Pūtaiao

MANAAKI WHENUA SCIENCE SUMMARY / ISSUE 2 / MAY 2020

Science for our biodiversity

Leaving no stone unturned

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to the second issue of *Putaiao* ('Science' in te reo Māori), our quarterly publication showcasing the work of our scientists at Manaaki Whenua.

We are the Crown Research Institute for our land environment, biosecurity, and biodiversity, and our role and responsibility to New Zealand is clear: this land, and everything that shares it with us, is our future.

Each issue of *Putaiao* will share the benefits and impacts of our science in helping ensure a sustainable, productive future for New Zealand. In this issue many of the stories focus on science for biodiversity – one of our four 'science ambitions' at Manaaki Whenua.

Aotearoa has a rich biodiversity, from the smallest bacteria to the largest kauri tree, but it is under threat from pressures such as invasive species, climate change, land-use intensification and conversion, mining, and urban development. Discovering, protecting and restoring this precious taonga requires exceptional science and infrastructure, practical policy, real-world tools and solutions, and everyone's support and participation.

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

Cover photo: Dr Janet Wilmshurst searches a cave for coprolites – fossil poo – near Lake Wakatipu, Otago. This work to establish pre-human ecosystem and species baselines is highly relevant to inform current conservation efforts.

The Honey Landscape

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 project that sets out to best maximise the opportunity presented by high-value mānuka honey production.

A large proportion of New Zealand's natural mānuka populations grow on Māori-owned land. The 'Honey Landscape' project is helping to create a sustainable native mānuka honey industry that reduces hive losses and helps landowners to increase honey production while protecting the honey bees, native mānuka and plant species.

Dr Gary Houliston is leading the Manaaki Whenua component of The Honey Landscape project, building a comprehensive model and map of New Zealand's native honey landscape that blends science and tikanga Māori. The model will show in real time the nectar and pollen being produced in native forests and scrubland all over New Zealand.

As part of this work, researchers have been working with Māori landowners to collect leaf samples from natural mānuka stands, extract the DNA, and analyse the data.

'By the end of the programme, we want a tool that a landowner can use to assess their property for how many hives they can actually place in an area: they would take our tool, consider what is on the land, look at what sort of vegetation they have, and assess how many hives they've got or can actually run on the land without overpopulating the bees,' says Dr Houliston.

Bit.ly/honey-landscape

Could these traditional fungi be a food of the future?

Fungi have long been a popular and important food source across the globe – but could the fungal kingdom meet the ever-growing modern demand for non-animal-based proteins and foods?

In a project co-designed by iwi, researchers at Manaaki Whenua are investigating whether three specific fungal species that are unique to New Zealand and were once traditional Māori foods, could be grown and reproduced at a commercial scale.

'There is a lack of New Zealand native food products or traditional Māori foods available to New Zealanders, and a substantial and growing demand from consumers for high-quality non-animal-based protein food products,' says Manaaki Whenua's lead researcher Christopher Smith, who has secured funding for the project via the Kiwi Innovation Network (KiwiNet)'s Emerging Innovators Programme.

'Several native plants have commercial food-related uses such as mānuka for honey, flaxseed oil, pikopiko (fern shoots), pūhā, and kawakawa, but our fungi haven't been at any scale to provide a contemporary food source. Our ambition is to bring to market three native New Zealand mushrooms that are each unique and attractive sources of food, as well as good sources of protein and high nutritional value,' he adds.

> *"Our ambition is to bring to market three native New Zealand mushrooms."*

Within New Zealand's fungal realm at least 7,000 to 8,000 unique species have been identified, and researchers expect there are thousands more.

The three species selected for the research project were suggested by iwi for their pleasant taste and potential for large-scale growth.

'We are going to be focusing on proving that the production methodology refined in lab-scale trials is adaptable to a larger scale for each of the three species, within a dedicated growing facility,' explains Smith.

'Throughout the project, we will gather robust data on the costs of operating and production to better understand the risks and inputs associated with providing these mushrooms as a product to the New Zealand market,' he says.

The project will then create a business case for iwi groups to consider investment into facility or container-style production.

Fungus growth in facility.

More Birds in the Bush

A progress report

With global biodiversity in freefall, research to prevent the decline of New Zealand's unique bird species on the mainland– the kiwi, kererū, kea, kōkako and others – is nationally critical. In response, Manaaki Whenua is leading an MBIE Endeavour research programme to discover the most important interventions to protect our iconic native birds.

Top: A rat fitted with a radio collar in Lake Alabaster, Fiordland.

Above: A New Zealand bush robin or toutouwai perches on a branch in Bushy Park in Whanganui, New Zealand.

The underpinning product of the research is a much-improved model for bird management in different forest types. Previous kiwi experience has provided the foundation for this model. Population outcomes for kiwi were forecast through mast events and management operations specifically in Fiordland beech forests.

Some 20–30 years of research into tree flowering and seeding and spikes in predator numbers have given us good predictive tools to manage bird/predator dynamics in cold beech forests. This new research programme, 'More Birds in the Bush', aims to improve the ability to forecast predator threats and bird responses across all New Zealand's forest types, and thereby improve our partners' effectiveness and efficiency in forest management nationwide. It's led by Manaaki Whenua scientists Drs Susan Walker and Adrian Monks, with Dr Gretchen Brownstein as programme manager.

Now some 18 months old, More Birds in the Bush already has significant momentum, helped considerably by research partners in large-scale predator control who have shared rodent-tracking, management and bird count data to inform the programme's forecasts. 'The More Birds research team has overcome significant challenges to rapidly scale up our science programme, facilitated greatly by the readiness and flexibility of our partners, especially the Department of Conservation, to lend their operations and monitoring,' says Dr Monks.

Several research strands will all contribute to an improved model that partners will use for better management outcomes. An overview of the contributing strands follows.

Ship rat dynamics and bird outcomes

To identify what drives rat dynamics, we are measuring the composition and structure of native forests at long-term predator tracking tunnel sites across New Zealand. Bird occupancy is also being measured with acoustic recorders at the same sites to characterise bird outcomes given

long-term rodent dynamics and other forest attributes. We have developed an enduring field method, which is now being rolled out in warmer northern forests.

Forest phenology
Understanding how forest flowering and fruiting seasons change with elevation will give us a fine-scale knowledge of forest resources, improving our ability both to forecast when and where ship rat populations and birds will thrive and to target appropriate predator control interventions.

Ship rat movements and mechanisms at Lake Alabaster in Fiordland
This research is on underlying rat population dynamics throughout a mast seeding cycle. The study will shine light on many aspects of ship rat biology, but we are asking two key questions:

Are rats more limited by cold or food? If rats turn out to be more temperature-limited than food-limited, a warming climate could have worrying flow-on effects for rat numbers in New Zealand.

What causes rapid 'bounce back' of rat populations following landscape scale poison operations? Insights into how rats increase in the months and years after aerial control with baits will enable better-informed future control operations that result in improved survival of nesting native birds and other fauna.

Where and when will predator management most benefit native forest birds?
We have built a bird demography database, interviewed expert ornithologists, and are conducting a field study at Mt Pirongia, to better understand how food resources and predation interact in New Zealand forests and the resulting outcomes for bird populations. Study species at Mt Pirongia are tītipounamu/rifleman, miromiro/tomtit, and korimako/makomako/koparapara bellbird.

Re-establishing bird populations in large forests
Dispersal of birds to unmanaged areas may hinder successful reintroductions to large mainland forests (due to predation). We are studying dispersal patterns of reintroduced birds in large forests to understand how big managed forest areas need to be, alongside community, council, and iwi partners.

Novel drone technology is being compared against standard techniques for post-release monitoring to see if we can get higher quality data for less time and money, working with with Dr Chris Muller at Massey University.

Iwi management of bird recovery
Researchers have started working with the Tūhoe Tuawhenua Trust, based at Ruatāhuna, towards their goal of kererū recovery in their forests. Over the winter, we reviewed the western science on kererū ecology for the Trust, to place this alongside their mātauranga as a basis for joint forest management trials. New work aims to understand both the contribution of rats and possums singly and in combination on forest fruit availability, and to understand environmental drivers of crop size and fruit characteristics in tawa.

Repo research gets the green light

A new year-long research project focusing on repo (wetland) education, awareness and kaitiakitanga has been funded and is underway.

The first of its kind project, '*Karangatia o ngā repo me ngā tangata*,' is a collaboration between Manaaki Whenua – Landcare Research and the University of Waikato Science Learning Hub. Researchers secured funding from MBIE's Unlocking Curious Minds to create a series of bilingual, multimedia educational resources, based on New Zealand scientific research into wetland ecology and restoration.

'The project's strong focus on mātauranga Māori will help educate the public on the importance of repo and give an in-depth understanding of how culturally significant wetlands are to Māori. It's a part of the effort to see our repo reconnected with Māori tauira, and communities,' says Manaaki Whenua Lead Researcher/Kairangahau Yvonne Taura.

The project began in February with a series of wānanga (workshops) with Kura Kaupapa Māori school tauira (students), kaiako (teachers), and whānau around Waikato, Canterbury, and Otago. Once completed, experts and science educators will then work closely with participants to produce online bilingual wetland education resources for both Kura Kaupapa Māori and mainstream schools throughout New Zealand.

'The mātauranga Māori focus of *Karangatia o ngā repo me ngā tangata* means that educational resources developed will hold the narratives of the repo as well as explaining the ecology of culturally significant plants, such as wātakirihi (watercress) or harakeke (New Zealand flax), through to harvesting tikanga (practices), along with techniques for monitoring and restoring wetland species such as kōura (freshwater crayfish),' adds Taura.

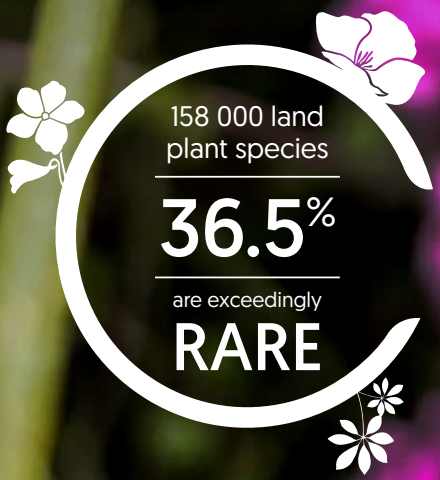
'It's important that we work closely with kura while developing these resources, in order to properly identify the learning priorities and delivery style of tauira. This is to ensure we create a suite of resources that foster kaitiakitanga and empower them to learn about and care for repo and rebuild their connectedness with repo across kaiako, tauira, whānau, and community members,' she explains.

It's rare to be common, and common to be rare

A key feature of life's diversity is that some species are common but many more are rare.

Rare plant species are far more likely to go extinct than common species, especially given current human pressures on land use and anthropogenic global climate change, yet we know surprisingly little about global patterns of plant rarity and even what proportion of the plant species on earth are rare.

However, with the rapid development of biodiversity databases and networks in the past decade, it has become increasingly possible to quantify continental and global patterns of biodiversity and to test competing models of these patterns at a global scale. Working with scientists from around the globe, Dr Susan Wiser from Manaaki Whenua recently took part in the largest compilation of global plant diversity, using more than 200 million observations of plant species occurrence, to find out the fraction of Earth's plant biodiversity that is made up of rare species.



The research, published in *Science Advances*, was startling – showing that for all known land plants, many more plant species are rare than previously thought. The team estimated that close to 36.5% of Earth's c. 435,000 land plant species (that's around 158,000 species) are exceedingly rare.

The study was published to coincide with the UN climate negotiations that took place in Madrid in January 2020, as the researchers also showed that climate change and human land use impacts are now disproportionately affecting areas with larger numbers of rare species. These new estimates of global species abundance have important implications for risk assessments and conservation planning in an era of rapid global change and potential species extinctions.

Dr Wiser thinks that it would be very interesting to re-run the study at a New Zealand scale. 'Although we already know that in terms of plant rarity, that regions such as northwest Nelson and Northland are standouts, it would be useful to document and map secondary patterns of plant rarity across New Zealand, to better underpin informed conservation and environmental planning and management decision making.'

https://advances.sciencemag.org/content/5/11/eaaz0414

Photo: Carmichaelia glabrescens, *a legume species endemic to New Zealand, declared "near threatened" in 2006, revised to "not threatened" in 2018.*

Anouk Wanrooy

Soil health and resilience

Oneone ora tangata ora

The ongoing capacity of soil ecosystems to maintain the services they provide is fundamental to our economic, cultural, social, and environmental well-being.

However, soil health and quality assessment in New Zealand currently uses a narrow science-based approach; largely analysing and reporting the soil chemistry and the physical properties of soil. This focus may be inadequate to assess long-term changes to soil health and resilience and additionally does not recognise cultural perspectives.

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. The programme is a collaboration with Plant & Food Research, AgResearch, the University of Waikato, the University of Auckland, and Auckland University of Technology.

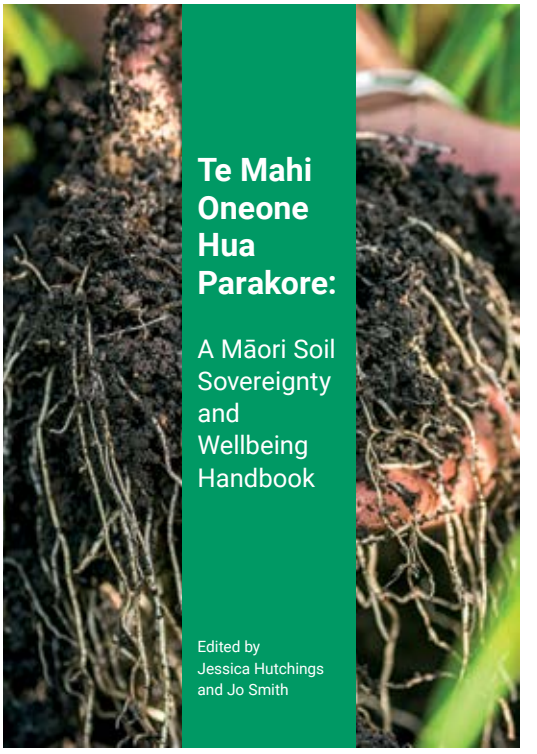
The conventional science part of this programme has involved sampling and analysis of more than 150 different soil profiles across New Zealand. We are investigating how land use affects changes in soil carbon and soil chemistry and how those in turn affect other soil properties such as soil aggregation and microbial activity. In collaboration with the S-map Next Generation Endeavour-funded project, we are researching how a soil's physical condition affects soil hydrology and soil function.

Recent work undertaken in the Waikato region has compared pasture and maize cropping on a range of soil orders. Different soils have different properties and intensification affects these soils differently. These studies will allow us to better measure land use intensification effects on different soils, particularly below the topsoil where soil health effects have typically not been measured.

The research programme also recognises Te Ao Māori perspectives and concepts of soil health – including the mana, mauri, whakapapa, wairua, and hau of soil. We are developing new mātauranga-based soil health frameworks, approaches, and indicators for use by a wide number of Māori organisations, iwi/hapū, and other agencies. This work will enable

> *Whakapapa defines what a healthy soil is, it comes from our whakapapa, we define ourselves from our pepeha, our land. So, whatever happens to the soil happens to me – when we are disenfranchised from our soil, our land, it also affects our physical and mental health... The indicators and measures of soil health can be seen in the place names, the geographical whakapapa.*
>
> Interview with Hema Wihongi (Kiri Reihana 2018)

Hema Wihongi in the organic community garden and maara rangahau [research garden] established by tauiwi from Te Whare Wānanga Awanuiārangi, Whakatane.



Te Mahi Oneone Hua Parakore: a Māori soil sovereignty and wellbeing handbook, forthcoming in 2020 by Jessica Hutchings and Jo Smith, contracted researchers in the Soil Health programme.

more effective and inclusive land-management decisions to be made and will strengthen the expression of Māori values and principles supporting responsibilities such as kaitiakitanga.

The programme draws on a wide pool of knowledge that includes traditional, historic, and contemporary mātauranga Māori, building grass-roots knowledge through approaches such as stakeholder engagement, workshops, industry participation, and interviews to augment the science knowledge. A large number of Māori individuals and organisations have participated throughout Aotearoa-New Zealand, including Māori researchers/kairangahau, Māori knowledge experts in soils and gardening, iwi/hapū groups and authorities, Māori landowners, Māori industry groups, and schools/kura.

Soil cores from an Ultic soil under pasture.

www *https://www.landcareresearch.co.nz/science/soils-and-landscapes/soil-health*

How ancient DNA can help restore our biodiversity

Top: Collecting wetland sediment core samples on the Kepler Track.
Above: The core sample is checked after being extracted.

Like other remote archipelagos, New Zealand's flora and fauna had many endemic species – found nowhere else – before human arrival.

Since then, more non-native species have been introduced and naturalised than almost anywhere else in the world except Hawaii. About half our flora are made up of naturalised non-native plant species, and with the extinction of more than 50 native land birds since human arrival there has also been a shift from a bird-dominated to a mammal-dominated fauna.

At Manaaki Whenua's Long-Term Ecology Laboratory, we study long-term ecological processes (over decades to thousands of years) to help understand the dynamics, function, and trajectories of present-day ecosystems and to inform their restoration.

Because New Zealand was settled so recently compared with many places on the planet, and at a time when climates were similar to today, pre-human ecosystem and species baselines are highly relevant to help inform current conservation issues.

For example, pollen and ancient DNA (aDNA) analyses of kākāpō coprolites (fossilised droppings) from Honeycomb Cave in NW Nelson have revealed these enigmatic threatened parrots once played a role as pollinators of the now endangered endemic parasitic flowering plant *Dactylanthus*, the wood rose. Until this revelation, it was thought that only native bats were pollinators of this strange plant; our improved understanding of ecosystem dependencies such as these is a significant contribution to species conservation and may help expand options for where both species might survive in the future.

In other work, our team's recent estimations of pre-human moa population densities, and their diets derived from coprolite analyses, will help us better understand and manage current pressures on native forest plant species following the replacement

Dr Jamie Wood from Manaaki Whenua talks with feature writer Kate Evans (right) as the field team search for coprolites.

Drs Jamie Wood and Janet Wilmshurst (right) search for coprolites on a field trip near Mt Nicholas Station, Lake Wakatipu, Otago.

*A tarsometatarsus (lower leg bone) of the extinct Finsch's duck (*Chenonetta finschi*) found at Walter Peak Station, near Lake Wakatipu.*

of moa in our landscapes by other herbivore browsers such as deer. Another ongoing study is a Marsden-funded project focused on the analysis of kiore (Pacific rat) coprolites found in New Zealand, which will help us define the impact of New Zealand's first naturalised invasive mammal on pristine island ecosystems.

New Zealand's offshore island reserves offer some of the best opportunities to restore and preserve native biodiversity. Deciding how to restore these reserves can be assisted by reconstructing their past states. For example, a recent project reconstructing the vegetation history of Tawhiti Rahi (Poor Knights Islands) using pollen and aDNA analyses revealed an interesting surprise. The currently native pōhutukawa-dominated forest, thought to be a climax forest type, is actually just a successional forest that established when a 550-year human occupation on the island came to an end. Before human occupation, the vegetation was dominated by a diverse range of angiosperm and conifer species and palms. Given that forested islands like Tawhiti Rahi have been used to help guide the restoration and revegetation of other degraded offshore islands, it is clear how our study of the past offers a useful tool to inform restoration.

Our research continues to turn up ecological surprises and, importantly, shows how the past can generate new insights that are directly relevant to the conservation and restoration of present-day ecosystems and species interactions.

http://ltel.landcareresearch.co.nz

International recognition for New Zealand's endangered fungi

Established in 1964, the International Union for Conservation of Nature's Red List of Threatened Species (www.iucnredlist.org) is a critical indicator of the health of the world's biodiversity and the world's most comprehensive information source on the global conservation status of animal, fungus and plant species.

However, until recently very few fungi had been assessed for their likely Red List status. As the second largest kingdom of multicellular life, fungi were represented in the November 2009 edition of the List by only three species worldwide, along with 17,288 species of animals and plants. Dr Peter Buchanan and Dr Jerry Cooper at Manaaki Whenua have been working hard to address this problem for New Zealand's fungi, drawing on the expertise of staff at Manaaki Whenua's nationally significant New Zealand Fungarium in Auckland.

Following an IUCN Red List workshop in July 2019 in Melbourne, 51 assessments of Australasian fungal species were finalised to IUCN Red List standards by the end of 2019, 30 of these from New Zealand. Of the 51, 3 species were formally Red Listed by IUCN as Critically Endangered, 12 as Endangered, 9 as Vulnerable, and 6 as Near Threatened, 7 were designated as Least Concern, and 14 as Data Deficient.

Progress has also been made on assessments for another 33 species – vastly increasing the knowledge and understanding of our rarest fungi. IUCN data on New Zealand's fungi has also been incorporated by Dr Cooper in a revision submitted to the Department of Conservation of the conservation status of over 900 species of New Zealand mushrooms.

Inclusion on the Red List doesn't confer legal protection, but the data included in each listing provide information about range, population size, habitat and ecology, use and trade, threats, and conservation actions to help inform necessary conservation and policy decisions.

Tea tree fingers (Hypocreopsis amplectens) – *a critically endangered fungus.*

Deconica baylisiana *(the alpine pouch).*

Tea tree fingers (*Hypocreopsis amplectens*) is one of the three Critically Endangered species, only known from seven sites, two of which are in New Zealand. Conservation action to protect this fungus is occurring in Australia but is not yet in place in New Zealand where attempts to relocate it have so far been unsuccessful.

'This is an especially rare and intriguing fungus, with a mysterious ecology,' says Dr Buchanan. 'While appearing to produce its fruitbody on fallen wood, some specimens indicate that it is growing on another fungus that is itself growing on the wood. With such a distinctive finger-like appearance, we hope that keen observers might locate it and report its presence on iNaturalist (https://inaturalist.nz/).'

RED LIST

Critically Endangered **3**

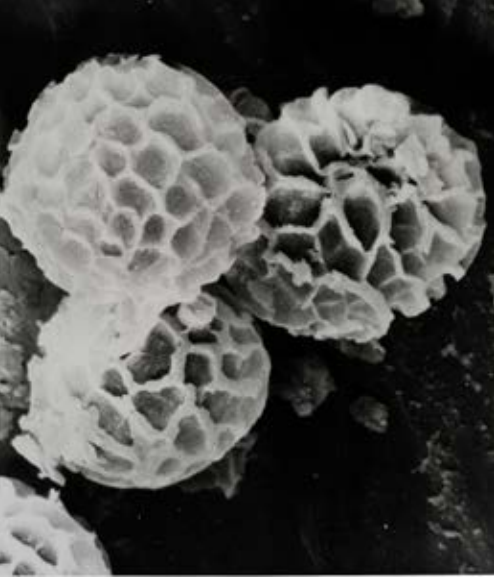
Endangered **12**

Vulnerable **9**

Near Threat **6**

Least Concern **7**

Data Deficient **14**



Abstoma purpureum *under magnification.*

Other ultra-rare New Zealand fungi assessed at the Melbourne workshop include *Deconica baylisiana* (the alpine pouch), an orange truffle-like fungus found only in alpine grasslands and rediscovered by an iNaturalist observer in 2014 after not being seen for 50 years, and *Abstoma purpureum*, a sand-dune puffball that may already be extinct because of decline in habitat.

As well as expertise in this traditional type of species identification, Dr Cooper brings a wealth of experience in informatics and data management to the assessment of New Zealand's fungal biodiversity and threatened status. 'Modern gene sequence-based techniques are allowing us to make more sense of the hidden world of fungi,' he says. 'Those data, combined with the recent explosion of citizen scientists recording species on the iNaturalist platform (https://inaturalist.nz), mean we are beginning to understand a lot more about our fungi and highlight those under threat.'

Funding from Manaaki Whenua, IUCN (UK), and from the Mohamed bin Zayed Species Conservation Fund made the Red List Assessment Workshop in Melbourne possible.

New Zealand's truffle-like fungi

Ghosts of mutualisms past

Elsewhere in the world, truffles and truffle-like fungi grow buried, are dull-coloured, and are spread by mammals. By contrast, here in New Zealand we have an abundance of them, brightly coloured, growing on the soil surface, and perhaps spread in the past by birds we no longer have, or are losing fast. We know from our recent work on ancient DNA in coprolites (see page 10) that they were part of the diet of moa, kakapo, and others; such evolutionary mutual advantages are well documented globally (animal gets food; seed gets spread), but are prone to upset if either mutual partner goes extinct.

A new Marsden research project, awarded in 2019 and led by Manaaki Whenua's Dr Jamie Wood, aims to understand for the first time the dispersal mechanisms of these little-studied fungi in New Zealand, both before and after the 'feathers to fur' transformation of our forest fauna after human arrival. Knowing whether any living animal species are now consuming and dispersing these fungi will help researchers understand their likely threatened status in the future and contribute to the conservation of our native taonga.

A purple pouch fungus.

Celebrating our achievements

Building on her significant contributions to the approval of the Global Assessment on Biodiversity and Ecosystem Services at the Intergovernmental Panel of Biodiversity and Ecosystem Services (IPBES) in Paris in May 2019, **Anne-Gaelle Ausseil** has now been nominated to scope the nexus assessment of interlinkages among biodiversity, water, food and health in the context of climate change for the IPBES.

Anne-Gaelle Ausseil

Sarah Richardson was the 2019 winner of the Te Tohu Taiao – Award for Ecological Excellence – conferred by the New Zealand Ecological Society at its annual conference at Lincoln University. This award is presented annually to recognise individuals who have made an outstanding contribution to the study and application of ecological science. In recognising Sarah, the award is "made to the person who has published the best original research regarding the ecology of New Zealand or to the person who has made a sustained and outstanding contribution to applied ecology, particularly conservation and management".

Nominees of Sarah's award drew attention to her many outstanding attributes, highlighting her ability to combine an impressive publishing record with an inclusive and supportive approach to other researchers. She has been an outstanding mentor to new staff and post-doctoral appointees at Manaaki Whenua, providing encouragement and assistance.

Sarah Richardson

Bevan Weir and **Eric McKenzie** are in a group of only 14 New Zealand researchers who are 'highly cited' according to the latest metrics from the Web of Science. The Highly Cited Researchers list has identified global research scientists and social scientists who have demonstrated exceptional influence – reflected through their publication of multiple papers frequently cited by their peers during the past decade. This shows the importance of the research publications from the Mycology and Bacteriology Group to global plant pathology research and diagnostics. One paper on which Bevan was a co-author has been cited over 3000 times.

Bevan Weir

Putting te reo into taxonomy

Writing in a recent issue of the *New Zealand Journal of Ecology*, Manaaki Whenua researchers Thomas Buckley, Andrew Veale, Holden Hohaia, Kiri Reihana, and Katarina Tawiri, in collaboration with external researchers, review the use of te reo Māori and ta re Moriori (spoken by Moriori on Rekohu – Chatham Island) in scientific taxonomy – the naming of species.

Tepakiphasma ngatikuri.

Current scientific taxonomic practice uses a binomial naming system, first introduced by Linnaeus in the 1750s and standardised and modernised since then.

The researchers identified 1269 different examples of Linnaean taxonomic names containing te reo and another 19 species with ta re in their names. The first species known to have been given a Māori epithet was the North Island tomtit, *Petroica macrocephala toitoi*, described by Lesson and Garnot in 1828. In te reo, 'toitoi' means to dart briskly, as the bird does. Another of the earliest named was *Tupeia antarctica*, the endemic mistletoe, also described by botanists in 1828 using a name to honour Tupaia, the navigator who accompanied Captain Cook from Tahiti to New Zealand and Australia.

Curiously, spiders and snails are overrepresented in the te reo namings, in part explained by enthusiastic individual taxonomists such as Ray Forster, who helped to describe over 670 species of endemic spiders and who used te reo in at least 35 genera and 106 of those species.

Naming a species is not an easy task – a great deal of thought, drawing on long expertise, always goes into each new name. The researchers recommend that taxonomists working on naming species from New Zealand consider the ways that te reo and ta re can be integrated into the naming process. Both taxonomists and Māori have deep and special relationships with the natural world, and have a lot to learn from one another, say the researchers. It follows that these connections to the natural world are best cultivated together and through consultation with one another.

As an example, Dr Buckley describes how he and colleagues collected a new genus of stick insect within the rohe of Ngāti Kuri in 2008, and then consulted Ngāti Kuri on the appropriate name to bestow. The name *Tepakiphasma* was chosen, fusing 'Te Paki' – the place where the insect was collected – with '*phasma*' – the Greek word for 'apparition' commonly used for stick insects. The species epithet *ngatikuri* was given to recognise the then-belief that this species was found only in the rohe of Ngāti Kuri, making the full name *Tepakiphasma ngatikuri*. Note that macrons and other embellishments are not used in the Linnaean system.

Tokenism in naming species with Māori words without consultation, the researchers warn, is likely to be inappropriate and offensive, whereas discussing naming with iwi/imi as part of a collaborative process allows ako (reciprocal learning) to take place. Moreover, under the Treaty of Waitangi (Wai262), the cultural relationship between kaitiaki and taonga species is 'entitled to reasonable protection', and thus the formal naming and description of new species should be done in partnership.

https://newzealandecology.org/nzje/3388

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