plan (2026–2030).

The past year has seen significant focus on developing the next version of Toitū's carbon programmes (carbonreduce, net carbonzero, climate positive). With carbon programmes accounting for over 80% of Toitū's revenue, it is important that they reflect the latest international best practice. These enhanced programmes will include requirements for full Scope 3 emissions measurement, along with more stringent science-aligned reduction targets. We are also planning to have a digital version of these programmes fully live and functional by the end of 2024/25. There has been increased demand for education and training, and formalising / packaging this component of our advisory work is well underway – indeed, it is a core component of Toitū's strategy.

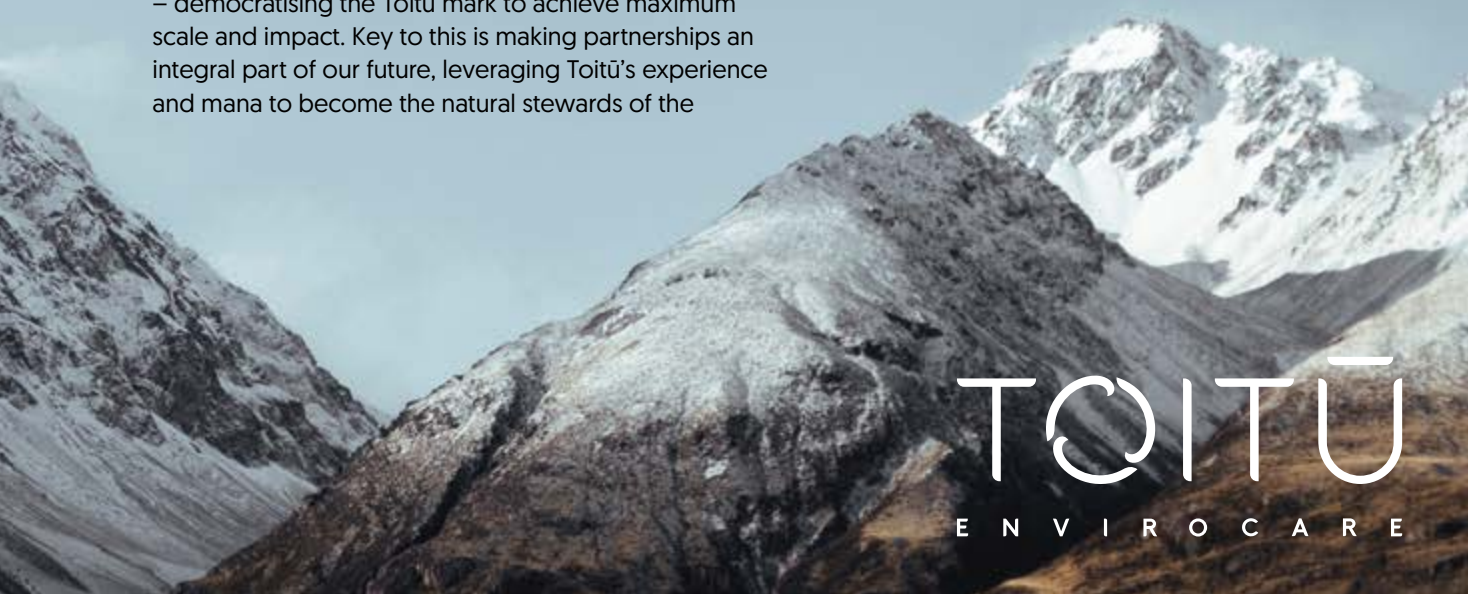
Education and partnership engagement
Driven by consumer demand, investor expectations, regulatory requirements, and heightened business competition, the demand for knowledge in carbon accounting has risen substantially. Toitū has responded to an increasing call for a more sector-specific approach, including hosting an event in March 2023 in relation to the Climate-Related Disclosures regime, featuring experts from Toitū, XRB, and James Shaw, Minister for Climate Change and Associate Minister for the Environment. In addition, with the increase in prominence of Science Based Targets, a comprehensive three-part webinar series was led by Toitū in FY23, in collaboration with the Climate Leaders Coalition.

Belinda Mathers, our Chief Science and Advisory Officer attended COP 27 in late 2022, enabling Toitū to provide real-time insights throughout the event, and as part of our committment to sharing international best practice, we hosted a post-event debrief led by renowned journalist Rod Oram. Toitū also had a strong presence at Fieldays 2023 as the Carbon Reduction Pathway sponsor within the new Sustainability Hub at Mystery Creek. As the agriculture sector grapples with legislative uncertainties, this platform facilitated brand visibility and impactful discussions about immediate actions for tangible change in the primary sector.

Transformation Programme
Toitū's transformation programme comprises three primary objectives – simplify and automate, scale through meaningful partnerships, and digitising our business to ensure simple, cost-effective access for all – democratising the Toitū mark to achieve maximum scale and impact. Key to this is making partnerships an integral part of our future, leveraging Toitū's experience and mana to become the natural stewards of the climate response ecosystem. To do this, we are designing our "Future State" business model to focus on what we are excellent at doing and partnering with others to do the rest. This involves defining tikanga and expectations for the ecosystem to set the tone of collaborative behaviour – recognising that to achieve impact we must focus on, and influence for, "co-opetition" rather than competition, and leverage the unique role that Toitū plays in the market.

The coming 12 months
The market is expected to continue growing at a similar pace to the previous 12 months. However competitive pressures are also expected to grow, with other firms targeting Toitū's clients, as well as looking to attract our highly skilled people. We have a defined and proactive strategy to manage this risk. Notably for 2024/25, we are committed to developing Toitū's Te Tiriti o Waitangi Model, recognising the unique and vital perspectives that Māori culture brings to the preservation and protection of nature and the environment.

Beyond 2024/25 we expect AoNZ's global commitments to climate change, along with other market dynamics, to further increase demand for the products and services of Toitū. Our planned "Future State" business model will ensure that Toitū is able to meet this demand at scale and enable AoNZ's goal of net carbonzero by 2050 to be achieved.



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, NGOs, 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 Western science and indigenous knowledge systems. It supports improved natural resource decision-making in AoNZ 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 annual New Zealand Colony Loss Survey continues to be very well received by the apiculture/honey industry, including by Comvita and Biosecurity NZ, including for its clear communication of main outcomes. Our work has been vital in estimating the costs of winter colony losses for commercial beekeepers, and for indicating the effectiveness and uptake of methods to control varroa mites.

We reached 4000 views of the research website i3, a guide to integrated research concepts and techniques. The site now has 535 users across 27 countries.

We showed that adoption of on-farm good management practices is higher if the farms have a busy road frontage. This effect was higher for dairy farms than for sheep and beef, consistent with higher levels of public scrutiny of the dairy sector.

On our advice, Waka Kotahi is working to reduce their roadside herbicide application amounts in North Auckland, Canterbury and Nelson/Marlborough. Reductions of up to 40-60% may be possible, which is important in relation to social licence to operate.

Our modelling work as part of a team providing advice to the Government has continued this year. Our latest advice was on the BA.5 Omicron COVID wave in July-August 2022 and was used to inform the subsequent response.

Using social return on investment analysis we discovered that $1 of food rescue investment delivers $4.5 of social value. This work was part of the High Value Nutrition National Science Challenge.

Kānuka flowers. Image: Peter de Lange.

Māori frameworks needed to recloak the whenua

In the wake of the devastation caused by Cyclone Gabrielle and the increasing impact of climate change, there is a call to ensure a Māori world view is incorporated into risk assessment frameworks and decision-making processes.

Led by Manaaki Whenua Kaihautū Dr Shaun Awatere, the impact of extreme weather events and climate change on Māori communities is being investigated by a team of researchers focused on a te ao Māori (Māori world view) perspective.

Shaun says during this period of recovery there is a need to ensure Māori are part of the process when it comes to making decisions on replanting, rebuilding, and economic choices concerning their communities.

"There is a need to rebalance the system and ensure Māori are at the decision-making table. For example, they will have views on what should be replanted and where, as well as the importance of certain culturally significant sites that have been lost or damaged. They know and understand their whenua [land]."

Cyclone Gabrielle highlighted the vulnerability of Māori communities on the East Coast of the North Island, as many marae and urupā (cemeteries) are located in coastal, low-lying areas that are prone to flooding and sea-level rise.

"It is mana whenua who understand their whenua and must be consulted and involved in the rebuild in order to ensure the whenua is recloaked for future generations," says Shaun.

Shaun has developed a kaupapa Māori disaster risk reduction framework, which gives mana (value) back to the environment and demonstrates that we are obligated to treat the environment with respect.

"The Māori view is more holistic, relational, and cyclical, emphasising the need for balance. The cosmic forces of mana and mauri provide a powerful yet relatively simple way of understanding risk and vulnerability," he says.

A reduction in risk is achieved through mātauranga (Māori knowledge), whakapapa (connectivity), kaupapa (key issues), community, and tikanga (principles and practices), which provide the knowledge, connections, ethics, scale, and behaviours for reduction.

"Likewise, the framework highlights that resilience can be enhanced through strengthening community, care, capital goods, culture, and control, empowering communities to take the lead on reinforcing their capacity to withstand hazards."

Shaun and his colleagues have also developed the framework He Waka Taurua, which conceptualises a decision-making framework through a te ao Māori lens, with the symbolic waka intended to serve as a Maōri cultural memory retention device.

He Waka Taurua explicitly identifies a te ao Maōri world view and associated values as a distinct and complete knowledge system, separate from a Western science (Tauiwi) world view. This is represented by two hulls, waka Māori and waka Tauiwi, and the hoe (paddles), which represent the tools, actions, and approaches relevant to each world view.

These world views are kept separate from each other, while the papanoho (deck) between the canoes represents a shared or 'negotiated space', where engagement and innovation can occur.

As the recovery and rebuild phase following Cyclone Gabrielle continues, it is hoped these frameworks can be used to empower Māori and create sustainable whenua and local economies.

Aerial photo of tree debris post-Cyclone Gabrielle, Hawke's Bay. Image: Andrew McMillan.

Giving whakamana back to Māori landowners through land science tools

A potential new kānuka industry is emerging thanks to Māori landowners partnering boldly with Manaaki Whenua to better understand their land through a te ao Māori-led approach to using land science tools.

Hikurangi Bioactives Limited Partnership (HBLP) is a majority community-owned entrepreneurial enterprise, set up to create economic opportunities for the communities of the Waiapū valley in the North Island. It is currently working with 14 Māori landowners to commercialise the bioactives in taonga species. Kānuka oil is the first product in the pipeline.

The Māori directors, staff and partners in HBLP and the Hikurangi Group predominantly identify as Ngāti Porou. Their activities are focused on the rōhe of Ngāti Porou.

From macadamia, kānuka, sheep farming and even blueberries under cover – the enterprise is rich with thriving resources and the potential to work with the whenua in ways that deliver to landowner aspirations.

Manaaki Whenua Kaihautū Dr Nikki Harcourt has worked closely with Māori in the region to understand their ambitions, then worked to uncover the characteristics of their land to help kaitiaki make decisions that will ensure good biodiversity on the land.

"There is a critical need for Māori communities in the Waiapū valley to feel connected to the science and innovation system. "In kaupapa Māori methods, knowledge sharing is most effective when skilled experts work alongside communities, and landowners/hapū can learn – and be motivated to use – scientific skills and processes."

Nikki and her team have achieved this using Manaaki Whenua tools such as S-map and WhenuaViz.

S-map is designed to help landowners understand soil type – its depth, stoniness, texture, and its capacity to hold water, and WhenuaViz is a visualisation tool for Māori landowners to access biophysical information about their whenua.

"Our core kaupapa is giving whakamana (empowerment) back to Māori landowners.

"We gather the data that they want, and for their purposes so they can achieve success for their land and for their people."

Ecosystem services: landscape appreciation and social media

Ecosystem services are defined as the benefits people obtain from natural environments and healthy ecosystems, and measurement of ecosystem services is an important part of policy-making in land management.

Ecosystem services such as pollination, pollution treatment, and food production can be measured relatively easily. However, it is harder to measure much more subjective cultural ecosystem services such as aesthetics or well-being benefits. This issue leads to cultural ecosystem services being overlooked when modelling future scenarios in land management.

In a novel piece of research, Manaaki Whenua's researchers Dr Dan Richards and Dr Sandra Lavorel used social media data – principally geotagged photos – to show where recreational, tourism, and cultural activities are being done, as proxies to infer the value of some cultural services being provided by an ecosystem.

They extracted over 150,000 geotagged landscape photographs uploaded to the website Flickr in AoNZ to develop an indicator of landscape appreciation, using the image recognition software Google Cloud Vision and a machine learning technique known as maximum entropy modelling that is also used to model species distributions. Around 40% of the photographs were defined as landscape appreciation photographs, and over 70% had keywords associated with landscape appreciation.

The researchers then extended the reach of their study, to see whether machine learning could allow social media data on landscape appreciation to inform future planning decisions. How might appreciation of an agricultural landscape change if, for instance, native forest was restored in that landscape, and how might enhancing landscape appreciation have trade-offs with other ecosystem services objectives – such as storing carbon?

The work showed that it is possible to quantify landscape appreciation as an indicator of cultural ecosystem services, and that this indicator can be meaningfully included in future landscape management scenarios alongside other, more familiar, ecosystem service indicators.

However, it was rarely possible to optimise both aspects of ecosystem service value – landscape appreciation and carbon storage – at the same time. Areas of high landscape appreciation – which tended to be coastal and closer to highly populated areas – did not necessarily gain further landscape appreciation value when increases in forest restoration were modelled.

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 AoNZ'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.

Recognising that wallabies are increasingly escaping containment zones and spreading into new territories, the need for improved control methods is growing. One promising approach is the use of bait stations designed for the specific feeding habits of wallabies. Using trail cameras, our researchers including field technician Emily Lawrence, pictured, tested how wallabies (and other wildlife such as possums) interact with several new designs of non-toxic bait feeder. The work was funded by the Tipu Mātoro National Wallaby Eradication Programme. Image: Graham Hickling.


FFM
AgriLux MAX

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

This year we have attracted and recruited many new research and support staff including from overseas. We are proud of our ability to attract high calibre people to Manaaki Whenua, and we aim to retain as well as attract them.

To this end, we have made a critical investment in in-house leadership programmes via the NZ Institute of Management for all our senior and middle tier leaders.

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.

We also recognise the importance of growing the bicultural capability of all our staff, an essential part of meeting our Te Tiriti commitments. Our Māori Capability Facilitator has continued to play a key role in this through the development of our internal, modular Kia Māia bicultural programme. We are supporting all staff to be confident in delivering their pepeha and mihi, to use karakia, and to participate in waiata. Our Tiriti knowledge programme has been rolled out across senior leaders and is now being delivered to other staff. A vital part of our bicultural programme provides support and guidance on being manuhiri – equipping tangata Tiriti to arrive as guests in knowledge processes, acknowledging and working through mistakes, cognisant of power imbalances, and aiming to build better relationships with tangata whenua.

Employee Experience staff survey results

We achieved a 78% response rate to this year's Employee Experience Survey. This survey helps us understand the overall experience for our people at Manaaki Whenua.

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.) – 69% (2021/22 = 74%)
- I feel included at this organisation – 74% (2021/22 = 76%)
- Diverse perspectives are valued at this organisation – 65% (2021/22 = 72%)
- I feel comfortable being myself at work/with my colleagues – 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. We continuously seek to mitigate risks inherent in our work in laboratories, on our sites, and in our fieldwork in remote locations.

We have continued to support the health and well-being of our employees through our Manaaki Tangata wellbeing programme, providing a monthly focus on different well-being themes including, for 2022/23, physical fitness, mental health, and mindfulness. Manaaki Whenua has zero tolerance for bullying and harassment of any kind.

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, for example as we finally transitioned out of COVID restrictions during 2022 and in dealing with the effects of the extreme weather events of early 2023 on our staff, our sites and our research activities in the North Island.

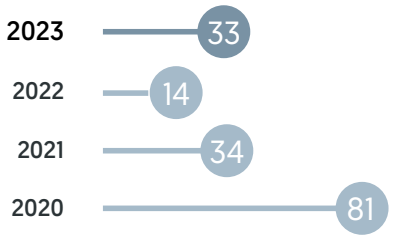
This year we achieved a successful TELARC audit of our Health & Safety systems and processes. The feedback from our auditor was extremely positive, acknowledging the strong health & safety culture we have at Manaaki Whenua and noting evidence of a commitment to continuous improvement. Fully involving our staff in this culture is fundamental: our Health & Safety representatives and general staff contribute their expertise to many groups including in fieldwork safety, laboratory and facilities management.

The aspects of our Employee Experience survey that deal with Health & Safety consistently achieve highly-rated responses from our staff.

Staff from Manaaki Whenua, DOC and Northland Regional Council working in Puketī Forest to understand how tree health is being affected by the combined impacts of myrtle rust, pests such as goats and possums, and climate-change-induced drought. Image: Peter Drury.

HEALTH AND SAFETY

Near misses



Lost-time injuries

Creating an equitable culture

This year we published our Gender and Ethnic Pay report, with an associated action plan to address pay gaps. This is linked to our commitment to Kia Toipoto – a Public Service Action Plan to reduce and ultimately eliminate gender and ethnic pay inequity.

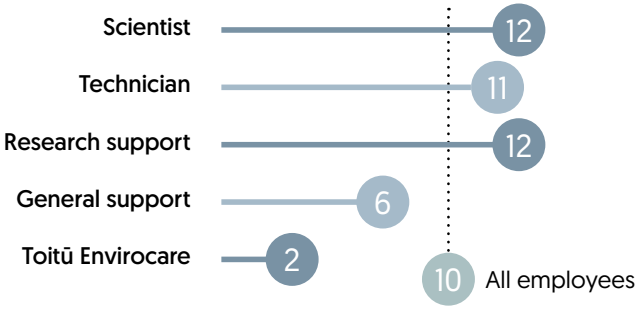
Analysis shows that we do not have a horizontal pay gap issue (like for like at the same grade), but that we do have a vertical pay gap (the differences between salaries for women and men across the organisation). This gap decreased from 16.7% in June 2020 to 14% in June 2022 but rose again by June 2023 to 17.3%. The key driver of our vertical pay gap is the under-representation of females at the senior levels of the organsiation.

We continually review our recruitment and remuneration processes to ensure they support our diversity and inclusion aspirations. Our Māori staff have a median pay gap in their favour of 4.82% compared with non-Māori.

STAFF OVERVIEW

Overall engagement (%)

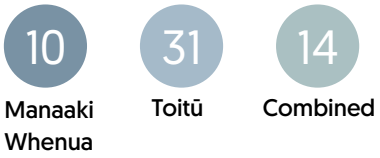
Average years' tenure



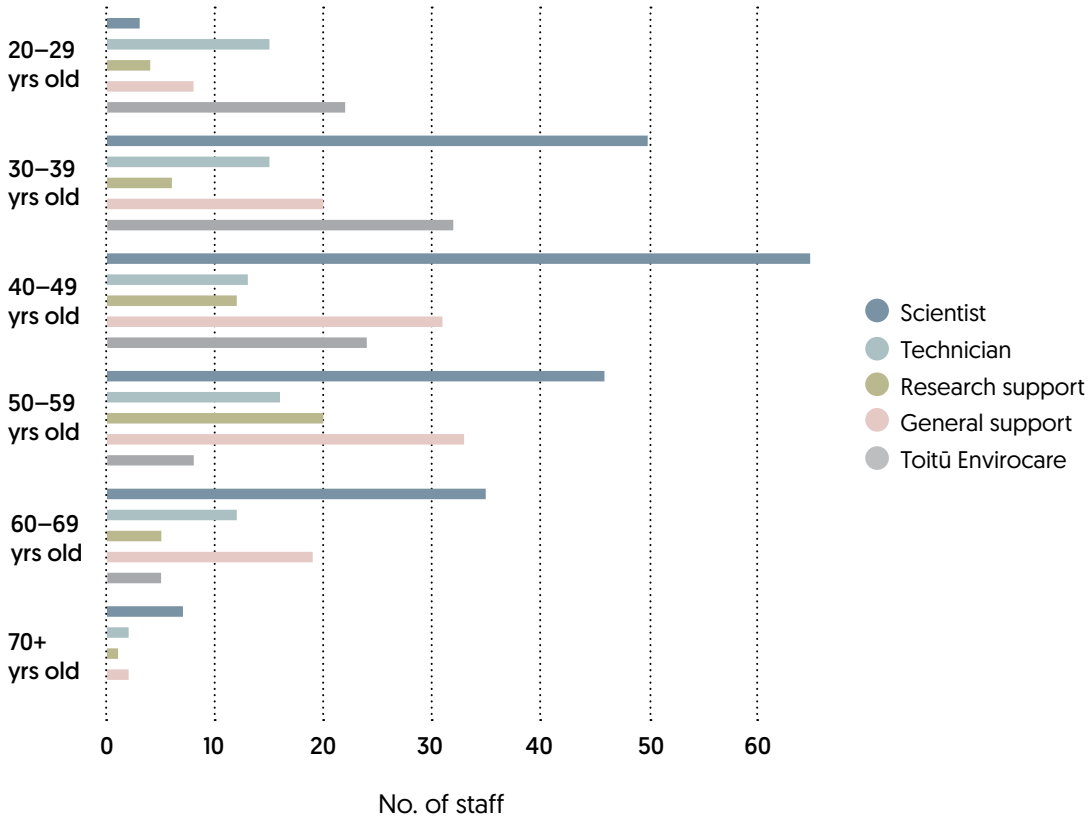
Overall gender distribution*

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

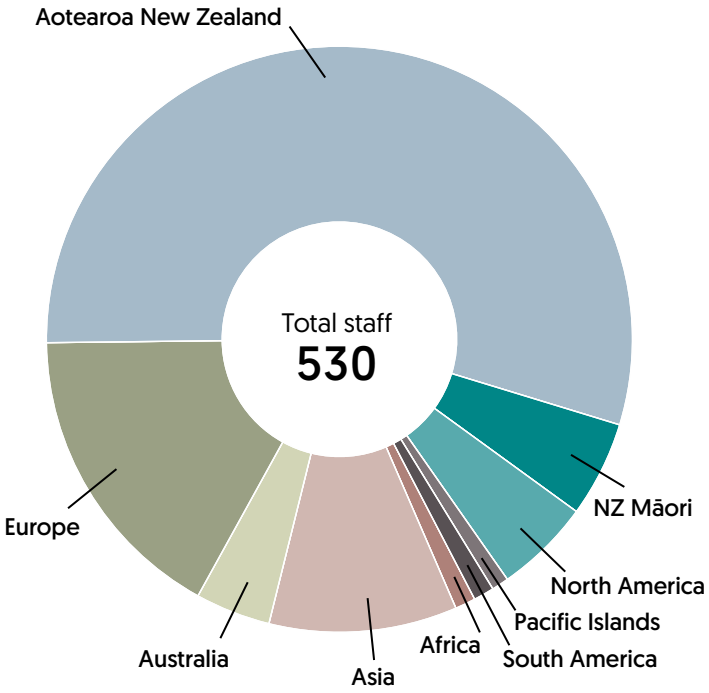
Annual turnover (%)



Age distribution



Origin of our staff



In June-July 2022, we held a variety of events at each of our sites to mark the inaugural national celebration of Matariki. In September 2022 Manaaki Whenua again celebrated Te Wiki o Te Reo Māori (Māori Language Week), encouraging all staff to give te reo a go. Our welcomes to new staff now regularly include powhiri as an integral aspect.

Our Kia Poipoiā Rere (Māori intern programme) has gone from strength to strength in the past 12 months, enabling interns to undertake quality science work in a supportive environment that includes Māori pastoral care. Success is demonstrated by an increasing number of interns (see also page 19). Two of our previous interns are now employees of Manaaki Whenua.

Well beyond a wide range of ethnicities, we celebrate diversity in all aspects of culture and life, including Sign Language Week, Pride Month and Pink Shirt Day, among others.

Building a diverse and inclusive work culture

Building on our diversity of thinking enables us to better understand the needs of our stakeholders and people and respond effectively to them. An inclusive environment means the diverse perspectives we have are more likely to be expressed, heard, and acted on.

Our Diversity and 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. In September 2022 the group held their first in-person workshop post-Covid to assess how we are tracking: the statistics show that Manaaki Whenua is a workplace that attracts, values, integrates, and cares for people of all backgrounds.

An understanding of and empathy for Māori culture is a key part of our Diversity and Inclusion Strategy, and we are committed to the development of our bicultural capability. Our Kia Māia programme aims to achieve a bicultural baseline, providing the resources and tools to support development of our staff.

Judging the Christmas baking competition at our Lincoln site.

Our infrastructure

Our goal is that our collections and databases, property, equipment, and IT infrastructure support excellent research; and that our sites provide great working environments, support our partnerships, and are a base of interaction with New Zealanders.

Selected highlights

We have commenced the Better Business Case to co-locate our Auckland operations to Plant & Food Research's Mt Albert campus. This includes development of a concept design for a shared facility for Manaaki Whenua Auckland staff and Plant & Food's Auckland entomologists.

We have undertaken a 10-year Capital Management planning process to inform an Asset Management Plan and our capital intentions.

Initiation work has commenced on a 3-year project to extend and upgrade Manaaki Whenua's molecular biology and research containment labs to enhance the organisation's capabilities in studying and researching various biological organisms.

We have continued to invest in science equipment and essential infrastructure, including for 2022/23 multispectral drones capable of collecting images beyond visible light spectra, a near-infrared spectrometer for analysis of the chemical composition of soil samples, and a combustion analyser to calculate the carbon and nitrogen content of soil samples.

Top: Megan Petterson in the NZ Arthropod Collection. Image Mel Nickerson. Middle: Dr Bevan Weir in the liquid nitrogen store, ICMP. Image: Mel Nickerson. Lower: Dr Jo Carpenter measuring specimens in the Allan Herbarium as part of a study of long-term plant responses to environmental stress. Image: Kim Triegaardt.

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 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.

Partnership with Māori

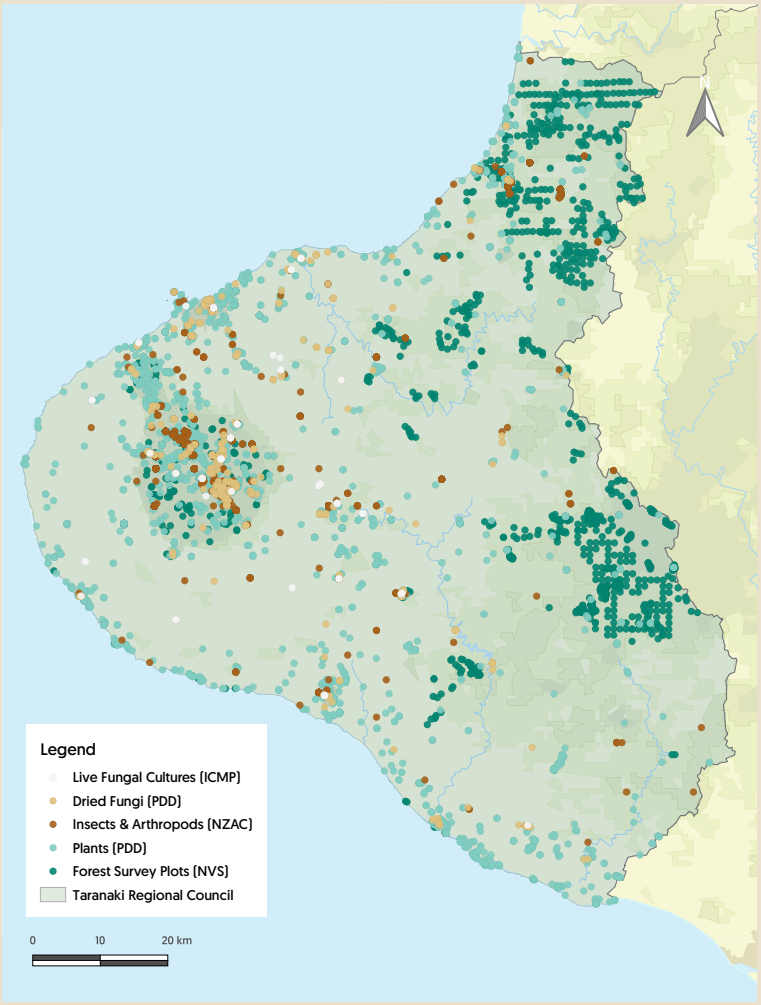
Manaaki Whenua has developed enduring partnerships with selected iwi, groups of iwi, Māori trusts/ incorporations, and Māori organisations. These partnerships support and contribute to our partners' aspirations. We engage regularly with these groups in the spirit of partnership, as expressed in the principles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

Staff at a noho marae event, Taumutu, Canterbury. Image: Sampson Karst.

QGIS Mapping Workshops – a new engagement opportunity for iwi to launch their expertise

Holden Hohaia, GM Te Tiriti Strategy, has released an email to 84 Māori Post Settlement Governance Entities (PSGE) offering free introductory workshops in QGIS (Quantum Geographic Information Systems) mapping and announcing Manaaki Whenua's intention to work with iwi and hapū beyond a business-as-usual transaction-based partnership. The in-person workshops are based on the basics of the QGIS geospatial mapping software. The potential for Manaaki Whenua is that the data used in these workshops could come from the National Vegetation Survey Databank (NVS), Systematics Collections Data (SCD), WhenuaViz and other databases that have relevance for iwi and hapū, thereby introducing some of our back catalogue of data that the organisation holds.



An example of data types available via QGIS.

There is a genuine desire from Māori for geospatial capability and mapping to ilustrate the ecological and geophysical past, present and future states of their whenua, noting that many rūnanga have limited access to mapping capacity (usually one skilled FTE), software licensing and support. Additionally, a number of iwi, hapū and rūnanga, due to relational breakdown with government entities, struggle to access datasets that have been collected on their whenua, and that relate to their people, without necessarily knowing that the data are publicly available e.g. NIWA and GNS data through NeDC and local council data through LINZ.

The overarching vision for these workshops is that they are our opportunity to:

A) promote Manaaki Whenua's databases to iwi/ hapū entities and talk about the potential of these databases at a high level

We expect there should be interest and follow-up opportunities here to pull in our science expertise to support data translation, interpretation and insights of relevant data.

B) support iwi and hapu to develop skills, capability and share knowledge access to data

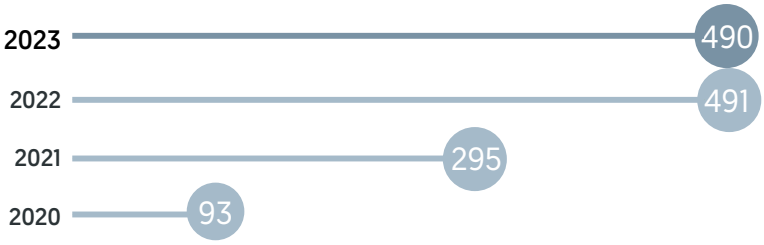
We expect there should be interest and enquiry for follow-up discussion/workshops in relation to the software, upskilling and updates of new databases.

C) promote and invite iwi and hapū entities to our physical biological collections and samples that Manaaki Whenua holds that are relevant to iwi and hapū

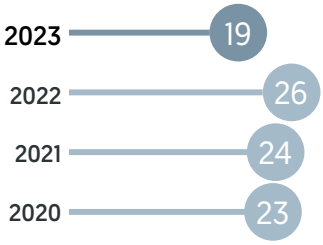
We expect these workshops will be followed up by the Kaitūhonohono as part of the role of connecting iwi and hapū to the collections based on relevance e.g. mahinga or kohi kai, rongoa, mātauranga, cultural significance etc.

VISION MĀTAURANGA PROJECTS

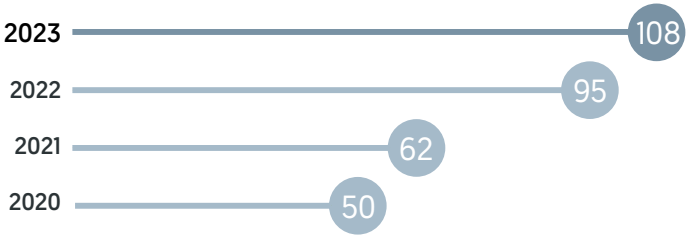
Research specifically relevant to Māori



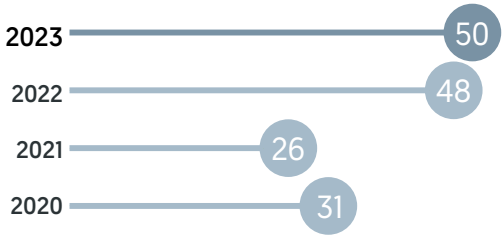
Kaupapa Māori



Research involving Māori

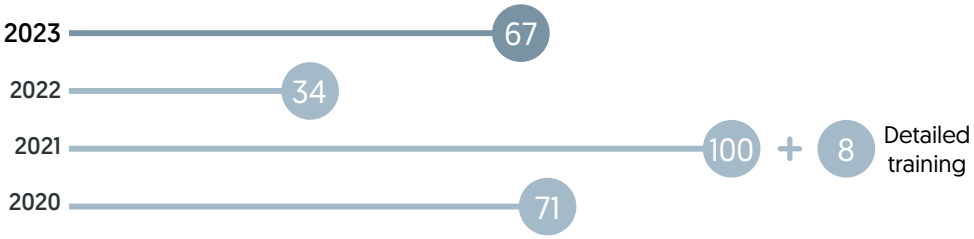


Māori-centred research

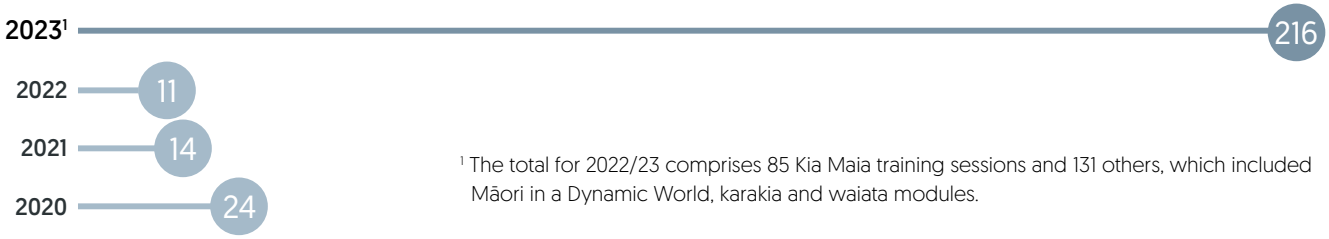


NUMBER OF WORKSHOPS

Treaty workshops



Cultural awareness workshops



[1] The total for 2022/23 comprises 85 Kia Maia training sessions and 131 others, which included Māori in a Dynamic World, karakia and waiata modules.

National partnerships

Local and regional sector partnerships
Collective concerns around land use and forestry in response to Cyclone Gabrielle is driving those council priorities in the affected areas especially demand for SedNet and erosion science. The weather events have changed the landscape for our LiDAR collaboration with Hawke's Bay Regional Council, with some changes to the programme now adopted. We are currently renewing our relationship with Greater Wellington Regional Council and reviewing the MOU with Waikato Regional Council, to continue with them under a Land Futures theme.

Ministry for the Environment (MfE)
and Manaaki Whenua signed a Partnership Agreement in 2019 which outlined a framework for working together and an engagement plan. Broad priorities were set (Capability Development, Land Use Adaptation and Resource Management System)

We delivered a Rapid Land Damage Assessment following Cyclone Gabrielle which provided broad scale estimates of the area damaged in each region to support prioritisation of funding for remediation on the ground. Further conversations – along with GNS and others – were focused on recovery and rebuilding phases including landslide susceptibility modelling.

During the year MfE released *The Freshwater State of the Environment* report, for which we provided data and scientific advice. We have also contributed to their expert advisory panel for Targets and Limits.

Ministry of Foreign Affairs and Trade (MFAT)
Our key relationship for work in the Pacific is MFAT, which has reached out to a number of CRIs to discuss a partnership that will sit outside a single contracting approach. Both the agriculture and climate sectors of MFAT are looking at specific partnerships to drive improved response in the Pacific for social wellbeing under climate change. Currently our main focus in the Pacific is on weeds, seeds and soil with some economic and social research. Funding and impact is restricted largely to one-by-one contracts. With the change in approach to funding and contracting and in-country development, it is anticipated a greater need across multiple portfolios will be required. MFAT recently approved our concept note for Managing Invasive Species for Improved Climate Resilience (MISCCAP), so we are now moving to co-design in country to design a substantive programme to achieve greater impact in the Pacific.

Department of Conservation (DOC)
A collaborative relationship agreement was signed in April 2021; the goals of this instrument are to achieve more relevant targeted conservation research and increase capability, work with iwi and share data.

We have established agreed priority areas for development of research: in 2023 we have been supporting the Predator-Free Programme, new research on ungulate control, scoping work needed for the cyclone recovery and developing biocultural frameworks for implementation of Te Mana o te Taiao. Our partnership with DOC is progressed through portfolio leaders and their counterparts at DOC, with support from relationship managers. Oversight of priorities and other areas of collaboration, in quarterly progress meetings between DOC's Deputy Director Generals and Manaaki Whenua's senior leadership team, ensures strategic alignment and review.

Ministry for Primary Industries (MPI)
We are involved in a range of areas where we are strengthening our relationships within MPI. These include expanding S-map coverage and working on multi-weed

JOURNAL PUBLICATIONS

Average journal citation score of MWLR articles[1]

261 Papers published[2]

[1] Scimago journal ranking.
[2] Web of Science 2011-2023, for financial year 2022/23. 59% (153) of these 261 papers were collaborations with international institutes.

SCIENCE DEN

biocontrol options. We have also established a new partnership with MPI for delivering the research needed for wallaby control in South Canterbury. The NZ Agricultural Greenhouse Gas Research Centre (NZAGRC) is funded by MPI and hosted by AgResearch. Manaaki Whenua's main research interests in NZAGRC are nitrous oxide mitigation, in which we play a small role, and soil carbon, where we are undertaking the first national scale audit of soil carbon stocks in productive land and stock changes through time. We have also contributed to the NZAGRC governance and strategic direction.

International partnerships

Following the signing of a MOU between CNRS/INRAE (France) and Science New Zealand (the CRIs collectively), we have partnered with CNRS for work on land use change for climate change adaptation.

In the period 2022–2023, 39% of our research publications were co-authored with overseas researchers.

Outside Thinking and Brilliant Writing

Outside Thinking and Brilliant Writing is designed to give researchers time to develop new thinking and novel ideas through collaborating both internally and externally, to provide significant mentoring to early-career scientists in writing and critical thinking, and to gain fresh inputs and to challenge our thinking. In 2022/23 we funded one initiative with $150k, 'The role of the microbiome in insect adaptation and invasion', which involved developing new international collaborations with the University of Bern, Switzerland, Leiden University, The Netherlands and the University of Tours, France. This collaboration resulted in a synthesis paper which has been submitted to the International Society of Microbial Ecology journal.

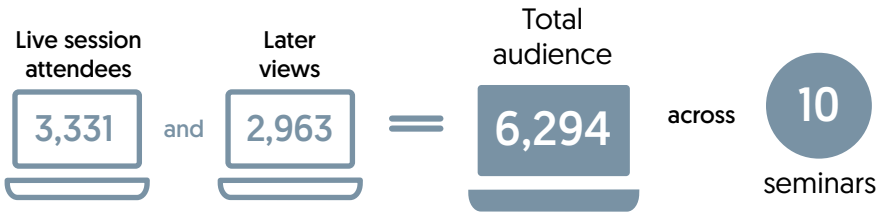
The Science Den

The Science Den is an initiative to support the development of innovative and challenging ideas. The scheme is all about the ideas themselves, not running projects or doing the actual research, because truly innovative research isn't possible without really good ideas in the first place. No ideas are out of scope. Risk-taking is encouraged, and failure is celebrated alongside success if we learn from it and try again. During 2022/23 we funded the development of four ideas:

- Developing a prototype modular conveyor system for rapidly digitising specimens.
- A 'unique model' for protecting and managing taonga and ecosystems.
- Novel approaches to differentiating invasive species.
- Preventing degradation of Māori rock art.

ONLINE ENGAGEMENT

LinkOnline seminars



Manaaki Whenua social media

Facebook likes[1]

10,839 ↑ 2022 9,679

15% ↑ 2022 11%

Increase in audience (all social media channels)

NZ Garden Bird Survey

Facebook Group members[1]

11,426 ↑ 2022 9,289

Instagram likes[1]

1,475 ↑ 2022 1,221

New Zealand GARDEN BIRD SURVEY

[1] Sprout Social media management tool.

Is our research being used by other scientists?

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.

In accordance with the Platform Plan, 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 AoNZ published in 2018-2022 have a citation impact of 1.43. Over this time period, we have had a citation impact of 1.55, slightly behind Auckland University of Technology, the University of Auckland and ESR, and ahead of all the other CRIs and universities.

We have two disciplines (Mycology and Evolutionary Biology) within the top 10% of all organisations globally. A further four disciplines (Geosciences, Entomology, Environmental Sciences and Ecology) are within the top third. A relatively low citation impact for Zoology (0.95) and Plant Sciences (0.82) is due in part to many of these papers being 'New Zealand-specific' or published in AoNZ journals, thereby not attracting many citations internationally.

Our average Scimago journal ranking (citations per document over 2 years) is currently 4.6, down slightly from 5.2 in 2021/22.

Is our research valued and trusted by all AoNZ?

Manaaki Whenua has a responsibility to support the understanding of complex challenges such as the climate crisis, biodiversity loss, and land-use intensification, with robust, science-backed information. Engaging Government, industry, Māori, other scientists, and the AoNZ 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 leads this strategic goal area, supporting 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 10 Link Online webinars seen by more than 6,200 people – an increase of nearly 50% 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 March 2023 – *Barriers and opportunities for planting native trees on farms* – which had 1,072 registrations, with 225 of those from the primary sector. A close second was held in June 2023 – *How can small clusters of trees add value to rural landscapes?* (see also page 33), with 826 registrations including 231 from primary industry. Both reflect keen sector interest in defining the potential contributions of native trees to farm carbon sequestration and ecosystem services.

Linked to this work, in June 2023 we again took part in E Tipu: The Boma Agri Summit, AoNZ's biggest food and fibre sector summit. Senior researcher Dr Sam McNally presented on tree-based landscape management for climate resilience and rural resilience.

We held a hybrid Biosecurity Bonanza webinar series in May 2023, both online and in person at Te Pae Convention Centre, Christchurch, promoting the latest research from our weed biocontrol and predator control teams. The event hosted 608 people across the country, with 2,962 registrations across nine webinars which were watched 2,585 times either live or via the recording. Several of the research stories were also covered in the national media.

Our second remote-sensing webinar series – *Remote Sensing: more than meets the eye* – held in May 2023 hosted 862 people virtually across the country (an increase of 151 people from 2022), with 2,181 registrations across five webinars which were watched over 1,572 times either live or via the recording. The most popular webinar in this series was about the use of AI in tree mapping (see also page 34).

The Beyond Myrtle Rust MBIE research programme continued to host webinars every month, with around 850 registered invitees and an average attendance of around 150 people including scientists, land managers, nursery owners and government.

Across our social media channels our audience grew to 34,410, an increase of 4,525 (15.1%). The biggest increases were seen on Linked In (2,046 new subscribers, an increase of 31%) and Facebook (1,907; 16.5%).

Our financial resilience

To fulfil our role as a CRI, we need financial strength to build and maintain critical research capability for AoNZ, 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 their own financial resilience. 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 target an average 6% return on equity to enable us to reinvest in our infrastructure. The shareholding Ministers have not required a dividend to be paid if we can show a valid investment of those funds in our assets. CRIs are responsible for funding their own capital developments (sites and equipment) in addition to staff costs.

Our financial performance for 2022/23 is outlined in Part 2 of this Annual Report.

The orange-spotted gecko (Mokopirirakau "Roys Peak") – a new population discovered in North Otago. Image: Samuel Purdie.

Our commitment to sustainable development

Our contribution to the future of AoNZ 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 broad 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.

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 travel procurement and making progress towards sustainable energy use in our buildings

We have been certified to the ISO14001 standard since 1998, and had a successful Telarc audit outcome in May 2023, meaning 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.

Where fit-for-purpose options exist, our vehicle fleet is fully comprised of hybrid or full battery electric vehicles. EV charging infrastructure is being added to three additional sites in 2023 to support our vehicle decarbonisation plan.

Our operational emissions have returned to near pre-pandemic levels in 2022/23, in part with a return of high fieldwork activity and travel to reconnect our staff and stakeholders and support our operations.

The impacts of providing improved air quality at our sites in response to the COVID-19 pandemic continue to be reflected in our high energy use in 2022/23. An internal energy management group has been activated to focus on reduction/ optimisation of our energy use, with promising early results.

Our photovoltaic solar panels at Lincoln help minimise our reliance on the national grid at our largest site, and we are poised to go to market for installation of photovoltaic panels at our Hamilton site.

Our tCO_2e emissions were significantly increased this year owing in part to three hidden, slow and significant refrigerant leaks at our Auckland site. These leaks contributed operational emissions exceeding our annual tCO_2e from international travel. The leaks were very hard to detect. In response we have introduced monthly detailed monitoring and system pressure testing of our mechanical plant holding refrigerants.

Carbon zero certification
2011–present

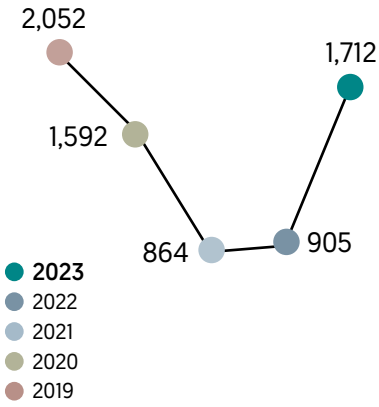
TOITŪ CARBON ZERO ISO 14064-1 ORGANISATION

ISO 14001 certification
1998–present

Telarc. Registered cert TM
Environment ISO 14001

Total emissions (tCO_2-e)

* tCO_2-e = tonnes carbon dioxide equivalent.



Partly because of COVID, in 2020 and 2021 our carbon emissions were reduced.

Non-financial KPIs

Here we provide an overview of our 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
How we work					
1. Employee engagement index	88%	81%	75%	76%	78%
2. Employee turnover	6.9%	4.5%	7.05%	8.33%	10.02%
3. Health & safety (near misses)	46	31	34	14	33
4. Health & safety (lost-time injuries)	2	1	5	3	2
5. Average tenure (years)	11	8	8.48	11	10
Science working with mātauranga Māori					
1. Research with no specific Māori component	570	490	233	64	18
2. Research relevant to Māori	89	93	295	491	490
3. Research involving Māori	49	50	62	95	108
4. Māori-centred research	24	31	26	48	50
5. Kaupapa Māori	23	23	24	26	19
Our sustainability					
1. Tonnes CO_2 per $m revenue*	25.2	19.0	10.1	10.8	17.5
2. Total tonnes CO_2-e*	2,052	1,593	896	905	1,712
Our impact processes					
1. Impact of scientific publications (mean citation score)	3.9	4.2	4.0	5.2	4.2
2. Facebook likes	8758	9206	9182	9679	10839
3. Participants in Garden Bird Survey	3082	7800	6632	6234	6237
4. Interactions per social media post	126	143	119	187	93

*This row shows provisional amounts for 2022/23. Full audited amounts are shown in Part 2 of the Annual Report.

Directory

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Deloitte Limited on behalf of the Auditor-General

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Buddle Findlay

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Dr Paul Reynolds (Deputy Chair)
John Rodwell
Prof Caroline Saunders
Justine Gilliland
Marje Russ
Dr Warren Williams
Dr Andrea Byrom
Ngarimu Blair*

SENIOR LEADERSHIP

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Chief Executive Officer

Dr Fiona Carswell
General Manager, Science

Dr Fraser Morgan
Chief Scientist (Acting)

Kylie Hansen
General Manager, People & Culture

Holden Hohaia
General Manager, Te Tiriti Strategy

Dr Nancy Garrity
General Manager, Māori Partnerships

Chris McDermott
Chief Information Officer

Dr Peter Millard**
General Manager, Science

Graham Sevicke-Jones
General Manager, Science and 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

*to 10 March 2023.
**to 31 August 2023.

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

E/S/R
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