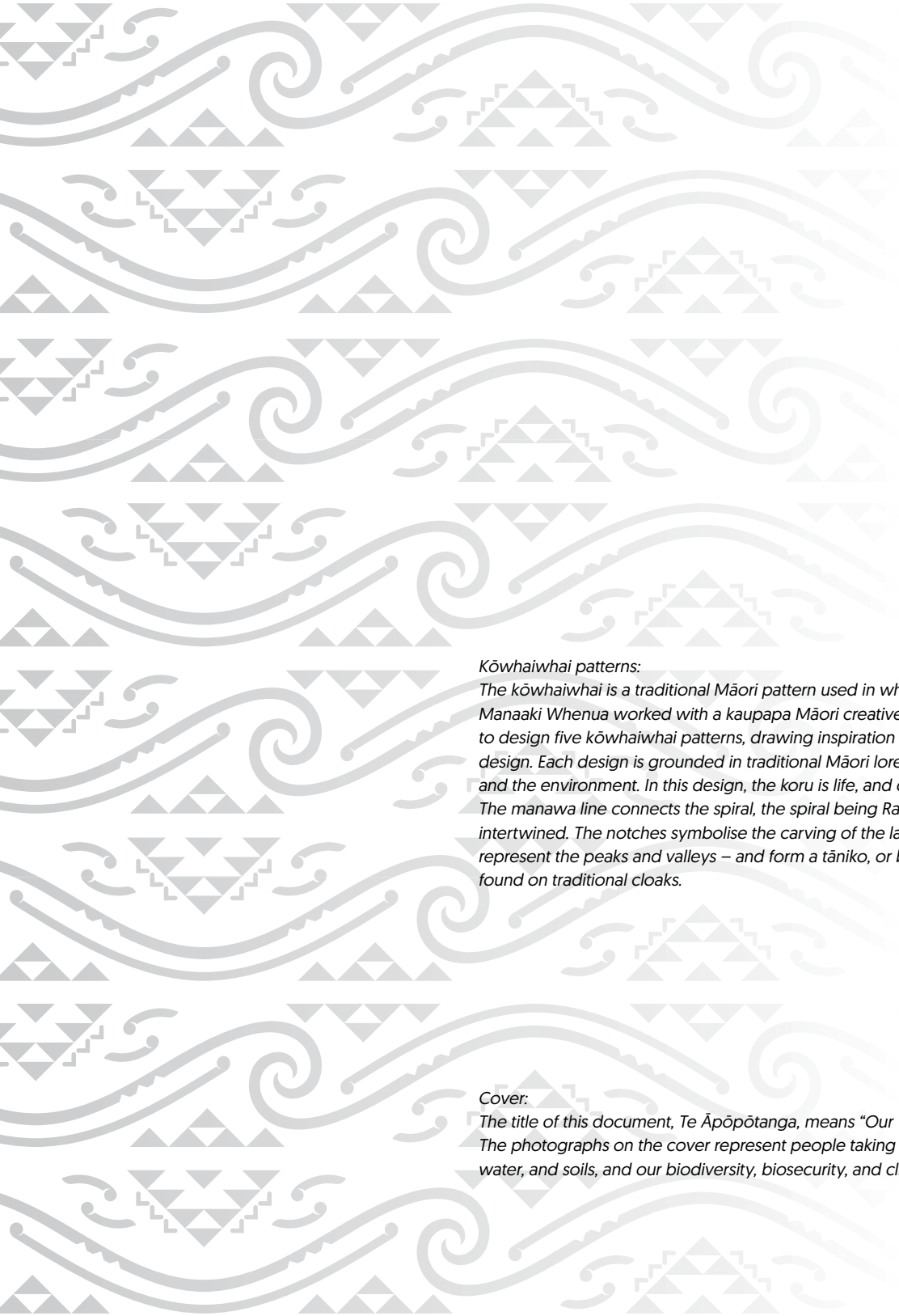


TE ĀPŌPŌTANGA

Our land, our people, our future



Manaaki Whenua
Landcare Research



Kōwhaiwhai patterns:

The kōwhaiwhai is a traditional Māori pattern used in whakairo (carving) and art. Manaaki Whenua worked with a kaupapa Māori creative agency, Ariki Creative, to design five kōwhaiwhai patterns, drawing inspiration from Māori art and design. Each design is grounded in traditional Māori lore and culture, aesthetics, and the environment. In this design, the koru is life, and derives from the forest. The manawa line connects the spiral, the spiral being Ranginui and Papatūānuku intertwined. The notches symbolise the carving of the land – the triangles represent the peaks and valleys – and form a tāniko, or border, that can be found on traditional cloaks.

Cover:

The title of this document, Te Āpōpōtanga, means “Our Tomorrow”. The photographs on the cover represent people taking action for our land, water, and soils, and our biodiversity, biosecurity, and climate.

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HAERE MAI

Welcome to Manaaki Whenua. We conduct science and research focused on environmental issues, opportunities, and solutions, and through partnering with users we aim to create value for Aotearoa New Zealand (AoNZ).

We work alongside people (our partners) with whom we can make a difference, in:

- central and local government
- Māori iwi, hapū, and other entities
- the food and fibre sector and other businesses
- the global research and science community
- community groups and individuals.

We are publishing *Te Āpōpōtanga* at a time when global society is navigating climate change, the Covid-19 pandemic, losses of critical biodiversity and habitat, and great societal and technological change. People are central. Whatever one's role in society or the economy, the decisions we make now will determine what we experience and pass on to future generations.

Those decisions have become more complex. People's needs have grown for knowledge to understand the issues, and tools to provide the capability, and confidence based on trust, to address them. Manaaki Whenua's role over 30 years has been to meet those needs.

In *Te Āpōpōtanga* we also share a view inside Manaaki Whenua, of our culture and aspirations. Here too, people are central to our vitality and sustainability. We thank them for their professionalism and dedication. We thank you for your support and we welcome your feedback.



Dr Paul Reynolds QSO
Board Chair (acting)



Dr Richard Gordon
Chief Executive

OVERVIEW

TIROHANGA WHĀNUI

Te Āpōpōtanga describes Manaaki Whenua's approach to creating value for AonZ through its research, people, and partnerships.

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 iwi Māori and their ancestral lands.

Te Tiriti

We are committed to upholding the principles of Te Tiriti in Manaaki Whenua. Those are Partnership, Participation, and Active Protection of Māori interests, especially in the natural 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.

Our research impacts and outcomes

We focus on four areas of impact: restoring biodiversity and beating invasive species; enhancing land, water, and ecosystems; acting against climate change; and achieving a positive relationship between people and their environment.

We target 12 outcomes that reflect our partners' diverse needs. In *Te Āpōpōtanga* we describe examples of our research, collaboration, and uptake that achieve those outcomes.

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. In *Te Āpōpōtanga* we discuss our progress and challenges.

Our strategic priorities

At a time of change in the environment, society, and economy, we have refreshed our 5-year strategic plan to focus on both 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 commitment to the United Nations Sustainable Development Goals

Throughout this document we refer to 12 relevant goals, our commitments and progress. Our own climate action comprises our research on mitigation and adaptation; the climate leadership of our subsidiary, Toitū Envirocare; and actions to drive down our emissions and influence our sector.

TE TIRITI

Te Tiriti [The Treaty of Waitangi] was signed between the British Crown and Māori leaders in 1840. Article II of Te Tiriti guaranteed Māori their right to “tino rangatiratanga” or self-determination, which included full, exclusive, and undisturbed possession of their tribal lands for as long as they wished to retain them. The rights that were conferred on Māori have been widely abused, resulting in significant and ongoing disadvantage of Māori. As a Crown Research Institute [CRI] we have a responsibility to Māori as a

Treaty Partner, and to implementing the principles of Te Tiriti.

Manaaki Whenua has a 30-year history of working with Māori in conducting research on matters of mutual interest, such as cultural harvest, species conservation, and indigenous forest management. We have also sought to increase participation by Māori within a safe culture at Manaaki Whenua. But we needed to go further.

In 2021 the Board and Executive of Manaaki Whenua made a formal commitment to uphold the principles of Te Tiriti and embed them in our organisation. This commitment recognised both the history and development of our relationship, and the ongoing and pressing need to restore balance and equity in the Treaty partnership, including in research, science, and innovation, where Māori have been disadvantaged.



Brad White



Brad White



Karakia by Matua Koro te Pania for a hikoī carrying kaikōmako [Pennantia baylisiana] saplings to Ngāti Kuri, August 2019

Manaaki Whenua is kaitiaki of the national collection of traditional weaving varieties of harakeke [New Zealand flax, Phormium spp.]: Te Kohinga Harakeke o Aotearoa.

Manaaki Taiao is a rōpū [group] of kairangahau Māori [Māori researchers], including Jade Hyslop, working on Māori-led research projects within a range of science portfolios.

Our tauākī ngākau titikaha [statement of commitment¹] to Te Tiriti¹ is as follows:

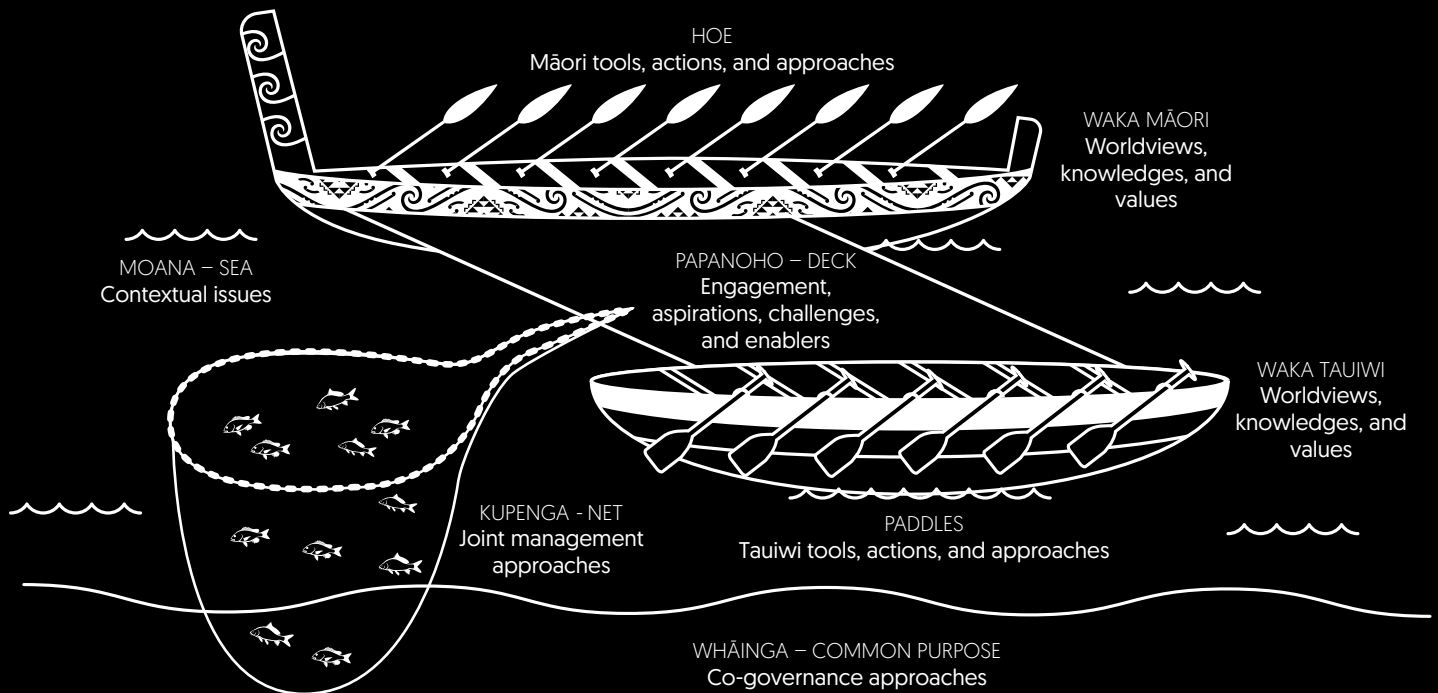
“*Manaaki Whenua commits to upholding the principles of Te Tiriti o Waitangi as defined by the courts and the Waitangi Tribunal, and reaffirmed by Te Arawhiti [The Office for Crown Māori Relations] and Cabinet Office guidelines of October 2019. These can be fairly summarised as the Treaty principles 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 whakatūturingia 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 tātou 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.

¹ Manaaki Whenua's Tiriti commitment was signed on 30 June 2021 by Jane Taylor [Board Chair], Ngarimu Blair [Board member], Dr Richard Gordon [CEO, Manaaki Whenua] and Holden Hohaia [General Manager, Māori Partnerships, Manaaki Whenua].

Waka Taurua – a metaphor for a Tiriti-led approach in science



The Waka Taurua¹ metaphor provides a framework for how we might approach governance and leadership jointly between the Te Tiriti partners (Māori and tauwiwi – non-Māori) within Manaaki Whenua and the wider research sector. The primary components of the framework include:

- the *whāinga* (common purpose), co-governance towards a shared vision
- the *kupenga* (net), joint management approaches
- the *hiwi* (hulls) of each waka (the waka Māori and the waka tauwiwi), which represent the two groups and their respective world views and values

- the *hoe* (paddles) of each waka, which represent the tools, approaches, and actions, derived from the respective waka
- the *moana* (or sea), which represents any contextual issues or threats that are discussed
- the *papanoho* (deck), which connects the two waka and creates a place for engagement between the two parties
- the *whāinga* (common purpose), which is identified through a joint approach.

This Waka Taurua metaphor also aligns well with a Te Tiriti approach in science. In a Tiriti context, the waka Māori could be seen as representative of Māori aspirations – *tino rangatiratanga* as guaranteed under Article II of Te Tiriti. The waka tauwiwi, on the other hand, is representative of *kāwanatanga*, as described in Article I.

The exciting place is the *papanoho*, the shared space for joint aspirations, strategic direction, and management approaches between Māori and tauwiwi coming together in Manaaki Whenua.

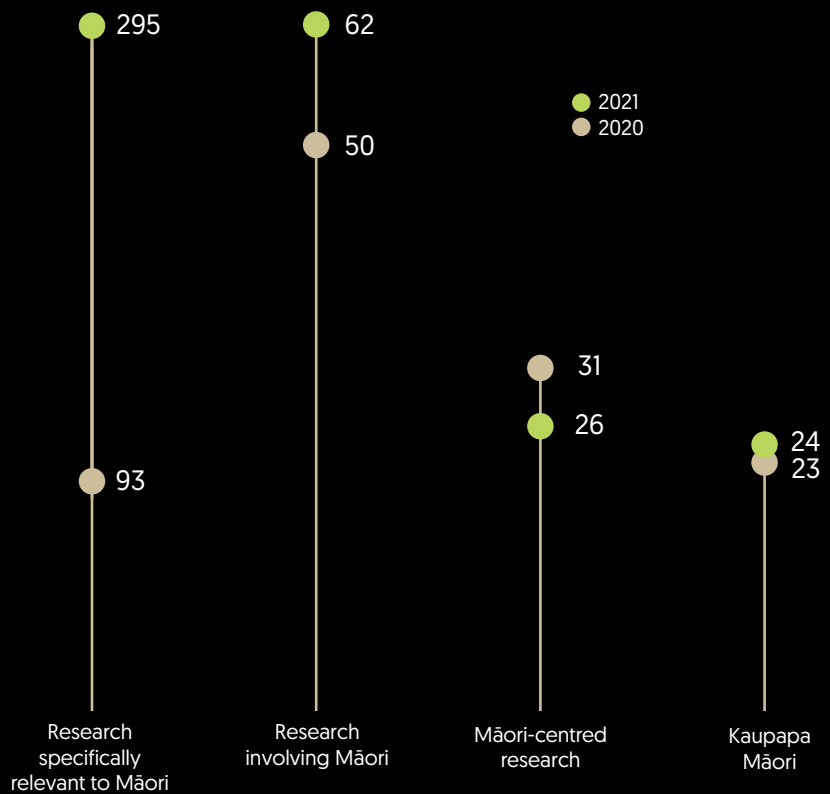
¹ Elements of this diagram are based on: *He waka e noa/We are all in the same boat: A framework for co-governance from Aotearoa New Zealand*. Maxwell K, Awatere S, Ratana K, Davies K, Taiapa C 2021: *Marine Policy*, in press.

Upholding Te Tiriti principles

Māori are at a double disadvantage. First, their whenua continues to suffer the consequences of colonial land losses and land-use decisions (e.g. clearing land leading to erosion, and biodiversity loss); and second, research investment has favoured the dominant science paradigm over indigenous knowledge and research.

We seek a better balance that enables Māori to set priorities, govern and lead resources, and build partnerships between science and mātauranga Māori (page 66). The relationship should be premised on an understanding of what was guaranteed under Article II of Te Tiriti. Tino rangatiratanga (Māori self-determination) is what drives hapū and iwi aspirations. If the relationship is to be honourable, we must acknowledge the desire for tino rangatiratanga as a legitimate aspiration that Crown agencies should support.

VISION MĀTAURANGA PROJECTS



OUR RESEARCH

TĀ MĀTOU MAHI RANGAHAU

Responding to Aotearoa New Zealand's needs

Urgency, action, hope

As we approach Manaaki Whenua's 30th anniversary in 2022, AoNZ's need for our work has never been greater. There is increased urgency to find solutions to the challenges of a changing natural environment. Warnings of climate change and biodiversity loss have been heard from the science community for 30 to 40 years. Recent publications from the IPCC and IPBES¹ have emphasised the adverse impacts of human activities. There can no longer be any doubt about the need to act if humanity and its natural environment are to flourish together. The question is how to act with impact, now.

The issues have been well publicised. Weather extremes bring more severe and damaging floods and droughts. Climate change puts us at risk of new invasive species. Land-use changes, including deforestation, agricultural intensification, and urban expansion, deplete our biodiversity and soils and threaten ecosystem services such as water provision, pollination, and spiritual well-being. Pollution overwhelms natural systems and their regeneration. The IPCC and

IPBES point the finger at people's activities as the major contributor to these changes.

The challenges facing society are daunting and largely of its own making, but people are willing to face these challenges and act. We are seeing more people mobilising themselves to act now. Community groups in cities, farmers, hapū, schools, and businesses are acting, often ahead of government policy and regulation. Many seek guidance and confidence from science, but indigenous communities have reason to trust their traditional knowledge. In AoNZ this is mātauranga Māori.

Māori thinking connects people with the environment through whakapapa (lineage). The expression 'Manaaki whenua, manaaki tangata, haere whakamua' links caring for the people and the environment and going forward together. The responsibility is reciprocal and the timeframe is long – indeed, in perpetuity. This philosophy resonates with an ecological mindset, typical of Manaaki Whenua's work.

We have used this philosophy to build integration across our research activities. The environmental challenges facing AoNZ are complex, with large uncertainty, high stakes, and polarised views. Manaaki Whenua addresses this complexity and finds solutions from integration between silos. Addressing complexity is a hard road to take in science and research, but it is the road to enduring solutions, with the Treaty partners working together to ensure we have a viable future.

Facing growing environmental and social challenges, people need the realistic hope these solutions can provide. Manaaki Whenua's role is to support and lead action with evidence-based understanding and capability. Thirty years is a short life in comparison with the great research institutes around the world. We continue to evolve and grow. The next 30 years will see Manaaki Whenua with our partners working for a society that achieves well-being through a respectful relationship with its natural environment.



Pathway to impact

Our work has impact when it contributes to actions that have benefits for society and the natural environment. What we call our pathway to impact leads from our research to its outputs, outcomes, and, ultimately, impacts. We work closely with our partners to ensure the investment in our work is well targeted, designed, and delivered – and that it is adopted.

All our work is done on contract to a purchaser, and the design, outputs and often the outcomes are agreed in advance. For the pathway to impact to work well, it must reflect the right priorities, the right design [which includes the collaborative team], and the right transfer of value to research users.

We ensure we bring together the right research skills through collaboration, which includes subcontracting 20–40% of our research revenue to other research organisations, both in Aotearoa and overseas.

Design for impact

A pan-CRI group was set up in 2018 to enhance skills in conducting research to achieve impact. To date over 900 CRI staff have attended training. Co-led by Manaaki Whenua, the iPEN group identified leverage points in the research pathway to impact. Most leverage can be achieved in the intent and design phases of research. Intent is the knowledge systems and values that define excellent research and impact. The design phase includes funding mechanisms and structures. As we weave Te Tiriti's principles into our research, we recognise that the Māori knowledge system must be reflected in our intent and design.

DELIVERING IMPACT WITH OUR PARTNERS

KIA TUKU WHAKAAWEAWE MĀTOU KO O MĀTOU HOA

Setting priorities

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. Their traditional approaches to decision-making and policy-setting have had to change.

Our partners have their own perspectives on those themes, and finding consensus to prioritise outcomes can be difficult (e.g. The Land and Water Forum report 2012). Yet research resources are constrained, and decisions must be made on where investment should be made in research.

We support the Parliamentary Commissioner for the Environment's [PCE 2020]¹ call for an expert entity that is equipped and charged with making such decisions by bringing the right people to the table, and empowered to invest in and monitor the strategic research that will deliver the agreed outcomes. We also support Science New Zealand's call² for a process that empowers the four major stakeholders – government, Māori, industry, and research – to invest in prioritised, strategic research towards specific outcomes.



Government



Māori



Industry



Research



People and communities

Our partners' priorities

National (and global) environmental priority themes are readily identified and agreed upon (e.g. *Environment Aotearoa 2019* and the PCE 2019)¹. The list includes:

- climate change mitigation (e.g. net-zero carbon), adaptation, and resilience
- indigenous biodiversity protection and restoration
- biosecurity against invasive weeds, pests, predators and diseases
- protecting, enhancing, soils and regenerating ecosystems
- protecting and enhancing freshwater, its supply, quality, and ecosystems
- reducing waste and pollution, and enhancing the circular bioeconomy
- enabling people to act as agents of change, regardless of their roles in society
- a holistic focus on well-being
- work on carbon, particularly understanding the processes and opportunities for native forest and soil sequestration.

Māori themes are integrative and support tino rangatiratanga and rebuilding of nationhood:

- iwi and hapū can act as kaitiaki of their lands
- he whenua koiora (better utilise resources for intergenerational well-being)
- makuru ana ngā mahinga kai (gather food from abundant and flourishing areas)
- hold mana rangatiratanga over indigenous knowledge and intellectual property.

Other partners have their own priority outcomes, such as:

- government's needs for resource management, biodiversity and biosecurity policy legislation, and community engagement
- food and fibre industries' attention to licence to operate and the market's sustainability demands
- infrastructure, energy, tourism, and other sectors' mitigation of environmental impacts
- community groups' own environmental actions (e.g. predator-free cities, land-care restoration)
- farmers' concerns for biosecurity, protecting waterways, and restoring biodiversity
- the global research sector's interests in integrative and transdisciplinary research, engaging with indigenous knowledge systems, and AONZ's unique biodiversity and ecosystems.

Outcome Advisory Panel

This panel helps our Board and leaders strengthen strategic alignment and collaboration with key users of our science. The panel comprises senior representatives from our partners in central and local government, iwi, the food and fibre industry, and business.

These connections provide insights into how organisations are prioritising their workstreams and thus how our science can provide knowledge to assist. The advice we receive enables a better translation of knowledge into the respective organisations, as well as providing to the senior representatives a science-relevant and human-centred view at a broader systems level. Their advice has been instrumental in shaping our strategies and work programmes.

In addition, we have formed strategic alliances and plans with specific regional councils and central government (Ministry for the Environment, Department of Conservation).

¹ Ministry for the Environment and Stats NZ: *Environment Aotearoa 2019*. Parliamentary Commissioner for the Environment 2019: *Focusing Aotearoa New Zealand's environmental reporting system*.

Our four research impacts



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.



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.



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.



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.

Much of our research work is focused where these 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 has 12 research outcomes, which are needed by our partners. Examples of our work are given on pages 16–42 under each of those 12 headings.



Our 12 research outcomes

1. Critical knowledge of the wealth, state, and trends in our biodiversity, soils, and lands informs natural resources decision-making
2. Hapū and iwi act confidently as kaitiaki of their whenua using science and mātauranga Māori
3. Māori land trusts and incorporations achieve their aspirations for their land
4. Ecological restoration is guided by knowledge of past and present ecosystems
5. Land-use, soils, and erosion are managed to improve freshwater quality
6. Productive lands are regenerative at the landscape scale
7. Risk and harm from invasive organisms are mitigated
8. Biosecurity tools are available with social licence
9. Communities and regulators have adaptation pathways for climate change
10. Greenhouse gas emissions and removals are managed to mitigate climate change
11. Environmental decisions are underpinned by advanced geospatial information
12. National environmental outcomes are improved by integrating social practice theory, policy tools, and economics

RESEARCH OUTCOMES HUA RANGAHAU

The icons that appear on the following pages indicate which interlinked areas of impact are critically relevant to the outcome.



People and
environment




Action on
climate change



Restoring
biodiversity,
beating invasive
species



Enhancing
soils, water,
and land



We have identified 12 outcomes of our research that contribute to achieving our integrated impacts. In the following pages we show how our current research contributes understanding, capability, and the confidence needed by people to act on the major issues of our time. In our examples, some involve research that has achieved impact over many years, others are recent and forward-looking, while others are where we seek to inform and lead thinking.

We judge the excellence of fundamental and applied research by the impact or difference the work has made, or is likely to make, in the future. In some fields of research, a simple economic measure may suffice, but many countries have struggled to find useful impact measures that integrate economic, social, cultural, and environmental benefits. The consensus is to use narrative, and we use that approach in this document through telling the stories of representative research.

Outcome 1



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

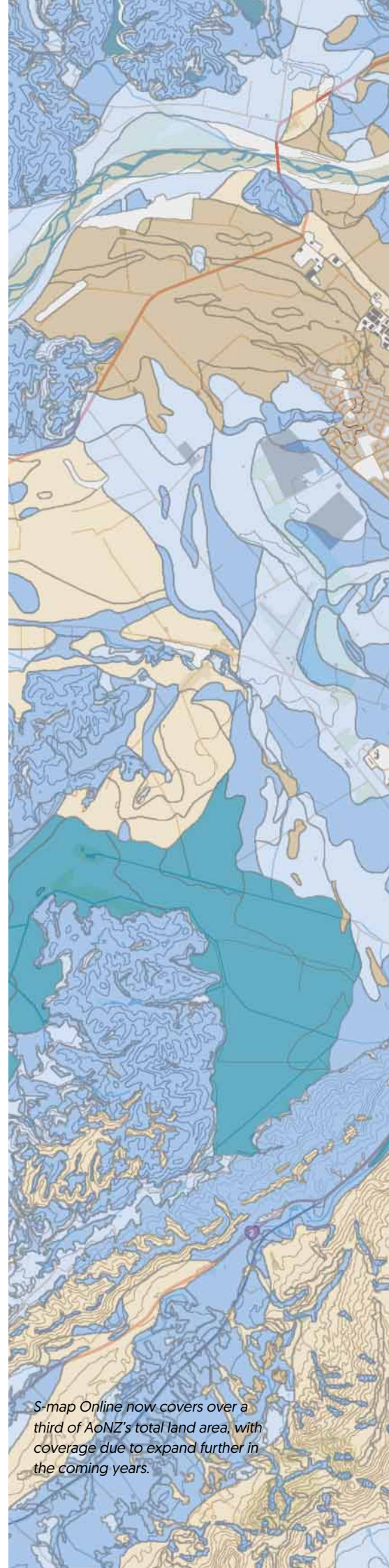
Our environmental data resources and foundational knowledge provide fundamental information for AoNZ's economy, environmental management, environmental recovery, and social development. Our data are used by policy makers and land managers across the country and further afield in the Pacific region to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

Long-term research delivery: **S-map Online**

S-map Online, a tool developed and updated by Manaaki Whenua, provides the best available soil resource data for AoNZ. Over the past 15 years S-map has transformed soil survey in AoNZ from a mix of hardcopy soil maps and bulletins and a few regional endeavours based on old-fashioned informatics tools (e.g. spreadsheets), into a robust, nationally consistent information system supplying soil information to a wide range of clients and users. Advances in computer power have enabled digital soil modelling methods to be incorporated into S-map, both for soil type mapping and to produce national three-dimensional soil grid layers. Another key focus has been improving the robustness of soil hydrological attributes.

S-map is a major strategic asset in environmental management. It is used extensively by rural consultants, councils, landowners, and others for crop and pasture management, nutrient budgeting, erosion control, irrigation management, drought resilience, and land valuation. In August 2020, S-map had a significant nationwide update, including increased coverage of the country, new parameters for estimating soil hydrological properties, and new maps for soil carbon, pH, and phosphorus retention. In a further boost for S-map, in December 2020 the Government committed \$6.25 million for further expansion of the tool, with funding allocated by MPI.

 smap.landcareresearch.co.nz



S-map Online now covers over a third of AoNZ's total land area, with coverage due to expand further in the coming years.



Recent research: Using our data for state-of-the-art environmental reporting

Work now being done across Manaaki Whenua, drawing on the resources of the Land Resource Information System, covers the breadth and depth of environmental research required by the ambitions of the Government's environmental reporting programme, which is led by the Ministry for the Environment and Statistics NZ. We have contributed to a growing national cache of environmental reporting data and new indicators for environmental reporting, and our staff have acted as science leads for much of the work.

Fit-for-purpose indicators need to be transparent, reproducible, and traceable, and all require robust supporting data. The latest report, *Our Land 2021*, focuses on dynamic land-use issues for which our inputs are invaluable – in particular, land fragmentation and a wide range of soil quality properties. In new work we are also working on deriving indicators of how ecosystems contribute to people's well-being.

<https://www.landcareresearch.co.nz/news/our-contribution-to-environmental-reporting-for-aotearoa-new-zealand-the-story-so-far>

Looking to the future: A new national inventory of naturalised plants

AoNZ is one of the world's top plant biodiversity hotspots. Because of historical isolation, many of our native plant species are endemic (found nowhere else). However, in the past two centuries an almost equivalent number of plant species have become naturalised: many were brought here deliberately as crops or ornamentals and have jumped the fence to establish wild populations.

Dating from 2006, AoNZ's existing inventory of naturalised plants was due for an overhaul. Working with university colleagues from Lincoln, Auckland, Canberra, and Syracuse (USA), as well as the Department of Conservation, researchers from Manaaki Whenua recently undertook an updated inventory of the entire naturalised flora of AoNZ, comparing its taxonomic and functional distinctions to the native flora.

The work is testing a new idea: whether valid comparisons of functional traits between native and naturalised plants could be made by focusing on leaf nitrogen content in trees. Comparison of functional traits such as resistance to fire or grazing will also support better management of invasive plant species.

<https://www.landcareresearch.co.nz/news/jumping-the-fence-a-new-inventory-of-new-zealands-naturalised-flora>

Outcome 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, hapū, 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.

Long-term research delivery: **The Honey Landscape**

A large proportion of AoNZ's natural mānuka populations grow on Māori-owned land. Scientists at Manaaki Whenua have teamed up with Māori agribusiness to learn more about mānuka DNA variation, beehive stocking rates, and honeybee food resources in a 5-year Ministry of Business, Innovation and Employment [MBIE] project that sets out to maximise the opportunity presented by high-value mānuka honey production.

The Honey Landscape project has helped to create a sustainable native mānuka honey industry that reduces hive losses and helps landowners to increase honey production while protecting the honeybees, native mānuka, and plant species.

Dr Gary Houlston has led the Manaaki Whenua component of the Honey Landscape project, building a comprehensive model and map of AoNZ's native honey landscape that blends science and tikanga Māori.



www.landcareresearch.co.nz/news/the-honey-landscape-2

The Honey Landscape project, a 5-year MBIE programme to 2021, has built a comprehensive model and map of New Zealand's native honey landscape that blends science and tikanga Māori.



Recent research: Freshwater and wetland monitoring

WAlora is a kaupapa Māori (based in Māori principles) assessment tool, developed to assess the state of health of freshwater from a te ao Māori perspective. The core values and concepts of the method were developed by working with the Waikato Tainui Technical Advisory Group in the Waikato tribal area. The framework was then completed and trialled as a field tool with iwi/hapū group Ngāti Tahu-Ngāti Whaoa (Waikato/Bay of Plenty), which was then transferred to a mobile application. The method was then replicated with the Tapuika iwi (Bay of Plenty), who developed their own customised versions of the tools.

Te Reo o te Repo – The Voice of the Wetland is an online handbook, now in its second edition, developed in partnership with Waikato Tainui to address cultural priorities for restoration. *Te Reo o te Repo* highlights a range of work undertaken by iwi and hapū to increase the health and well-being of their repo. There has been wide uptake, both nationally and internationally, including incorporation into classroom teaching resources using mātauranga Māori.

<https://www.landcareresearch.co.nz/publications/te-reo-o-te-repo>

Looking to the future: A bicultural approach to indigenous regeneration

A recent collaborative study between Tūhoe Tuawhenua Trust and Manaaki Whenua aimed to understand the values central to the Tuawhenua community's relationship with the forests, lands, and waterways. It is part of a larger BioHeritage programme to investigate how kaitiakitanga (Māori guardianship) approaches help to reverse the decline of AotNZ's biodiversity.

Led by Tuawhenua researcher Puke Timoti and Manaaki Whenua's Dr Phil Lyver, the study aimed to understand and compare the spectrum of values held by different generations in the community to guide future planning, management, and monitoring of Tuawhenua forests, and to understand what type of trade-offs might be associated with different management decisions and economic development opportunities.

This thought leadership has, in turn, led to a new MBIE Endeavour research programme, funded in 2021 and led by Dr Lyver. The programme

aims to use a te ao Māori world view and whakapapa frameworks, alongside the integration of value and ecological networks, to re-imagine biocultural solutions that simultaneously restore ecological systems, reinforce identity, reconnect people to place, enhance community well-being, and deliver sustainable economic growth for communities.

Research will be embedded within iwi-specific cultural learning institutions (e.g. Whata Kōrero), which will support the training and development of new kaitiaki and tangata tiaki. Both te ao Māori and scientific knowledge systems will be used to develop whakapapa frameworks and social-ecological networks, and to test how the impacts of kaitiakitanga interventions and economic activities cascade through ecosystems and our human communities.

<https://www.landcareresearch.co.nz/news/he-matawara-o-mua-taking-account-of-shifting-ecological-baselines>



Two generations of Tūhoe, Te Whenua Te Kurapa and Puke Timoti, discuss their impressions of abundance and productivity witnessed in the forests of Te Urewera over their lifetimes.



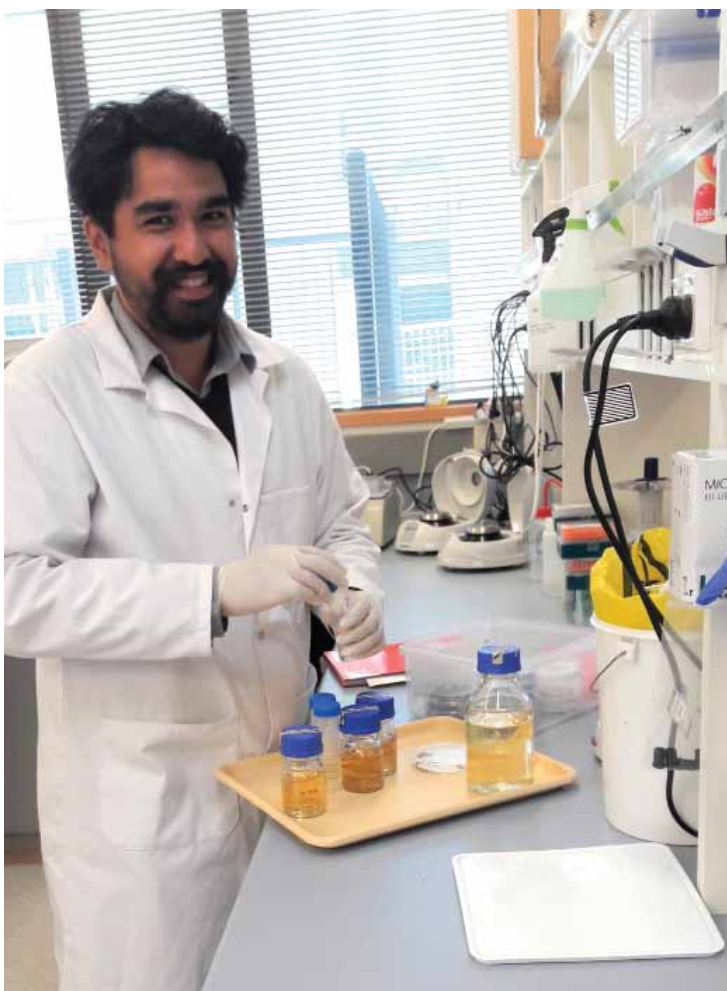
Māori land trusts and incorporations achieve their aspirations for their land

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

Long-term research delivery: **Building long and deep relationships in effective land management**


Over time we have built an enduring relationship with Te Awahohonu Forest Trust, in northern Hawke's Bay. Manaaki Whenua was initially approached by the Trust to provide them with a kaupapa Māori land-use opportunities assessment for their Tarawera C9 block, based on word of mouth about the reputation of our research group, Manaaki Taiao, in the land assessment space. Tarawera C9 is a huge land block, comprising some 10,000 hectares of pristine indigenous forest with both lowland podocarp and high-altitude beech, as well as another 15,000 hectares of plantation pine and areas of reversion scrub, bordered by five rivers, and it has very high biodiversity.

Further alignment of our capabilities with Trust aspirations has led to the initiation of studies on āwheto (kūmara caterpillar), huhu, and social research. In the spirit of reciprocity, we created a summer internship for one of the Trust's uri (descendants). The Trust's long-term aspiration is to develop a research hub and wellness retreat, and they are excited about the potential to explore an enduring relationship with us. It is also important for us to be able to whakamana back to the Trust.



The Honey Landscape project, a 5-year MBIE programme to 2021, has built a comprehensive model and map of New Zealand's native honey landscape that blends science and tikanga Māori.

<https://www.landcareresearch.co.nz/news/how-one-thing-leads-to-another-building-long-and-deep-relationships-in-effective-land-management>



An MBIE Endeavour-funded science programme, 'Soil health and resilience', led by Manaaki Whenua, is exploring how conventional knowledge of soil health can be made more meaningful and holistic by engaging with a diverse group of stakeholders that includes the Government, industry, landowners, and iwi/hapū.

Recent research: **Māori land-use feasibility studies**

In 2020/21 we completed feasibility assessments for 38 land trusts in Tairāwhiti Gisborne, and 80 land trusts across the Bay of Plenty, from Whangaparāoa in the east to Horohoro in the west, and inland to Tarahore and Te Waimana. Of these, 67 proceeded to the final business case stage. We have also provided online training in the use of GIS tools to help users better depict and explore their natural resources.

Looking to the future: **The cultural dimensions of soil health**

Complementing conventional models of soil health, mainly based on soil chemistry and physical properties, our recent MBIE programme 'Soil health and resilience: Oneone ora tangata ora' has explored the broader social and cultural values of soil, incorporating te ao Māori concepts of soil health. Applying a well-being lens to soil health provides an innovative way of thinking about the long-term management of land and soil ecosystems.

Fundamental to indigenous knowledge is that people are an intrinsic part of the natural environment, and that the benefits and values people derive from nature are not just cultural but occur across all ecosystem services. Thus, for AONZ, work into soil health should be inclusive of an indigenous Māori perspective of soil ecosystems and soil health derived from traditional beliefs, values, and concepts, based on mātauranga Māori, elucidating the values, uses, and aspirations Māori have for soils and the practices they wish to follow.





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.

Long-term research delivery: **Wetlands, sanctuaries, and kiwi management**

Improved wetland management.

This is needed to reverse declines in state, biodiversity, and ecosystem services, primarily in productive landscapes. Our research focuses on ensuring wetlands are sustainable within productive systems. We study processes to ensure resilience in wetlands, encompassing drainage, nutrient inputs, and weed invasion. Vision Mātauranga outcomes are guided by our Māori research partners to reflect tikanga, and support capacity building and rangatiratanga.

Pest-free sanctuaries. Dr John Innes and other Manaaki Whenua researchers have been pivotal in providing the scientific underpinning

and practical management of pest-free sanctuary projects nationwide, including developing the operational strategy for Sanctuaries New Zealand. A highlight of our work has been the long-term study of vegetation, invertebrate, and bird responses to the eradication of all pest mammals (except mice) in Aotearoa's largest mainland sanctuary, Maungatautari. Insights gained from our studies have important implications for landscape-scale pest eradication goals, such as Predator Free 2050.

Rescuing an icon. Manaaki Whenua's Kiwi Rescue research programme aims to reduce the decline in kiwi and improve the management of kiwi protection, working with the

Department of Conservation, Kiwis for Kiwi, Māori, and community groups. As part of the work we examined all kiwi type specimens, and genetically sequenced specimens of brown kiwi to enable a comprehensive revision of brown kiwi and tokoeka taxonomy, thus enabling robust decisions about genetic restraints on translocations.

A second highlight was the development and trialling of a kiwi mātauranga tool with Ngāti Rangī and Te Roroa.

[HTTPS www.landcareresearch.co.nz/news/turning-the-next-page-on-predator-control-in-new-zealand](https://www.landcareresearch.co.nz/news/turning-the-next-page-on-predator-control-in-new-zealand)

Recent research: **Ecological restoration at Māori rock art sites**

Research underway by Manaaki Whenua and Ngāi Tahu Māori Rock Art Trust aims to enable Ngāi Tahu Te Rūnanga o Arowhenua to promote, manage, and restore the Māori rock art sites at Ōpihi, South Canterbury.

The 14 sites are of the highest cultural value to Ngāi Tahu, and to the mana whenua, Te Rūnanga

o Arowhenua. During the 2-year project researchers will conduct a deep ecological study of the sites to help mana whenua develop a more detailed understanding of the interplay of the cultural and natural values of the sites, and the lifeways of the Ngāi Tahu tīpuna who inhabited them. Pollen, charcoal, ancient plant DNA, and preserved plant and animal remains will be

used to reconstruct the vegetation history of the sites to provide a baseline from which current biodiversity can be compared and restored.

[HTTPS www.landcareresearch.co.nz/news/deep-ecological-research-funded-for-nationally-significant-maori-rock-art-sites](https://www.landcareresearch.co.nz/news/deep-ecological-research-funded-for-nationally-significant-maori-rock-art-sites)

Looking to the future: Delving into the deep past to inform the present

At our Long-Term Ecology Lab, internationally important research is being done into the causes and consequences of environmental changes, with valuable findings across many branches of environmental science. Three highly collaborative scientific papers published in 2020/21 have demonstrated the importance and quality of the lab's work.

The first used palaeo-archives to identify what caused some species to be more sensitive to climate-driven change in the past than others, helping present-day researchers to improve early-warning systems for the effects of current climate change on ecosystems. The second was a major international collaboration between 31 scientists from seven different research fields (geochronology, climate modelling, atmospheric chemistry, solar physics, anthropology, palaeontology, and genetics) that examined the impact of the last reversal of the Earth's magnetic poles some 41,000 years ago. The third paper analysed the impacts of human arrivals on islands around the world, including Aotearoa.

The results of all three papers show how reference periods in Earth's history are important natural laboratories for understanding biodiversity responses to climate and anthropogenic change.

<https://www.landcareresearch.co.nz/news/reconstructing-long-term-climate-change>



Information about the past improves our understanding of current ecosystems, and can inform conservation and restoration planning. Here, researchers from our Long-Term Ecology Lab search for kiore [rat] droppings in a cave in Otago.

Outcome 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

Long-term research delivery: **STEC and SedNet**

Land-based erosion and transfer of sediment is a huge problem for AoNZ. The country is losing an estimated 192 million tonnes of soil each year due to erosion, almost half of it from pastoral land. Smarter Targeting of Erosion Control (STEC) is a 5-year MBIE programme to explore cost-effective ways of targeting erosion control and improving water quality. Ongoing work includes the 'fingerprinting' of waterborne sediments to discover their source, the measurement of earthflow movements / landslides / bank erosion, and the analysis of satellite imagery to map the location and seasonal changes in grazed and bare ground.

Adding to our capability, SedNet NZ is an adaptation of an Australian soil erosion model, developed by Manaaki Whenua over the past decade to estimate sediment load generated by different soil erosion processes, allowing improved targeting of erosion mitigation measures. It has been used successfully by several regional councils, including Hawke's Bay and Northland.

[HTTPS://www.landcareresearch.co.nz/news/getting-smarter-about-sediment-control](https://www.landcareresearch.co.nz/news/getting-smarter-about-sediment-control)

Extensive earthflow in the upper Tiraumea catchment, a tributary of the Manawatū River. A five-year MBIE-funded programme, 'Smarter Targeting of Erosion Control' (STEC), is exploring cost-effective ways of targeting erosion control and improving water quality.





Recent research: **LiDAR mapping to understand landslide susceptibility**

Large rainfall events in Aotearoa New Zealand often trigger hundreds to thousands of shallow landslides, especially in more marginal pastoral hill country, causing significant damage to land and infrastructure as well as contributing large quantities of sediment to aquatic environments.

Within the STEC programme our scientists have been using new remote-sensing techniques to map over 100,000 landslide scars from high-resolution satellite or aerial imagery across the North Island. These landslide inventories form the basis for machine learning models that predict where landslides may occur in the future, based on landscape factors such as topography, land cover, and rock type.

In linked work, our researchers working with colleagues at Massey University have used LiDAR to delineate individual tree crowns and classify these into one of four dominant tree classes – poplar/willow, eucalypts, kānuka, and conifers – on two pastoral hill country farms near Masterton to estimate future landslide erosion based on the known ability of the roots of different tree species to bind soil.

<https://www.landcareresearch.co.nz/news/getting-to-the-root-causes-of-soil-erosion-using-high-resolution-remote-sensing>

Looking to the future: **Towards a national strategy for soil**

Across Aotearoa New Zealand the soil underpins our economy, our biodiversity, environmental health, and the well-being of our communities. It sits at the nexus of many of the national and global challenges we face.

In 2015 the Ministry for Primary Industries (MPI) commissioned a comprehensive multi-agency review of future requirements for soil management in Aotearoa New Zealand. One of the main outcomes identified was the need for a national soil strategy. Since then the importance of soil to the nation's well-being has been increasingly recognised, even while the pressure on this taonga has continued to increase.

We propose that it is timely to develop our national soil strategy. While we can learn a lot from other nations, we would also make a strong global contribution through embedding our soil strategy in the goal of sustaining national well-being. To achieve this, it is logical that development of the national soil strategy follows a Te Tiriti approach, recognising soil as a national taonga.

<https://www.landcareresearch.co.nz/news/towards-a-national-strategy-for-soil/>

Outcome 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.


Long-term research delivery: **Maximising the value of irrigation**

In 2013 the MBIE-funded collaborative programme 'Maximising the Value of Irrigation' (MVI), led by Manaaki Whenua, with Plant & Food Research and the Foundation for Arable Research, took on the challenge of creating new irrigation scheduling and management systems at the paddock scale.

One group of MVI researchers used high-resolution sensor mapping and in-field soil and crop sensor monitoring systems to assist with precision irrigation. The team designed, built, and used wireless sensor networks for near real-time monitoring at irrigation sites. The information was then sent via a smartphone app to participating farmers to inform them of precise

irrigation schedules and to monitor daily crop water usage. Another group of MVI researchers used remote-sensing methods to create a technique for monitoring daily crop water usage to help calculate how much water a crop is using each day at the paddock scale.

The results were a step-change in irrigation management, leading to water savings of between 9 and 30% when irrigation was varied according to the different soils at the site.

 www.landcareresearch.co.nz/news/reducing-the-effects-of-land-intensification

Recent research: **Wide-ranging science for our productive landscapes**

'Reducing nitrogen losses from farms', a recently completed and highly collaborative MBIE-funded research programme led by Dr David Whitehead, has investigated and recommended practical changes to farm management practices to reduce soil carbon and nitrogen losses from dairy farms on stony soils. Using Lincoln University's Ashley Dene Research & Development Station, the programme investigated links between the plant and soil processes that regulate carbon and nitrogen cycling. The aim was to provide management options to manipulate carbon inputs using different grassland and fodder species, and irrigation to reduce carbon and nitrogen losses.

Other recent work on productive lands and landscapes has included:

- the incorporation of ecosystem services (the benefits that nature provides) into a cost-benefit analysis to inform the 2019 National Policy Statement for Highly Productive Land, as part of growing national concerns about urban encroachment onto versatile soils
- using geospatial modelling to optimise land use at the landscape scale
- investigation of the benefits of more diverse pasture types for the dairy industry.

 www.landcareresearch.co.nz/discover-our-research/land



Research technician Graeme Rogers taking soil cores at Lincoln University's Ashley Dene research farm.

Brad White

Looking to the future: **Regenerative practices for environmental and social well-being**

We have recently addressed a large knowledge gap for AoNZ in the claimed benefits of regenerative agriculture. A collaborative and consultative research project into the implications of regenerative agriculture in AoNZ was undertaken from June to December 2020, involving more than 70 AoNZ-based organisations and 200 people, including producers, researchers, private consultants and educators, industry levy bodies, banks, retailers, not-for-profit organisations, and overseas researchers. The project included representation from a wide range of attitudes towards science, scientific institutions, and farming systems in AoNZ, and a white paper was published in mid-2021.

In linked work, we are baselining the performance of conventional and regeneratively run farms across 20 indicators. The project involves both dairy and drystock pastoral farms in the south of the country. Indicators of proposed benefits include visual soil assessments, soil moisture and water infiltration, soil stability, soil carbon and nitrogen stocks, and various measures of ecosystem biodiversity, including plants, insects, soil invertebrates, and soil microbes. Additional survey work among farmers, industry, government, and scientists will consider the economic and social outcomes of regenerative agriculture.

[HTTPS://www.ourlandandwater.nz/incentives-for-change/regenerative-agriculture-regen-ag/](https://www.ourlandandwater.nz/incentives-for-change/regenerative-agriculture-regen-ag/)

Outcome 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. Our expertise in predator modelling has also been crucial to AoNZ's response to the Covid pandemic.

Long-term research delivery: **An end to bovine TB**

The Australian common brushtail possum (*Trichosurus vulpecula*) has invaded most AoNZ landscapes and established itself as a ravenous and problematic pest. It has been linked to defoliation and native habitat die-back, and has had a devastating impact on bird life. As a carrier of bovine tuberculosis (TB), it is also a significant threat to AoNZ's agricultural industries.

Since the 2000s our researchers have worked with epidemiologists and operational planners to

develop strategies to accelerate the eradication of bovine TB, integrating novel technologies and decision-support systems for pest management and collaborating directly with operational managers on the ground. Our work has underpinned the success of the National Pest Management Strategy for Bovine Tuberculosis, which currently aims for the biological eradication of TB from AoNZ by mid-century.

[HTTPS://www.landcareresearch.co.nz/news/next-level-possum-control/](https://www.landcareresearch.co.nz/news/next-level-possum-control/)

Recent research: **Beyond myrtle rust**

To protect AoNZ's highly valued native trees from the invasive fungus myrtle rust, Manaaki Whenua, Plant & Food Research, AgResearch, and Scion are currently collaborating to understand its short-term and long-term impacts on native ecosystems. The research programme, 'Beyond Myrtle Rust', aims to boost the resilience of AoNZ landscapes to this fungus and reduce its impacts.


Our research activities span four main research areas:

- improving understanding of how the fungus reproduces in AoNZ
- assessing resistance to the disease

- investigating broad-scale impacts of the pathogen on ecosystem functions
- assessing cultural and Māori-led priorities alongside disease impacts.

As an example of our work, we have established habitat ranges for tree species susceptible to myrtle rust, and will use them to identify potential refugia where these species might be able to ride out the threat of the disease.

[HTTPS://www.landcareresearch.co.nz/discover-our-research/biosecurity/ecosystem-resilience/beyond-myrtle-rust](https://www.landcareresearch.co.nz/discover-our-research/biosecurity/ecosystem-resilience/beyond-myrtle-rust)



A radio-transmitter being attached to a wild ship rat at a study site near Lake Alabaster, Fiordland, to enable rat population dynamics to be studied.



Looking to the future: Progress in eradication science

Manaaki Whenua has world-leading expertise and decades-long experience in the control of invasive mammalian predators, which are vital to the success of the Predator Free 2050 initiative. Our 'Eradication Science' MBIE programme currently underway aims to understand why some individual animals survive control operations, and our research advances on many other fronts too.

Eradication science is a combination of interdependent approaches. We are improving our understanding of survivor personalities, which allows us to use specific cues to alter the attractiveness of sites and traps. We are identifying and manipulating these cues (e.g. odour, visual or auditory cues). We are working with iwi and hapū partners to identify mātauranga associated with traditional trapping and luring, including seasonal behaviour changes. We are also using artificial intelligence, including image recognition, to allow targeted pest control via smart traps. In linked work, we are in the early stages of developing species-specific toxins that do not harm non-target species and are not persistent in the environment.

We are also working closely with urban Predator Free groups such as Predator Free Dunedin on possum trapping techniques and building social licence to trap.

Our research will enable land managers to achieve eradication cost-effectively, rather than the current paradigm of sustained [costly] predator control with repeated applications of toxins.

Outcome 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.

Long-term research delivery: Control of weeds through biocontrol agents

The Weed Biocontrol group at Manaaki Whenua is internationally acknowledged in weed biocontrol research and practice – the only sustainable, cost-effective, and practical way of managing widespread weeds. Biocontrol operates in a rigorous regulatory environment and takes decades of painstaking, meticulous work for results to become apparent.

The group has cost-effectively developed and released biocontrol agents to control serious intractable weeds across Aotearoa, from native forests in Northland to farms in Southland, and further afield in Pacific nations. Their research has benefited all sectors required to more sustainably and effectively manage weeds, including government agencies such as regional councils and the Department of Conservation,

farmers and forestry operators, and community groups battling to save local bush remnants. The group has maintained social licence to operate through careful consultation, collaboration, and communication, with opposition to their work rare.

Training a network of end-users nationally to assist with releasing, monitoring, and redistributing agents, and to spread the word about biocontrol, has allowed a relatively small group with modest funds to release more agents, more quickly and widely, more successfully, and more cheaply than any other country.

[HTTPS://www.landcareresearch.co.nz/publications/weed-biocontrol](https://www.landcareresearch.co.nz/publications/weed-biocontrol)

The tradescantia leaf beetle Neolema ogloblini, brought to Aotearoa by Manaaki Whenua to control the pest plant tradescantia.



Brad White

Recent research: **Setting a thief to catch a thief**

Current pest control relies heavily on the use of toxic baits, for which social licence is partial. As part of our 'Eradication Science' work we have been working on more subtle behavioural and motivational aspects of predator control, identifying and testing a range of 'social lures' for their ability to attract target species to traps. We have discovered that ferret odour is a powerful attractant for smaller predators, a finding of both practical and theoretical importance. By exploiting this drive to investigate predator odour we can drastically increase capture rates: for every 10 introduced mustelids caught with a standard approach, we caught 25 mustelids by adding predator odour to the standard approach. Increasing the capture rates of stoats and weasels by between 150 and 300% in this way will make a material difference to native species conservation.

[HTTPS://www.landcareresearch.co.nz/news/smarter-trapping-for-better-results](https://www.landcareresearch.co.nz/news/smarter-trapping-for-better-results)

Looking to the future: **Social licence to operate**

An essential ingredient in successful applied research, social licence to operate is sought after by groups and organisations wishing to bring about environmental changes. For example, if AoNZ's ambitious predator-free goals are to be realised, social licence to operate will need to be built around the introduction of new pest control technologies.

However, social licence to operate is much more than good PR and promises: it involves the sequential building of credibility and trust over time with affected communities of interest. Social licence is not a single specific permission granted by communities to an organisation, but is better thought of as multiple licences achieved across various groups at different times. It is subject to change as opinions and perceptions change, and needs to be continually managed for, rather than obtained.

Manaaki Whenua's social researchers have recently developed a practical framework informed by both Western and indigenous views of engagement, which is now being used to guide organisations in gaining and maintaining a credible and effective social licence.

[HTTPS://www.landcareresearch.co.nz/news/building-social-licence-to-operate](https://www.landcareresearch.co.nz/news/building-social-licence-to-operate)

Outcome 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.

Long-term research delivery: **Survey of Rural Decision Makers**

The biennial Survey of Rural Decision Makers, run by Manaaki Whenua since 2013, is completed by around 6,000 farmers, foresters, and growers, including commercial operators and those on lifestyle blocks. Participants represent all types of primary production across all 16 regions of the country. Each survey incorporates emerging topics of interest, most recently focusing on climate change and well-being, and enables the delivery of a wide range of analyses and statistical information to support national, regional, and sector policy development and evaluation.

The results from 2019 show that farmers are more aware than ever of the risks climate change poses to their activities. Most farmers, foresters, and growers believe that climate change is already affecting

AoNZ, but encouragingly most also stated that they had introduced management practices to mitigate climate change effects, such as changing stock rates, increasing feed reserves, changing stock breeds, investing in infrastructure to stop flooding, increasing water storage, and planting trees. For 2021, the early results have shown interesting trends in well-being and mental health among farmers, using the World Health Organisation Well-being Index (WHO-5).

[HTTPS://www.landcareresearch.co.nz/srdm](https://www.landcareresearch.co.nz/srdm)



Farmland after the floods of 2015, Foxton. Our social scientists aim to support farmers to make decisions, increasing their resilience to future climate change.



Recent research: **Changes in the rural Aotearoa New Zealand hazardscape**

AoNZ is a highly dynamic, multi-hazard environment, with coastal, riverine, and seismic landscape hazards. Manaaki Whenua's social scientists are currently building a wide body of knowledge about the importance of co-creating knowledge with practitioners on the ground about disaster response, allowing effective knowledge sharing across AoNZ's locally devolved and complex disaster management response systems.

Our most recent research has found, for example, that farm-level flood resilience can be enhanced through farm-level response and recovery plans. We also monitored the capacity to absorb shocks and prepare for future uncertainty among Marlborough winegrowers and the wider wine-production industry following the 2016 Kaikōura earthquake.

We have begun developing applied approaches to support adaptation planning and decision-making, beginning with Hawke's Bay. A 'pathways planning' approach is one method: it creates a framework to support decision-making in the face of deep uncertainty, importantly adding a participatory element, engaging with diverse values and conflicting objectives, and opening up conversations to identify ideas that participants might pioneer and test in preparation for change (e.g. climate change).

[HTTPS://www.landcareresearch.co.nz/news/changes-in-the-rural-hazardscape](https://www.landcareresearch.co.nz/news/changes-in-the-rural-hazardscape)

Looking to the future: **Exploring the impact of climate change on Māori**

Māori governance institutions are increasingly asserting their rangatiratanga (autonomy) to manage climate change risks and meet the well-being of whānau, hapū, and iwi. However, there is a shortage of guidance and understanding on how to prepare for and respond to this changing environment, and how to address the challenge in a way that reflects Māori world views and values.

Manaaki Whenua researchers, including Senior Kairangahau Māori Dr Shaun Awatere, have been part of a multidisciplinary team of Māori researchers, coordinated by Ngā Pae o te Māramatanga, to help fill this knowledge gap, identify risks, and explore climate change mitigation and adaptation solutions for Māori.

There is a need for further integrated assessments and understanding of climate change risks from a te ao Māori perspective. Researchers say that whānau, hapū, and iwi will need to consider adaptation strategies that protect the integrity of te reo me ōna tikanga (Māori language and customs), future-proof existing cultural infrastructure, and provide flexibility and safeguards to enable whānau to engage in social/cultural activities that enhance well-being and ensure an enduring cultural legacy for future generations.

[HTTP://www.maramatanga.ac.nz/te-arotahi-07](http://www.maramatanga.ac.nz/te-arotahi-07)



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.

Long-term research delivery:

Measuring and mitigating on-farm emissions

Several inter-related research programmes are in progress at Manaaki Whenua. These programmes aim to determine the processes and drivers regulating greenhouse gas emissions from grassland, shrubland, and forest systems, reduce uncertainties in measuring and scaling emissions and removals, and provide the modelling and analytical tools for assessing, scaling, and reporting emissions at farm to national scales.

Our research on greenhouse gas mitigation has involved both fundamental and applied work. We have delivered a significant impact through our applied research to refine AoNZ's greenhouse gas inventory. We have also worked on novel ways to inhibit nitrous oxide (NO) emissions from urine patches. At a more fundamental level, we have discovered a new pathway combining reactive N with organic N to create benign N₂ in soils, without any formation of harmful NO.

With average soil carbon stocks in AoNZ's agricultural soils estimated at about 100 tonnes per hectare in the top 30 cm, changes in soil carbon could make a significant contribution to our national carbon footprint. We are currently opening the black box of soil carbon on farms, measuring and monitoring soil carbon at 500 sites across the country as part of a national soil carbon benchmarking programme, with funding from the New Zealand Agricultural Greenhouse Gas Research Centre and MPI. We are also working on methods to allow farmers to determine soil carbon on their individual farms.

AoNZ's pasture soils generally have high stocks of carbon that seem stable under contemporary management practices, but more comprehensive data are needed.

[HTTPS www.landcareresearch.co.nz/partner-with-us/our-science-portfolios/climate-change-adaptation-and-mitigation/](https://www.landcareresearch.co.nz/partner-with-us/our-science-portfolios/climate-change-adaptation-and-mitigation/)

Recent research:

A first for on-farm carbon certification

Lake Hawea Station, a 6,500-hectare station on the eastern shores of Lake Hawea that runs close to 10,000 Merino sheep and 200 Angus cows, has been named as the first farm in AoNZ to have a carbon footprint certified by environmental certifications provider Toitū Envirocare, a subsidiary of Manaaki Whenua (see page 63).

Developed in partnership with Overseer and AsureQuality, Toitū's farm certification programme is AoNZ's first carbon certification designed specifically for farms. The programme uses Toitū carbon management software that integrates OverseerFM greenhouse gas emission analysis. AsureQuality's role is to independently verify the farm's carbon footprint.

The certification process Toitū has undertaken on Lake Hawea Station is planned to be the first of many for AoNZ farms, as the country moves to lower its overall carbon footprint and consumers worldwide demand carbon-positive food and fibre.

[HTTPS www.toitu.co.nz/home](https://www.toitu.co.nz/home)

Looking to the future: Native forests and carbon removal

September 2020 saw the publication of *Native Forests: Resetting the Balance*, a report by the Aotearoa Circle that explores ways in which we can accelerate the regeneration of native biodiversity at scale while optimising the use of Aotearoa's land assets. The report offers one solution: to plant or regenerate native forests as carbon sinks.

As Manaaki Whenua's Land Resources Inventory shows, there is plenty of agriculturally marginal land across the country that could support native forests. Planting, or regenerating, native forests instead of exotic timber is estimated to provide \$6,677 per ha of monetised ecosystem services, including carbon sequestration, biodiversity and freshwater benefits, and social and cultural benefits. This is more than is estimated can be derived from exotic forestry (\$6,092 per ha), even allowing for the value of the harvested exotic timber.

Encouragingly, there is already strong support within the primary sector for the planting of natives. Native forests are an international gold standard in emissions trading, and their offsets are sought after by businesses to help them create value-laden products; Fonterra's carbon-neutral Simply Milk, certified by Toitū Envirocare, is a good example. Manaaki Whenua's most recent Survey of Rural Decision Makers also found that those who intend to plant trees in the near future on their land disproportionately plan to plant native trees, often citing guardianship, or kaitiakitanga, as the primary reason.



[www.landcareresearch.co.nz/
news/getting-offset-not-offside-
about-native-forests](https://www.landcareresearch.co.nz/news/getting-offset-not-offside-about-native-forests)



Dr John Hunt and Dr Scott Graham inspect instrumentation for continuous field measurements of carbon dioxide exchange at paddock scale for irrigated lucerne at Lincoln University's Ashley Dene research farm.

Outcome 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.

Long-term research delivery: **The Land Cover Database**

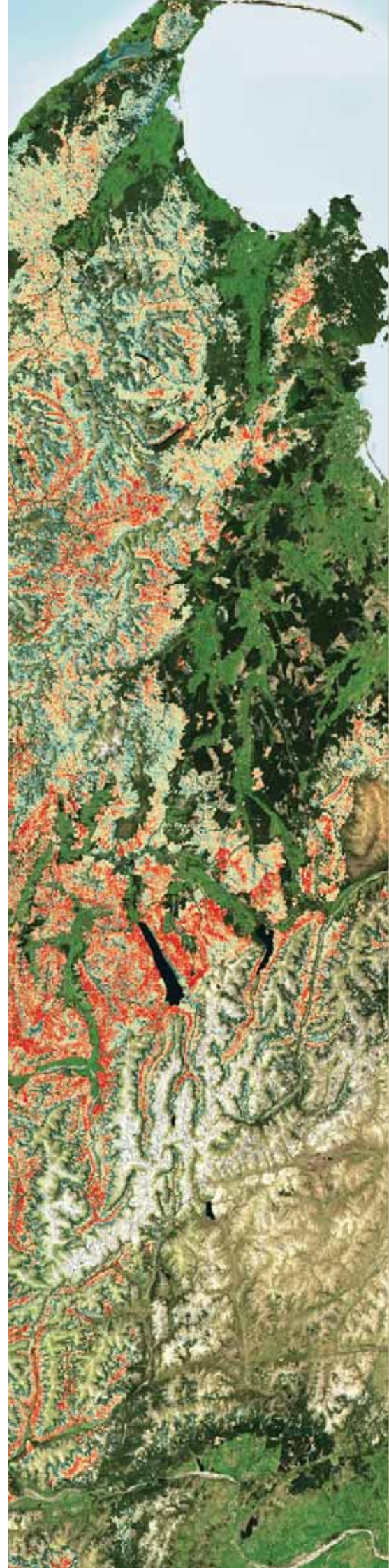
The first Land Cover Database (LCDB) – a digital map and multi-temporal thematic classification of AoNZ's land cover – was released nearly 20 years ago. Since then, progressive improvements in land-cover mapping have been made, with a major upgrade to the latest version (version 5) made at the start of 2020.

The LCDB describes the extent of vegetation, built environments, water bodies, and bare natural surfaces across AoNZ. It is used for a surprising number of applications, from international and national reporting of the state of the environment, through to the production of better maps, and the management and monitoring of land cover and land use. Measuring the composition of land cover and its changes is crucial to help decision-makers understand the pressures that different land uses are placing on our land and waterways, along with the implications for biodiversity and the functioning of ecosystems.

One changing land-cover concern is the ongoing decline in wetlands. Our data show that wetlands – AoNZ's most depleted and threatened ecosystem – have continued to reduce in the past 6 years, with only 220,000 hectares remaining. Other preliminary results of the latest upgrade show that growth in the country's built-up area appears to be at a rate of one to three thousand hectares per year, of which 65–75% is on high-producing pastoral land and 8–10% on cropland, orcharding, and other land covers.

 www.lris.scinfo.org.nz

The data in this image show beech forest flowering (red = higher intensity); used to predict beech mast years and subsequent rodent increases.




Recent research:

Advanced Remote Sensing Aotearoa

Modern remote-sensing techniques use all parts of the light spectrum and are very high resolution, and the data sets are updated every 5 days as satellites pass overhead. However, perfectly cloudless skies are rare, and even wisps of high cloud can distort and hide important details on an image. As part of our Advanced Remote Sensing Aotearoa research programme we developed a full cloud-clearing method for satellite images on one of New Zealand eScience's high-performance computers in Wellington. The new method, run on the supercomputer known as Mahuika, is a big step forward in remote sensing, enabling scientists to efficiently clean and prepare large archives of satellite imagery, removing clouds and their shadows to create sharp topographical mosaics. The cleaned images allow analysis of landscape and vegetation changes over relatively short time scales, including patterns of crop flowering and growth, soil erosion, and forest health.

We have also developed a new remote-sensing method to identify when beech trees flower. This work is especially useful to predict the likelihood of prolific seed seasons known as beech masts, because these in turn predict rodent population increases in our native forests. Combining this technique with the cloud-clearing method allows patterns of forest canopy behaviour, including the unusual beech mast signal, to be seen clearly.

 www.landcareresearch.co.nz/news/smarter-remote-sensing-for-effective-land-management

Looking to the future:


Geospatial data science at the cutting edge

We combine our researchers' expertise and our data-handling capabilities to produce unique insights for environmental management, with colleagues both in AoNZ and further afield. We are involved in many cutting-edge geospatial projects, including the following.

- Building on recent success in depicting stands of forest through LiDAR imagery, we have been developing techniques for monitoring biodiversity and ecosystem structures via remote sensing. We know that some species populations' data can be obtained by this method, along with the trait of phenology (where changes can be picked up visually). However, ecosystem structure shows most promise for remote approaches through live cover fractions and ecosystem distribution/vertical profiles. The work is being helped by a major collaboration between Manaaki Whenua, Scion, two Singaporean research institutes, the University of Canterbury, and Victoria University of Wellington.
- We are adding expertise to a project using machine-learning modelling of electromagnetic and gamma-ray spectrometry data to predict patterns of cation exchange in a sugarcane field in north Queensland to

assist the precision application of fertilisers. We are also using three-dimensional modelling of electromagnetic data and inversion software to predict in-time soil moisture status during wetting and drying cycles across an irrigated cotton field in northwest New South Wales to improve irrigation efficiency.

- In work for the Parliamentary Commissioner for the Environment, we are using 'deep learning' (artificial intelligence) to map buildings and urban green spaces back to 1940 from historical aerial imagery.
- We are also exploring deep learning to generate weekly maps for land-use change detection, using the LCDB.
- As part of our Predator Free 2050 work, we are refining automatic species detection in camera trap images for citizen scientists and ecologists through the Trap.NZ website.

 www.landcareresearch.co.nz/uploads/public/Publications/capability/MWLR-Informatics-factsheet.pdf

Outcome 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.

Long-term research delivery: **Achieving better policy performance in resource management**

Our social and economic scientists focus on the social, cultural, and economic aspects of natural resource management to improve policy performance and enhance decision-making among all stakeholders. The development of effective policy entails:

- designing, undertaking, and evaluating engagement processes and strategies
- understanding preferences, attitudes, values, and governance processes for natural asset management
- assessing information to underpin choices and decisions
- designing policy instruments and their implementation
- tracking policy performance to enable adaptive management.

A key focus has been developing frameworks, tools, and approaches for environmental decisions that support Māori participation, recognise indigenous Māori rights, and promote obligations underpinning the Treaty of Waitangi.

For example, our multi-year MBIE-funded BEST research programme (Biodiversity and Ecosystems Services for resource management), completed in 2019, aimed to build biodiversity into an ecosystem service-based approach for resource management. The idea was to help key stakeholders from regional councils, central government, Māori organisations, and industry sectors to make better-informed, more integrated decisions that preserve options for future resource use.

<https://www.landcareresearch.co.nz/discover-our-research/environment/sustainable-society-and-policy/best-biodiversity-and-ecosystem>

Recent research:

Future drought could drain primary sector profit

New research by the Deep South Challenge and Manaaki Whenua, with the support of Motu Economic and Public Policy Research, has found that more intense future drought is likely to lead to drops in farm profit.

Comparing trends in 70,000 farm tax returns with temperature and soil moisture data, scientists were able to understand the historical relationship between local weather and farm profits in both the dairy and sheep & beef industries, and apply it to future scenarios.

The research showed that under a high climate change scenario – the pathway representing little climate action and high economic growth – sheep & beef farmers, vulnerable to high temperatures and soil moisture loss, could see a profit loss of up to 54% by the end of the century, subject to a high degree of uncertainty.

In AoNZ very little research has been done on the implications of climate change for society using approaches that measure the historical relationship between weather conditions and economic and social outcomes. This research is among the first to do so.

<https://www.landcareresearch.co.nz/news/future-drought-could-drain-primary-sector-profit>



Looking to the future: **Increasing capability and confidence among land managers**

The primary sector underpins the country's economy, and land managers are integral to achieving environmental goals. However, many land managers are not achieving the scale of action necessary to improve environmental performance, and are overwhelmed by the complex issues they face. Our new MBIE programme, 'Moving the Middle', will address this issue and provide the systemic changes needed to enable land managers to act. This will improve farm environmental performance, ecosystem function and biodiversity,

farm financial viability, national economic performance, rural mental health, and environmental, economic, and social resilience in the face of disruptions such as Covid-19 and climate change.

Past research has often assumed the problem is an 'information deficit' and has focused on understanding and influencing either 'leading' or 'trailing' land managers. In contrast, our research focuses on the middle cohort of land managers who are willing to make necessary changes but are constrained by the

multiple systems (finance, policy, social, market, etc.) that affect how they shape their decisions and actions. Our social science research examines, innovates, and tests points at which levers to the systems can be applied, enabling the middle cohort of 'overwhelmed' land managers to respond proactively to the environmental, market, and societal challenges they face.

[HTTPS://www.landcareresearch.co.nz/partner-with-us/our-science-portfolios/society-culture-and-policy](https://www.landcareresearch.co.nz/partner-with-us/our-science-portfolios/society-culture-and-policy)

OUR RESEARCH CAPABILITIES O MĀTOU ĀHEINGA RANGAHAU

As a Crown Research Institute (CRI), Manaaki Whenua has a responsibility to maintain national capability for excellent research in its field. We define excellent research as being innovative, fit for purpose, rigorously conducted, and achieving impact.

In short, we think of the right research, done by the right team to achieve the right outcome. This demands both excellence and capability.

Researcher Phil Novis taking snow and ice samples from the Fox Glacier as part of a study of the effects of Australian bushfire dust on AONZ's glaciers and the snow algae they contain.





Maintaining excellent research and capability

Excellence

One measure of world-class research is through publications and citation metrics. Manaaki Whenua's citation score since 2016¹ has led the CRIs, and with a score of 1.69 in 2020 was first among Aotearoa's CRIs and universities, and ranks alongside the world's leading environmental research institutes. Research publications are valued by the users of our work because they provide credibility for the evidence used by those users in developing policy and deciding on their courses of action.

“From 2018 to 2020, over 2,200 (67%) of our research publications were co-authored overseas”

To keep our research at the leading edge we collaborate extensively in the global research community. In the 3 years from 2018 to 2020 over 2,200 (67%) of our research publications were co-authored overseas. Consistently, over 90% of all our research publications are co-authored by researchers outside Manaaki Whenua.

Right teams

Almost all our research involves collaboration with other organisations. In leading the 'right teams' for our research projects, we subcontract around 20% (approx. \$16 million) of our annual research revenue to other research providers in CRIs, universities, and independent research organisations such as the Cawthron Institute. In certain research funds, such as MBIE's Endeavour Fund, the percentage we subcontract out is typically higher (up to 40%), as we lead research teams that combine diverse skills.

International Science Advisory Panel

Our Science Advisory Panel² brings an international scientific perspective, helping us to evaluate our scientific excellence, explore emerging science needs, and develop research areas. In 2019 and 2020 the Panel evaluated our major research areas, and its summary conclusions of the science excellence of the work we do in 'soils, water and land' and 'climate action' were as follows: "The Panel finds the work in the reviewed platform to be at the high level expected of this leading CRI. There is clear evidence of breakthrough science by traditional metrics (papers in high-impact journals such as *Nature*, high citations, etc), and evidence of impact through the development and provision of nationally critical databases and information services and through deep engagement with a growing range of stakeholders. Manaaki Whenua is internationally competitive despite existing in a national environment which requires significantly more funding to be obtained competitively than in equivalent overseas systems."

The Panel encouraged us to focus on creating a culture in which Māori and Māori research can flourish, and in which time is protected for innovative thinking and experimentation. They recommended fresh thinking about the role of our collections, which is the subject of their next review.

² Science Advisory Panel members November 2020: Prof Jason Tylianakis FRSNZ (Chair), University of Canterbury; Dr Simon Lambert (Tuhoē and Ngāti Ruapani), University of Saskatchewan; Dr Susan Hubbard, University of California, Berkeley, USA; Dr Brajesh Singh, University of Western Sydney, Australia; Dr Jenny Webster-Brown, Director, Our Land & Water National Science Challenge; Prof Jan Bebbington, University of Birmingham, UK.

Research capability

Manaaki Whenua has a responsibility to maintain national research capability in our impact areas, balancing the demands of present and future research areas with talent availability and fluctuating research income. In recent years our focus has been on recruiting individuals that can lead and work in integrated teams to broker holistic solutions. Disciplinary areas where we have invested are:

- **Soils research**, receiving little national investment between 2000 and 2010, has become a high priority because of its importance to production and water quality. The period of low investment hindered our provision for succession, but we have since rectified this through sustained effort over the past 4 years to grow capability and develop new leaders to meet the present high demand.
- **Māori research**, receiving little dedicated research investment until recently, is now an area of great demand in which many research organisations want to build capability. But there is a limited pool of Māori researchers and a need for collective action to bring more through the tertiary system into research roles and leadership positions [see page 46].
- **Social and economic research**, critical to achieving environmental goals through social, regulatory, and governance processes, has also struggled to compete with biophysical sciences for research investment. Over two decades we have built a world-class research

capability in applied integrative research.

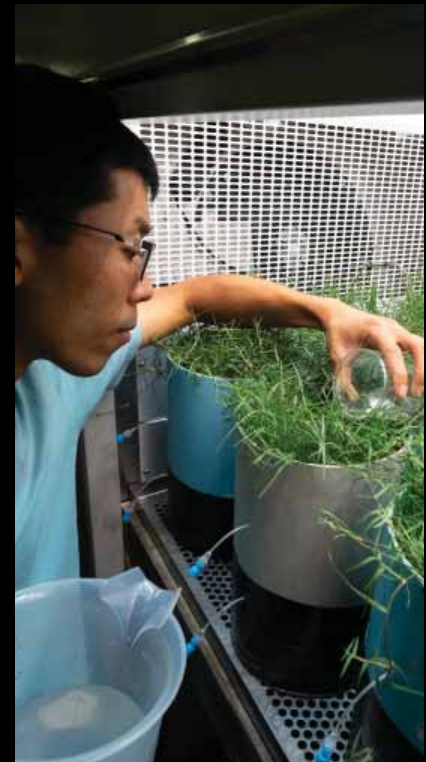
- **Genomics research**, while providing a key to new technologies for understanding and managing our biodiversity and the risks it faces, has grown significantly and put pressure on international talent pools. Much of this research also requires deep bio-informatics skillsets.
- **Data science and digital technologies**: in implementing our e-Research strategy, we have employed a data science leader and a data science capability advisor. The capability advisor

has a sole focus on upskilling our researchers and connecting them with data scientists attempting similar tasks in other universities and CRIs. We are extending our capability in data science and Earth observation/spatial mapping and focusing on succession, a skillset that supports our long-term partnerships with central government agencies requiring customised solutions to achieve national environmental outcomes. Our expertise in geospatial, whole ecosystem modelling and in surveillance/modelling of wildlife disease was recently applied to COVID modelling as well.



Brad White

Dr Jessica Riviera-Perez in the ancient DNA lab, Manaaki Whenua



Brad White

Lincoln University PhD student Yuan Li watering his Bermuda grass experiment at Manaaki Whenua.

Capability to uphold Te Tiriti

We continue to grow our pool of Māori scientists and researchers across all our disciplines, which also hold equally strong te ao Māori (Māori world-view) perspectives, connections, and cultural skillsets. We have a dedicated Māori capability group (Manaaki Taiao ki Kirikiriroa) that focuses on the development of the kaupapa Māori skills of our kairangahau. Kairangahau Māori can either join a different [science discipline-based] team after an initial grounding in these methods, or may choose to remain in this capability group. In 2021 we recruited an additional experienced Māori Land Mapping Programme Manager and a Māori Cultural Capability Adviser. This complements our already strong Māori team. We are also appointing new strategic leadership roles in Manaaki Whenua [see page 67].

It is important to expose our Pākehā colleagues to iwi/Māori organisations so that they gain experience and confidence in working in Māori settings, but we do not expect our kairangahau Māori to provide this teaching role. We have been offering noho marae training to all staff for several years, and enjoy some long-term relationships with iwi and hapū that provide on-the-job familiarisation in tikanga. In 2021 we added a staff member to extend our cultural training.

Encouraging kairangahau into research requires concerted effort across the sector. We are engaging in ongoing discussions with the Director of Māori Research, Science & Innovation at MBIE, and others, to work together to enhance Māori outcomes. An example is the Māori emphasis in the Joint Postgraduate School that links Canterbury and Lincoln Universities with three CRIs (AgResearch, Plant & Food Research, and Manaaki Whenua), as well as the Māori summer studentships for undergraduates we have supported through our partnership with the University of Auckland (Centre for Biodiversity and Biosecurity).

Growing research talent

To build the next generation of researchers and address the shortage of AoNZ-trained PhD researchers in our fields, we support on average 60 AoNZ PhD students annually through co-supervision of their studies. We formalised this arrangement in two postgraduate schools: since 2010 with the University of Auckland on biodiversity and biosecurity, and since 2020 with the University of Canterbury, Lincoln University, AgResearch, and Plant & Food Research on Food Transitions 2050.

“ We support on average 60 PhD students each year ”

Research capability to address national emergencies

At the time of the Covid-19 outbreak in AoNZ, Manaaki Whenua was able to reallocate the efforts of two highly skilled mathematical modellers from their work on predator control strategies. They joined the national team that later won the Prime Minister's Science Prize 2020 for its work in advising government on pandemic responses. Eighteen months later our Dr Rachelle Binny and Dr Audrey Lustig continue to work in that virtual team, which has published numerous international scientific findings from their Covid-19 modelling.

This example of providing research capability at times of national emergency is typical of the role and readiness of CRIs. Manaaki Whenua's emergency responsiveness role is especially in biosecurity. However, skills are transferable, as in the example above, between predators and human viruses. Manaaki Whenua is frequently called upon to identify potential invasive species detected at the national border and in agricultural settings.

Our work extends to supporting government agencies in dealing with border incursions, such as myrtle rust disease, through rapidly building a profile of the invasive species. Ideally the chance is taken to identify threats before they reach our shores and to model their potential impacts should they gain access.

Our social researchers help government with understanding people's behaviour in national emergencies, and the effectiveness of public interventions, including mask-wearing and vaccination.



National biosecurity issues include wilding pines (left), myrtle rust (centre), and Covid-19 (right).

Collections and databases: underpinning nationally significant science

Manaaki Whenua holds and curates a range of collections, databases and information systems on behalf of AoNZ. They are a significant national asset. The estimated cost of recollecting the data for the National Vegetation Survey alone is over \$300 million, but the data were collected over 70 years and could not be replicated. Likewise, the samples in the biological collections have been collected over more than 100 years, with some collected by Banks and Solander on the voyage of Captain Cook in 1769.

Our collections and databases have special significance for Māori, who have whakapapa (kinship) with the material in the collections. They are taonga (treasures) to Māori because they contain thousands of specimens of indigenous species. Manaaki Whenua has the responsibility to maintain their vitality and value, and to protect Māori interests in them. We have taken care to ensure this responsibility

is discharged, reflecting the special issues of data sovereignty, intellectual property, potential for beneficial use, and accessibility that empowers communities to add and derive value. But there is much more to do to fulfill our commitment to the principles of Te Tiriti. We are now exploring pathways with Māori for sharing accountability and collectivising value.

The material and data underpin critical science-based services and scientific research in AoNZ and internationally. Five of the collections and four of the databases are deemed to be 'nationally significant', and as such receive dedicated, but inadequate, government funding each year for their support. We invest to fill the gap at about \$1 million per year. Others, such as S-map and the Land Cover Database, fall outside of this system, and their funding is sporadic.

A summary of the activities that ensure they deliver value to AoNZ and the world, such as supporting national biosecurity and emergency responses and underpinning land use and the protection of water quality, is given on pages 74–75. The collections and databases are part of an integrated international network and are a key contribution to the Global Biodiversity Information Facility. They are also important infrastructure for Pacific countries, such as Tonga and Niue, who do not have the resources to have such facilities.

Collections and databases become more valuable over time. They must be maintained to enable people to derive as yet unknown value and address unknown future issues.

Specimen of Pittosporum collected by Joseph Banks and Daniel Solander, 1769, in the collection of the Allan Herbarium, Manaaki Whenua



New Zealand's Biological Heritage National Science Challenge

The challenge of public good research

Most of Manaaki Whenua's research is for the public good and focused on enhancing the natural environment and people's well-being. Research for the public good runs the risk of market failure, however, where individual investors do not take responsibility for research with broadly distributed benefits. This research is dependent on government funding for the public good, and must be prioritised against the multitude of other government spending priorities.

An example is investment in the national databases and collections in which we maintain vital information about the nation's natural assets – biodiversity, soils, and ecosystems. These support multiple organisations and create multiple benefits. Our policy is to make the value of these assets widely and freely available. Most are under-funded and constrained. Our challenge is to leverage funds from multiple sources, as we do with the national soils map database, S-map Online [see page 18].

In 2014, the Government established 11 national science challenges (NSCs) to focus collaborative research on major national priorities. Manaaki Whenua plays a role in six of the NSCs, and we host the NZ Biological Heritage NSC. The goals of this NSC align very closely with our own for biodiversity and biosecurity, and we are the largest research provider for its work. In addition to driving collaboration in the research community, this NSC has made very significant progress in reaching out to Māori and bringing Māori into the work of the NSC.

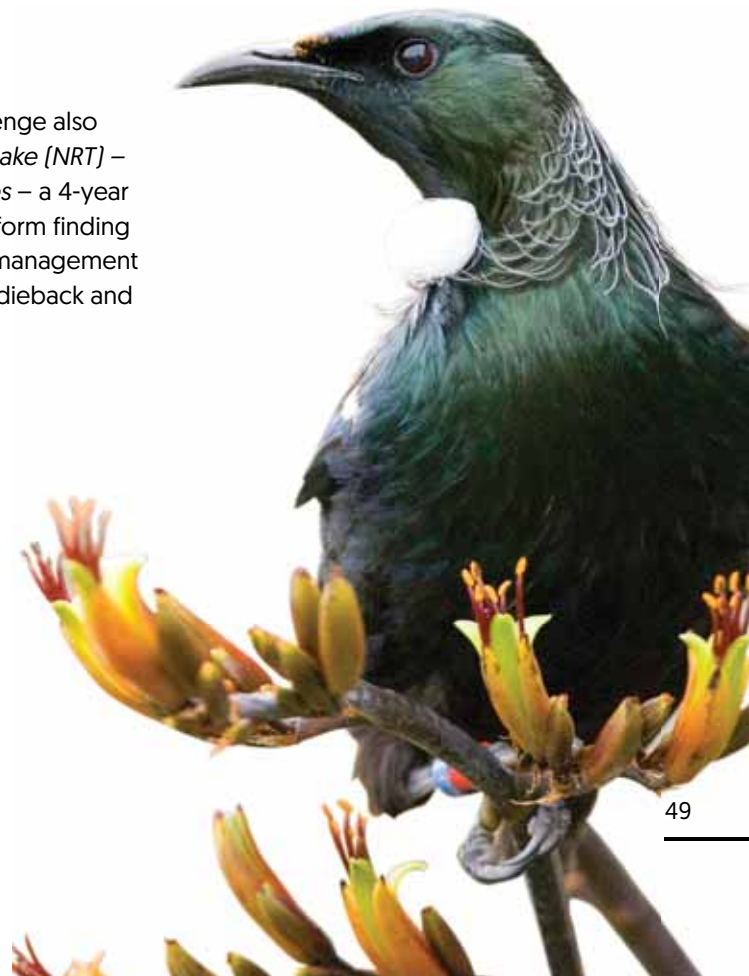
BioHeritage is strategically focused on three impact areas that strongly align with Manaaki Whenua's work:

- whakamana – empower
- tiaki – protect
- whakahou – restore.

The BioHeritage Challenge also leads *Ngā Rākau Taketake (NRT) – Saving Our Iconic Trees* – a 4-year strategic research platform finding new solutions for the management of two diseases: kauri dieback and myrtle rust.

BioHeritage Challenge parties

Eighteen organisations formally partner to create the BioHeritage Challenge. They are: AgResearch, Auckland University of Technology, Cawthron Institute, Department of Conservation, 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, Victoria University of Wellington, with Manaaki Whenua as the Challenge host.



A woman with long dark hair, wearing a teal jacket with a logo, is walking through a forest. She is looking down and to the right. The background is a dense forest with many trees and ferns.

OUR PEOPLE MŌ MĀTOU

*Dr Manpreet Dhani and Dr Peter
Buchanan take part in the 2021 Fungal
Foray, Stewart Island.*



Putting people at the centre

The well-being of the environment and of people are mutually dependent. People strongly influence the state and fate of the natural environment. At all levels, from our backyards to the wider world, people's decisions and actions determine the balance between damage and repair to the environment. What matters is how people make decisions, how they work together in organisations, and how they influence each other through regulations, expectations, and cooperation. Our research seeks to understand and support those dynamics because they are critical to the future state of the environment and people's well-being.

People are also central to Manaaki Whenua – to our values, culture, ways of working, and effectiveness. Our culture of health, safety, and well-being is founded on the value of caring for people [manaaki tangata]. Our culture of personal development reflects our aspirations for excellence and contribution to the best of our abilities. Our culture of equity, diversity, and inclusion respects and values differences between people. We are on a journey alongside changes in society. The effectiveness of our corporate processes depends on their being fit for use by our people. We have learned the hard way that it is essential to put people at the centre when developing infrastructure projects such as new buildings and IT developments.

People make up the Manaaki Whenua community. That community extends beyond our 444 staff in Manaaki Whenua and Toitū Envirocare, and includes the hundreds with whom our people interact in government, iwi, industry, and community groups; the hundreds we collaborate with in the AoNZ and global science communities; those around the world in the families of our people, with half of our recruits being from overseas; those who have worked at Manaaki Whenua in the past and are still active in related jobs; the many research associates and volunteers who graciously give their time to support our work and people; and the thousands who contribute to our research through surveys and citizen science.

We salute everyone in our wider community and thank you for your involvement and for supporting our ambition.





Putting people at the centre, in practice

To create an environment where high impact research can thrive, we must put people at the centre. In practice this means working to understand the needs of our people and those they collaborate with, and building processes, systems, and infrastructure that support their needs.

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.

We have recently begun to employ human-centred design¹ (HCD) to achieve this. We are developing a specific and replicable set of skills within the organisation that enables our staff to collectively make decisions and participate fully in workplace management and workplace change.

We are using HCD methods to develop new infrastructure to enable the future of environmental research for AoNZ. This approach is also helping us to reshape the processes that underpin how we imagine the future of work, of our infrastructure, and the future of projects. Together these underpin our financial resilience.



¹ Human-centred design, developed at Stanford University, is an approach to problem-solving that includes the human perspective at every step.

Our people and culture

As a part of our strategy over the past 5 years we have worked with our people to define the culture that Manaaki Whenua needs to achieve its ambition. Through our annual staff experience survey and working groups we have focused on areas that are important to our people and to the sustainability of Manaaki Whenua. Many of these themes align with the UN Sustainable Development Goals, and we have developed KPIs and goals for our performance [see pages 76–77].

Providing for health, safety, and well-being

Our work in laboratories and remote field locations is intrinsically hazardous. In recent years we have taken steps towards a “safety differently” culture, which puts people at the centre and learns from work as it is done. We focus on ensuring our people have the right approaches, tools, and guidance. We seek to learn from accidents and near-misses without blame. Importantly, our people consider that Manaaki Whenua takes their well-being and safety very seriously.

95% of staff feel
Manaaki Whenua is committed to their health & safety [2021].

Mental well-being has been an issue globally with the Covid-19 pandemic, greatly increasing stresses on staff in their own work and in the lives of their families and friends. We have adopted a flexible working environment where most staff combine working from home and the company’s sites at hours that enable them to meet competing demands. We organise events to ensure staff keep in contact and meet up informally during working hours. Our people have free access to independent and confidential help-line services.



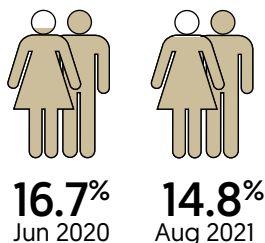
Creating an equitable culture

In focusing on people, we seek equity in opportunity and reward across all groups in Manaaki Whenua. This includes addressing the slow-changing legacy across the science sector of researchers and leaders having been mostly male of European descent. When equivalent roles are compared, we have achieved gender equity in remuneration. However, the lower proportion of females in leadership roles means we have an overall gender disparity in remuneration. We want to ensure that more women and people of non-European descent are shortlisted for leadership roles, and that staff are not disadvantaged by taking career breaks to support family and whānau.



VERTICAL PAY GAP

difference between salaries for men vs women across the organisation¹



We are committed to closing this gap. Our average horizontal pay gap is below 5%.

ETHNIC PAY GAP

*Our Māori staff have a median pay gap in their favour of **11.6%** compared with non-Māori.²*

This reflects the number of Māori staff who are senior scientists.

¹ The gender pay gap compares the median hourly earnings of women and men in full and part-time work and is shown as the difference between men’s and women’s earnings as a percentage of the men’s earnings. The average vertical public sector gender pay gap is 9.6%. Our pay gap is driven by the fact that only 20% of our Senior Leadership Team and only 25% of our Tier 3 science leaders are women. We also monitor horizontal pay gaps (differences in pay between men and women in the same pay grade). Our average horizontal pay gap is below 5%. ² European, Asian, and Middle Eastern/Latin American/African (MELAA).

Building a diverse and inclusive work culture

A key facet of our culture is embracing diversity. This recognises that complex, or wicked, problems, such as climate change, will only be solved if we can bring together a diversity of thought, experience, values, perspectives, and skills. There are many parts to building a culture that truly embraces diversity. To help us navigate this journey we invited our people to volunteer for an internal Diversity and Inclusion working group.

This group, which is itself highly diverse, is working with the organisation to identify, prioritise, and champion specific initiatives to develop a diverse and inclusive culture. The group decided in 2020 to focus on a wide range of diversity issues, including building bicultural capability among staff through Māori language training, recognising

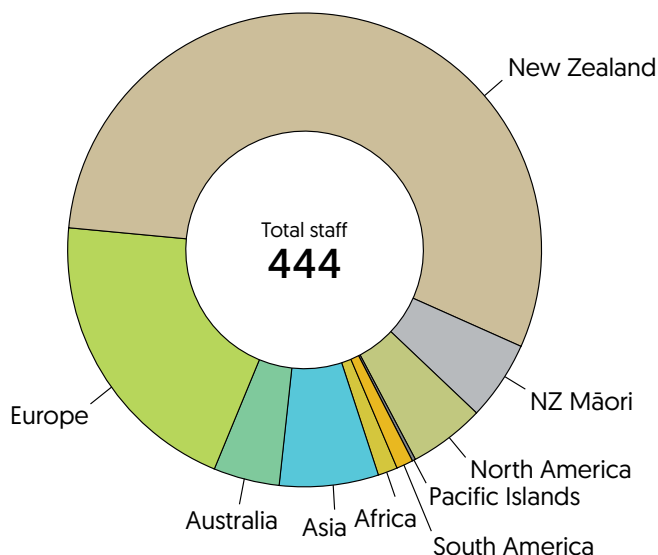
and celebrating neurodiversity, and introducing staff training on unconscious bias. Good progress has been made, and a recent staff experience survey has shown that our people recognise and support our efforts.

In recent years we have enjoyed a steady influx of overseas recruits, adding diversity to our culture.

Our challenge has been to lift the proportion of Māori and Pasifika staff to better represent national demographics. Our emphasis has been on creating a culture in which people of different ethnic groups can thrive and feel safe. Good progress has been made, such that our staff experience survey has shown that our people recognise and support these efforts.



ETHNICITY OUR PEOPLE DECLARE



Employee Experience staff survey results

Each year we run an Employee Experience survey among our staff. In 2021, 85% of our staff responded to the survey. The following statements and results are from the inclusivity section of the survey:

- I feel comfortable bring myself at work, with my colleagues - 84%
- I feel accepted as a valued member of the team - 81%
- I feel included at this organisation - 76%

Living our values and behaviours

Our values are manaaki tangata and science that delivers. In a series of workshops with our people, we developed five behaviours [below] that support those values.

They apply equally to our researchers and the people who support research. Since defining these we have run initiatives to support our people in living these behaviours.

Our Future of Work

In the past year Covid has presented us with the ultimate opportunity to develop skills, tools, and processes around how we work.

Our Future of Work programme explores how new ways of working can enable greater collaboration (inviting input from others, and sharing freely and often), and allow us to better embrace the diversity of working needs our people have.

In the first lockdown (April 2020) we saw an opportunity to ‘experiment to learn’ with our future of work. A series of human-centred design thinking workshops were used to explore what we could bring from this experience into our future way of working.

For many of our people, lockdown created a new sort of equality in work. Parents could freely work from home and balance childcare with work. Staff at remote sites were no longer left out of in-person meetings and workshops (everyone was virtual). These findings enable us to refresh our flexible working processes.

We also learned a lot about how to collaborate virtually. Old barriers to collaboration (such as challenges of diary scheduling and travel) were overcome by new virtual methods. We are now building these skills into our new normal, and starting to realise the benefits both to our people and the environment of reduced travel.

OUR VALUES

SCIENCE THAT DELIVERS

Excellence – Relevance – Integrity

MANAAKI TANGATA

Caring – Partnering – Common Purpose

OUR BEHAVIOURS



Experiment to learn
Mā te hē ka tika



Embrace diversity
Awhai mai, awhi atu,
tātou tātou e



Share freely and often
Kia rite tonu te tohatoha



Commit to excellence
Whāia te iti kahurangi



Invite input from others
Kia areare mai ōu taringa



Infrastructure for our future

Our sites

Manaaki Whenua is based at seven sites across Aotearoa. They are places of collaboration, both internally and with other organisations and local communities. All are co-located with a university or major partner (MPI, DOC, other CRIs). Our infrastructure includes laboratory facilities and equipment, our collections and databases [page 74], and IT systems.

Lincoln: Our Te Rauhitanga project (“The Gathering Place”) is an example of putting people at the centre. Originally a project to replace a single 1960s office block that was not up to earthquake code, it became an opportunity to redesign not only our workspaces but also our ways of working together. This required a fundamental understanding of how and why our staff, stakeholders, and visitors use our buildings and interact with each other. We worked closely with our people to design all aspects of the build process, from initial brainstorming to fine-tuned workspace planning and furniture layouts, to reach consensus on the best uses for our new spaces. These have been designed with ergonomics, soundproofing, light, energy efficiency, and access to technologies in mind, to create effective spaces in which to work, meet, collaborate, and take breaks. Te Rauhitanga will be opening in early 2022.

Auckland: Changes at our Auckland site have led us to consider alternative locations. Our preference, subject to government financing, is to move to Mt Albert, where CRIs Plant & Food Research and ESR are co-located. MPI, who lease space in our Auckland building, have made an in-principle decision to move to Mt Albert. Co-locating with those organisations would strengthen that science centre and enable us to create national centres of excellence in biosecurity and Pacific research. At the time of writing MBIE is conducting an integrated infrastructure review, which includes options for CRI facilities in Auckland.

Wellington: Manaaki Whenua is head tenant at our Wellington site, which has become a hub for CRIs in the capital.

Sustainable procurement

Our procurement policy applies to all tenders, and demands disclosure of sustainable performance by our suppliers. This is given significant weighting in our selection process. We use the Aotearoa All-of-Government tendering process and supplier pools in most cases, and follow government guidelines on matters including electrifying our vehicle fleet, and the purchase of goods and services from Māori suppliers.



Our impact process

Manaaki Whenua delivers high-impact research through a huge variety and number of research projects and programmes. In any given year we can have 600 to 800 different research projects on the go. While it is easy to focus on the outcomes of these projects, the approach we take to run research projects, from their conception to the delivery of outcomes, is critical to the impact we create.

Increasingly we are working with wider groups of partners and stakeholders at the point of idea conception. The journey itself is a collaborative effort, among our own researchers and with partners outside Manaaki Whenua. This collaboration extends to those who will use the research: communities, iwi, councils, Ministries, industry bodies, and more.

Dr Scott Graham inoculating soil samples.

The increasing complexity of running research projects is necessary to address the increasingly wicked problems we are exploring. But it does create a huge load for our research leaders, who must also be skilled project managers, business development experts, knowledge translators, relationship managers, accountants, communicators – the list goes on.

In 2021 we initiated a project to step back and re-examine how we deliver high-impact research projects. This follows a lesson we have learned the hard way in the implementation of new systems. We are now working with our people to understand what it takes to lead and manage effective research today, and how that will evolve in response to the needs of our partners in the future. These insights will help us to co-design our research impact process.

We expect this will challenge our current processes, systems, and even our ways of organising people to deliver. But we are excited about the potential to create a more supportive environment for our researchers to deliver these complex, but critically important, projects for AoNZ.

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.

CRI's 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. CRI's are responsible for funding their own capital developments (sites and equipment) in addition to staff costs.

Our financial performance in the past 5 years has been robust, enabling us to invest in our future – our people, strategic initiatives, and capital assets. These included the \$15 million Te Rauhitanga project at our Lincoln site. The Covid-19 pandemic softened revenue over 2020–2022 as the Government's budgets have been constrained and our ability to fulfil contracts has been affected by periods of lockdown. Like others in the sector, we face the challenges of fragmented research funding, and large revenue swings when contracts start and stop.

	Revenue \$m	Net Profit After Tax \$m	Return On Equity
June 2021	97.1	3.3	6.40%
June 2020	89.6	4.9	10.50%
June 2019	85.5	3.0	7.00%
June 2018	77.7	4.9	12.40%
June 2017	65.0	3.7	10.40%



OUR COMMITMENT TO SUSTAINABLE DEVELOPMENT TĀ MĀTOU NGĀKAU TITIKAHA KI TE WHAKAWHANAKE TOITŪ

In 2020 we identified which UN Sustainable Development Goals (SDGs) are most relevant to Manaaki Whenua's research impacts and how we operate as an organisation. Thirty-eight people from within and outside Manaaki Whenua contributed to selecting 12 of the 17 SDGs. That process was certified to the AA1000 standard. We then used those 12 goals as the framework for our Sustainability Policy and have worked towards setting our own targets.

In the Reference Material (pages 76–77) we indicate the SDGs to which our research and organisational activities contribute, and also show our progress with the SDGs as a framework for our target setting. Our experience of target setting for the SDGs has been that targets and KPIs are more readily set in the management of our operations, which is under our control, than in the impact of our research, where we are dependent on the actions of others.

The SDGs do not specifically address indigenous peoples' rights in relation to land and the impacts on their land of matters covered by the SDGs (e.g. responsible production [SDG12]). Indigenous peoples' rights are covered by the UN Declaration of the Rights of Indigenous Peoples (UNDRIP), to which AoNZ is a signatory. We now address this matter within our commitment to the principles of Te Tiriti [page 6].



Our own climate action

Manaaki Whenua’s climate action has three dimensions:

- the impacts of our research on greenhouse gas emissions [page 36] and climate change adaptation [page 34]
- our own role and the activities of our subsidiary Toitū Envirocare in influencing other organisations’ actions [page 63]
- management of our own business emissions and resilience.

Manaaki Whenua has been independently certified as net carbon zero since 2008 through measuring and managing our emissions and offsetting what we cannot reduce. We use a combination of Gold Standard certified offset credits sourced from emissions-reduction projects overseas and credits from indigenous forest regeneration projects [carbon removals] in AONZ. The supply of the latter does not meet the demand from AONZ organisations, and we have used our research to address that challenge. Nationally, we are working with

DOC and MPI to support indigenous not-for-harvest forest as a credible carbon removal. This builds on work started in 2002 when Manaaki Whenua established the Emission-Biodiversity Exchange (EBEX-21) for that purpose. Carbon credits give landowners income while the forest provides multiple benefits. In 2019 Manaaki Whenua contributed to an Aotearoa Circle project on this topic [see page 37].

Dominant in our profile are emissions from staff travelling nationally and globally to conduct research and interact with users of our research. The Covid-19 pandemic has reduced our travel emissions by more than 50%. We aim to maintain at least half of that reduction when travel restrictions are lifted, but this requires cooperation within our sector.

Aiming to influence our sector, we instigated Why Fly?, led by the CRIs in 2020, to reduce demand in the science and research sector for people to fly to meetings that could be conducted effectively online.

The challenge remains that our people need to interact globally to build and sustain research relationships, but much domestic travel could be substituted.

We seek to decarbonise our business as technologies make this feasible. We are installing solar panels on our new building at Lincoln to provide base load; we are replacing our vehicle fleet with hybrids and EVs, where they can meet our needs for reliability in remote locations; and we are minimising the loss of refrigerant gases. Regrettably, there is no option in AONZ to purchase electricity from wholly renewable sources.

CERTIFICATION

Carbon zero certification

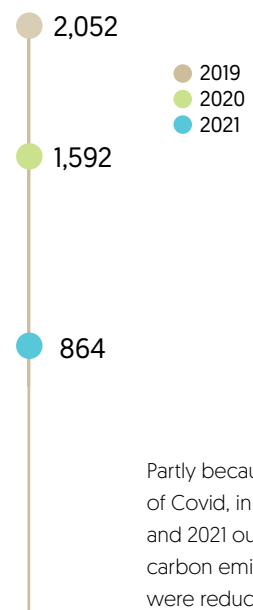
2011–present

ISO 14001 certification

1998–present



TOTAL EMISSIONS (tCO₂-e)



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

* tCO₂-e = tonnes carbon dioxide equivalent.

Toitū Envirocare: climate leadership for businesses

For most businesses in AoNZ the challenge of operating successfully during a global pandemic has been significant. Increasingly, however, business has also recognised the opportunity, importance, and indeed necessity to take positive climate action for the future of the planet. We expect this will increase further after the world focuses on the outcomes of the COP-26 climate conference in Glasgow in November 2021.

Toitū is a wholly owned subsidiary of Manaaki Whenua, established as a business unit in 2004 and as a company in 2011. Through its carbon emissions management programmes and advocacy for indigenous not-for-harvest carbon offsets and removals it has influenced a generation of people in organisations across the economy and many in the UK. Through its support for its customers taking meaningful action and making credible claims about their achievements, Toitū has made action easy and a powerful endorsement of organisations' contributions to climate action.

In the year to 30 June 2021 alone Toitū verified over 9 million tonnes of CO₂e [up 25% on the previous year] and offset over 194,000 tonnes of CO₂e [up 60%]. This was achieved in partnership with 417 clients in their carbon programmes (up 35%). Toitū also has 139 clients working on their wider environmental impacts through the Toitū Enviromark programme,

and another 80 working on non-programme environmental initiatives, including verification only, science-based targets, and carbon credits. Toitū's staff are up 23% to 49.

In July 2020 the Toitū Board and management set out an ambitious 5-year strategic plan with the overall objective to catalyse action for a zero-carbon future and lead the way for AoNZ business to achieve net zero by 2050. Key areas of strategic focus have been expanding Toitū's reach across sectors and supporting mandatory climate impact reporting; launching tools for small-to-medium enterprises and supply chains to help them on the journey; education and advocacy through fostering sustainability, knowledge, and capability across AoNZ; and building the global ecosystem for action through partnerships.

Toitū has built strong relationships with existing and new clients, from large AoNZ corporates such as Fonterra, Westpac, ANZ, The Warehouse Ltd, and Fisher & Paykel Healthcare, through to public sector organisations including the Climate Change Commission, MBIE, Accident Compensation Corporation, Ministry of Transport, MPI, Ministry of Social Development, Ministry of Justice, and Fire and Emergency. Toitū's international licence partner, Achilles, has also seen strong growth in their UK clients' demand for Toitū's carbon programmes.



TOITŪ
E N V I R O C A R E

OUR STRATEGIC PRIORITIES O MĀTOU WHAKAAROTAU RAUTAKI

In 2017 we developed Strategy 22 – our strategic priorities for the 5 years to 2022. As we approach the end of that period, significant changes are occurring in our operating environment, so we chose to refresh Strategy 22 for a 2- to 3-year transition period.

Since 2017 we have achieved significant gains under the three pillars of Strategy 22: our culture, ways of working, and enhancing the impact of our science. Many of those gains, described in our Annual Reports, have been built into our business as usual.

Our Strategy 22 refresh has identified goals and priorities for the next 2–3 years. The desired outcomes of these are summarised below and explained in the following pages.

Strategic goal 1. Weave the principles of Te Tiriti into our fabric

The Treaty 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.



Strategy 1.

Weave the principles of Te Tiriti into our fabric

Partnership, Participation and Active Protection. Applying the principles of Te Tiriti will change the way we think about partnership, participation, and active protection, and about our research priorities and impacts, the way we do our research, and the skills and roles of our people. Moving forward we will apply the principles in how we engage with hapū and iwi 'at place' and where our research is relevant to Māori and can create equitable impact for them. We will reach out and seek to connect early on to co-design projects, and we will approach our engagement with iwi in the spirit of partnership.

Over time Manaaki Whenua will gradually re-design our operating model into a more genuine partnership with Māori, both in how we engage externally with iwi, but also internally in the way we work with our kairangahau Māori, particularly the Manaaki Taiao Māori research team. Our goal is to create sustainable roles and career pathways for our Māori staff, and work with other organisations to attract more Māori into such careers. We will address the unsustainable pressure on Māori staff to conduct their own work, facilitate engagement between their non-Māori colleagues and Māori collaborators, and meet the expectations of their own people to create positive impact.

The WAI 262 Claim. We recognise the findings of the Waitangi Tribunal on the claim by Māori (WAI-262) for protection of taonga (treasured possessions, including all aspects of indigenous culture) and intellectual property relating to those taonga. Working with Māori, we will seek to move the model of governance of our national collections and databases from one of "collect, curate and classify" to a more holistic "connect, create and collectivise" model. The need for this change was strongly signalled in our Te Tiriti-led review of Manaaki Whenua's collections, done in late 2021.

Indigenous Data Sovereignty. We acknowledge the importance of indigenous data sovereignty to hapū and iwi, and the role that Manaaki Whenua can play in reconnecting indigenous communities to their data. We learned recently, through our Te Tiriti-led review of the collections and databases, how reconnecting hapū and iwi to their indigenous data can in turn help empower hapū and iwi in the exercise of their tino rangatiratanga. This will promote indigenous nation-building as envisaged under Article II of Te Tiriti. However, we also acknowledge that we still have much to learn in this area. We will work with Māori to re-imagine Manaaki Whenua's data governance platforms based on the need to reconnect, and return control of, indigenous data back to indigenous communities.

Our priorities are:

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

Success will look like: the spirit of partnership guiding how we work together, through groups of senior, external Māori meeting with our leadership regularly. Initially we will explore a partnership group guiding our work with the Collections.

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

Success will look like: joint development of our research strategy and relationships with Māori, through co-leadership by our own senior Māori staff. Initially, we will establish new senior roles for this purpose, and increase the proportion of MBIE SSIF-funded projects that are co-designed with Māori and under the leadership of the Manaaki Taiao members.

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

Success will look like: Māori attracted into a research or research support career, especially with Manaaki Whenua. Initially, we will increase our level of scholarships and other support for kairangahau Māori and help them plan their career with Manaaki Whenua.



Kairangahau Māori Jade Hyslop (left) and Mahuru Wilcox are an integral part of our Manaaki Taiao research team.

Strategy 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.

As the Government considers reform of the science system in 2022, we anticipate much discussion of national research priorities and the opportunity to improve the national systems of partnership and strategic investment in research. Commentators¹ have called for a more strategic and less fragmented approach than the current model. Manaaki Whenua supports their calls.

The research community needs to be at the table with Māori in decisions on research priorities and investment, alongside government and industry. Strategic investment should enable researchers to work consistently, rather than make fragmented contributions with uncertain continuity.

Technology is advancing rapidly in our areas of research. Data, digital, and genomic technologies have much to offer and must be managed to add value. We should enhance understanding, capability, and confidence and avoid merely overwhelming users with more information.

¹ Parliamentary Commissioner for the Environment [environmental research in NZ] 2020; Te Pae Kahurangi [CRI review] 2020; Te Pūtahitanga [agenda for Māori research] 2020; Pathways to the Future [CRIs' report].

Our priorities are:

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

We will speak to how and what research can contribute to national goals.

Success will look like: with our partners we have set national research priorities and ensured that investment in them is fit for purpose by being impact-focused, strategy-led, coherent, and consistent.

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

This will require a user-centred approach informed by our partners' world views. It will see new partnerships and new technologies.

Success will look like: we have been innovative in addressing barriers to research impact, notably investment in partnerships for research uptake, and in the process of co-design and co-leadership with Māori and investment in partnerships for research uptake.

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.

Success will look like: we understand users' needs from research, and we apply data and digital technologies that reliably meet those needs.



Dr Ben Jolly uses satellite and aerial (drone) data in his research on AoNZ's land cover.

Strategy 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.

In refreshing our strategic priorities we reflect and anticipate significant changes in society, the sector, and our ways of working.

Change is a reality, not an option. But change must be managed to retain and grow what is valued in the sector, and to enable people to fulfil their potential without undue disruption. That potential encompasses leadership and relationships that enable effective outcomes from investment in research. Longevity of relationships is critical to building trust, and trust is central to partnerships for impact.

Our priorities are:

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

The global pandemic has changed people's expectations of their place and style of working. This has coincided with changes in the social dynamics around equity and diversity, health and well-being. Social media and online connectedness have transformed people's interactions, and the world faces exponentially increasing cybersecurity risk. The Future of Work recognises these changes and responds to changing workforce demographics and expectations.

Success will look like: our staff experience survey results indicate our people's support for how we balance their needs and those of the organisation to be resilient.

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

Government's far-reaching change in the research, science, and innovation sector will create opportunities and risks for our people and culture. We will pursue these opportunities and work hard to sustain what is valued by our people and partners – the strength of our community and external relationships.

Success will look like: Our partners are satisfied that they continue to receive a high level of value from Manaaki Whenua through the sector reform and into the future model.

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

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.

Success will look like: we have enhanced our project lifecycle systems and processes to deliver value from all our research while resolving the challenges experienced by our people.



Researchers take a break during fieldwork in the Upper Rangitata whilst banding native birds.

A landscape of rolling hills and mountains at sunset. The sky is a mix of purple and blue, and the sun is low on the horizon, casting a warm, golden light across the terrain. The hills are covered in sparse vegetation, and the overall scene is serene and majestic. The text is overlaid on the left side of the image.

**REFERENCE
MATERIAL
NGĀ TUHINGA
TOHUTORO**



Our collections

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.



Allan
Herbarium
[CHR]

AoNZ's national herbarium with 700,000+ specimens of AoNZ and South Pacific algae, lichens, liverworts, mosses, ferns, and seed plants.
- www.landcareresearch.co.nz/allanherbarium



New Zealand
Arthropod
Collection
[NZAC]

Largest collection of AoNZ insects and related arthropods with 7 million+ specimens. Includes the National Nematode Collection of New Zealand [NNCNZ].
- www.landcareresearch.co.nz/nzac



New Zealand
Fungarium
[PDD]

Primary information source on AoNZ and Pacific fungi with 105,000+ dried fungal specimens, and voucher specimens documenting most plant diseases recorded in AoNZ.
- www.landcareresearch.co.nz/pdd



International
Collection of
Microorganisms
from Plants
[ICMP]

One of three major international collections for plant and soil bacteria, with living cultures of 22,500+ strains of bacteria and fungi from plants and soil.
- www.landcareresearch.co.nz/icmp



Te Kohinga
Harakeke
o Aotearoa
[National
New Zealand
Flax Collection]

Living collection of *Phormium* species of cultural, economic, and historical interest.
- www.landcareresearch.co.nz/harakeke

Used by AoNZ's biodiversity and biosecurity systems, benefiting conservation, forestry, horticultural and agricultural sectors.

Used for research into traditional and new uses.

 Nationally significant

 Significant

Our databases



National Soils Data Repository [NSDR]

5,900+ AoNZ soil profile descriptions, plus analytical data on their chemical, physical, and mineralogical characteristics. Includes the National Soils Archive, a reference collection of soil samples for the NSDR.

- <https://viewer-nsdr.landcareresearch.co.nz/>



Land Resource Information Systems [LRIS]

Includes the New Zealand Land Resource Inventory (NZLRI), Land Use Capability (LUC), Fundamental Soils Layer (FSL), and related datasets and materials.

Presents general land characteristics and land evaluation information, plus a range of environmental, climatic, management, and production attributes.

- <http://Iris.scinfo.org.nz>
- <https://ourenvironment.scinfo.org.nz/>



Land Cover Database [LCDB]

A classification of land-cover change across AoNZ in a series of 5 snapshots dating back to 1996. Contains 33 mainland classes (35 including the Chatham Islands).

- <http://Iris.scinfo.org.nz>
- <https://Iris.scinfo.org.nz/layer/104400-lcdb-v50-land-cover-database-version-50-mainland-new-zealand/>
- <https://vizbe.landcareresearch.co.nz/>



S-map

A national system that provides comprehensive, quantitative soil information to support sustainable development and scientific modelling.

- <https://smap.landcareresearch.co.nz>
- <http://Iris.scinfo.org.nz>



National Vegetation Survey [NVS] Databank

A national repository of plot-based vegetation survey data from 121,000+ survey plots going back over 70 years. Covers Northland to Stewart Island, the Kermadec and Chatham Islands, and from coastal to forest to high alpine.

- <http://nvs.landcareresearch.co.nz>



Ngā Tipu Whakaoranga – Māori Plant Use Database

2,400+ records on Māori names and cultural uses of New Zealand native plants, fungi, and algae.

- <http://maoriplantuse.landcareresearch.co.nz>

Used for national and regional state-of-environment monitoring, forest and shrubland inventory, biodiversity assessment, trend analysis, and infrastructure planning.

Also used by regional and central government, primary industry, and the finance, environment, and education sectors.

The Pacific Soils Portal is an important part of our soils information - <https://psp.landcareresearch.co.nz/>

Key part of AoNZ's biodiversity and biosecurity information infrastructure.

Used for research into traditional and new uses.

Our research outcomes and the UN Sustainable Development Goals

Our research outcomes and activities align with the UN Sustainable Development Goals as shown in the table below.

UN SDG	Our goal statement	Our outcome statements
 <p>15. Life on land (and in water, from SDG14) Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.</p>	<p>We will empower stakeholders to:</p> <ul style="list-style-type: none"> • conserve, restore, and protect land-based ecosystems, soils and their services • reverse the decline of indigenous biodiversity and natural habitats • reduce the impact of invasive species • develop the sustainable use of land resources • develop equitable policies through partnership. 	<p>Critical knowledge of the wealth, state, and trends in our biodiversity, soils, and lands informs decision-making.</p> <p>Ecological restoration is guided by knowledge of past and present ecosystems.</p> <p>Hapū and iwi act confidently as kaitiaki of their whenua using science and mātauranga Māori.</p> <p>Risk and harm from invasive organisms are mitigated.</p> <p>Biosecurity tools are available with social licence.</p>
 <p>2. Zero hunger End hunger, achieve food security and improved nutrition, and promote sustainable agriculture.</p>	<p>We will inform the development of food production systems that enhance soil, land, water, and ecosystem services, and ensure climate change adaptability, while working especially with Māori in Aotearoa New Zealand and indigenous peoples in Pacific nations.</p>	<p>Māori land trusts and incorporations achieve their aspirations for their land.</p> <p>Productive lands are regenerative at the landscape scale.</p>
 <p>6. Clean water and sanitation Ensure availability and sustainable management of water and sanitation for all.</p>	<p>We will guide the use of land in ways that improve freshwater quality, enhance water-use efficiency, protect, and restore water-based ecosystem services, and support integrated catchment-based governance and management.</p>	<p>Land use, soils, and erosion are managed to improve freshwater quality.</p>
 <p>11. Sustainable cities and communities Make cities and human settlements inclusive, safe, resilient and sustainable.</p>	<p>We will inform the development of integrated policies and planning that enhance resource-use efficiency, ecosystem services, climate change mitigation and adaptation, resilience to natural disasters, and inclusive governance processes, while decoupling waste from growth.</p>	<p>Communities and regulators have adaptation pathways for climate change.</p> <p>Environmental decisions are underpinned by advanced geospatial information.</p>
 <p>13. Climate action Take urgent action to combat climate change and impacts.</p>	<p>We will empower organisations, sectors and the nation to measure, manage, reduce, and mitigate their greenhouse gas emissions; understand climate risk and increase resilience; create opportunities, and develop policies and plans that integrate social, economic, cultural, and environmental dimensions.</p>	<p>Communities and regulators have adaptation pathways for climate change.</p> <p>Carbon emissions and removals are managed to mitigate climate change.</p> <p>The work of Toitū Enviocare.</p>
 <p>16. Peace, justice and strong organisations Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable, and inclusive institutions at all levels.</p>	<p>We will support the development of responsive, inclusive, participatory, and representative decision-making and governance by our stakeholders and the Treaty Partner, Māori.</p>	<p>National environmental outcomes are improved by integrating social practice theory, policy tools, and economics.</p>

Provisional non-financial KPIs for corporate sustainability

The table below shows how our corporate activities align with the UN Sustainable Development Goals, including proposed KPIs.

UN SDG	Our goal statement	Our provisional target/s
 <p>3. Good Health and Well-being</p>	<p>We will empower our people to commit themselves 100% to health, safety and well-being while executing our own responsibilities as their employer.</p>	<ol style="list-style-type: none"> 1. Every staff member feels that MWLR cares about their well-being. 2. Every staff member believes MWLR is committed to the health and safety of its people. 3. Implement relevant actions from the 2022 HSE Operational Plan by 30 July 2022.
 <p>5. Gender Equality</p>	<p>We will ensure gender equity in participation, leadership opportunities, conditions and reward in all aspects of our work, using enabling technologies where appropriate.</p>	<ol style="list-style-type: none"> 4. Gender pay gap of less than 4% within each pay grade. 5. Gender leadership representation of 40% female, 40% male, 20% any gender identity. 6. Implement relevant actions from the 2022 Gender Equity Action Plan by 30 July 2022.
 <p>8. Decent Work and Economic Growth</p>	<p>We will achieve sustainable economic performance that supports innovation, entrepreneurship, job creation, staff development, fulfilling roles, and advancement opportunities with fair remuneration.</p>	<ol style="list-style-type: none"> 7. Financial sustainability to ensure ability to invest in the medium/long term, and provide fair remuneration. 8. Every staff member feels their role is satisfying.
 <p>10. Reduced Inequality</p>	<p>We will enhance the inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic, or other status and sustain income growth for our lower earners.</p>	<ol style="list-style-type: none"> 9. Every staff member feels included at MWLR. 10. Implement relevant actions from the 2022 Equity Diversity and Inclusion Action Plan by 30 July 2022. Also refer to targets 1, 4, 5, 6, and 8.
 <p>12. Responsible Consumption and Production</p>	<p>We will measure and manage our own consumption and outputs to sustain and restore natural resources, reduce waste and emissions and foster a circular bio-economy, while through our procurement and services encourage other to adopt sustainable practices.</p>	<ol style="list-style-type: none"> 11. 5% annual reduction on the previous year in: <ul style="list-style-type: none"> - total waste to landfill - total potable water consumption. 12. All procurement processes recognise and prioritise suppliers' sustainability and ethical sourcing practices. See <i>Climate Action for GHG targets</i>
 <p>13. Climate action</p>	<p>We will measure, reduce, and mitigate our greenhouse gas emissions, understand climate risk to our business, and increase our resilience.</p>	<ol style="list-style-type: none"> 13. Positive net carbon emissions through Toitū's Climate Positive Programme. 14. 5% annual reduction of gross emissions per \$m revenue. 15. Retain post FY22 at least half of the reduction in flying kms achieved during Covid-19 per \$m revenue.
 <p>17. Partnerships to achieve the Goals</p>	<p>We will partner nationally and globally to build capacity, enhance knowledge and data sharing and access to science and technology, and enhance the Global Partnership for Sustainable Development</p>	<p>Māori</p> <ol style="list-style-type: none"> 16. All partnerships with Māori organisations are based on Te Tiriti principles. 17. Year on year an additional 10% of staff feel they are equipped to work in partnership with Māori groups. <p>End-users</p> <ol style="list-style-type: none"> 18. Partnership/engagement plans for major stakeholders are in place by 30 June 2022. <p>Science partners</p> <ol style="list-style-type: none"> 19. ≥55% of papers are co-authored with other AoNZ institutes and ≥ 60% of papers are co-authored with international institutes. <p>International development</p> <ol style="list-style-type: none"> 20. Develop a strategy to enable MWLR to transfer knowledge and technology to developing countries and grow their capacity, enabling their sustainable development, by 30 June 2022.

Manaaki Whenua: a summary

- Te Tiriti

PARTNERSHIP • PARTICIPATION • ACTIVE PROTECTION

.....

We are committed to upholding the principles of Te Tiriti o Waitangi in all our activities.

- Our Ambition

KIA MAURIORA TE WHENUA ME TŌNA TAIAO

The life-force and vitality of the land is strong

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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.

- Our Purpose

SCIENCE FOR OUR LAND AND OUR FUTURE

Ko te pūtaiao mō tō tātou whenua, mō āpōpō

.....

Manaaki Whenua is a purpose-driven research community. Our research and innovation focus on understanding the land, life on land, and the relationship between people and the land. Manaaki Whenua works in partnership with others to achieve our ambition, which we cannot achieve alone. People's decisions and actions affect the environment, so the purpose of our work is that they should have understanding, capability and confidence to enable society and environment to flourish together.

- Our Partners



Government



Māori



Industry

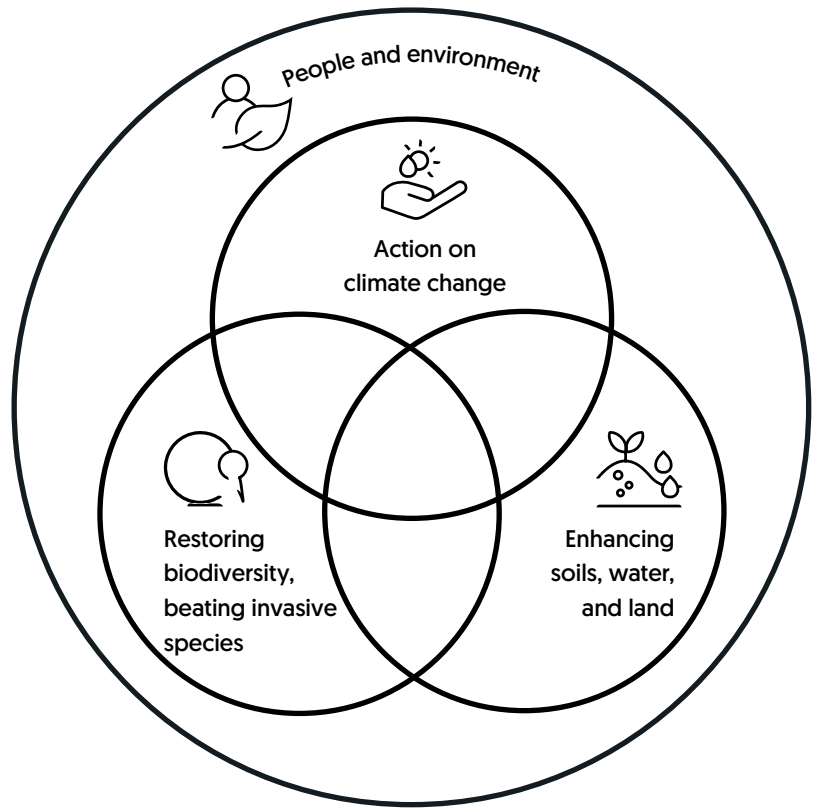


Research

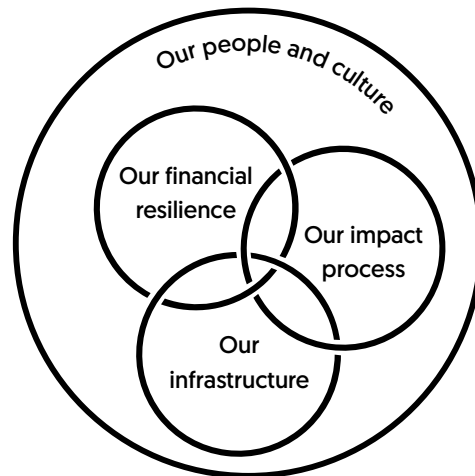


People and communities

• Our Areas of Impact



• Our People and Processes



• Our Values and Behaviours

SCIENCE THAT DELIVERS

Excellence – Relevance – Integrity

MANAAKI TANGATA

Caring – Partnering – Common Purpose



Experiment to learn

Mā te hē ka tika



Share freely and often

Kia rite tonu te tohatoha



Invite input from others

Kia areare mai ōu taringa



Embrace diversity

Awhai mai, awhi atu, tātou tātou e



Commit to excellence

Whāia te iti kahurangi

