Pūtaiao

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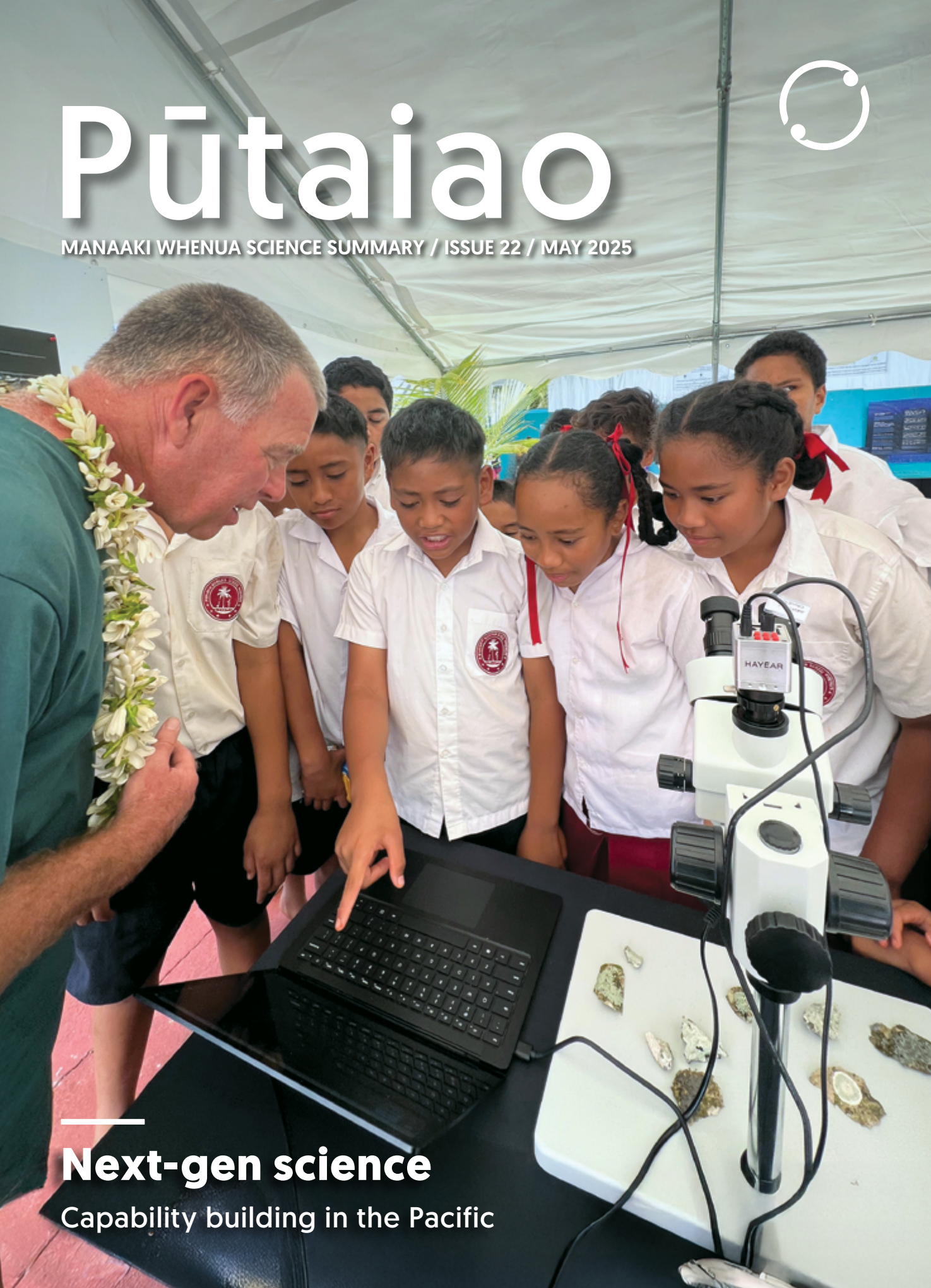

Next-gen science

Capability building in the Pacific

Pūtaiao

Science for our land and our future

Tēnā koe and welcome to Issue 22 of *Pūtaiao (Science)*, our quarterly publication showcasing the work of our scientists at Manaaki Whenua.

Each issue of *Pūtaiao* shares the benefits and outcomes of our science in helping to ensure a sustainable, productive future for Aotearoa New Zealand (AoNZ). In this issue, many of the stories focus on progress in restoring biodiversity and beating invasive species, through collaborative science with real-world impact.

This issue outlines recent progress in developing controls for one of AoNZ's most destructive but simultaneously best-loved introduced predators – the domestic cat. We also bring you news of weed biocontrol successes in the Pacific, a much-anticipated return of biological materials from Kew in London to our fungarium in Auckland, and a review of extensive work outlining how moa paleoecology can inform current conservation of native birds. There's an update on research into the reddening of AoNZ's glaciers in 2022 which is also a neat demolition of the *post hoc* fallacy – the often-mistaken notion that if something happens after an event, it must be caused by that event. We also – literally – delve into over 200 stomachs of rats caught in beech forests in the deep south, to find out what they prefer to eat.

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

You can also sign up to our online webinar series LinkOnline, where we share our science with key stakeholders, here: landcareresearch.co.nz/events/linkonline

Cover image: Dr Peter Heenan presenting to high school students of Mangaia, Cook Islands, on the local native plants and lichens. Peter visited Mangaia during December 2024 to assist with the Te Rangi Ātea Science Expo 2024 organised by Climate Change Cook Islands, the Office of the Prime Minister.

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Herding cats – the science of deterrence

Aotearoa New Zealand (AoNZ) has among the highest per capita ownership of domestic cats (*Felis catus*) in the world, with an estimated 1.2 million nationwide. Some 41% of households own at least one cat.

AoNZ also has significant numbers of stray cats (that partly rely on people) and feral cats, originally descended from domestic cats (so, also *Felis catus*) but which live independently and don't depend on or interact with humans. Exact numbers of feral cats are unknown, although work is underway to model and map their population densities and detectability. They are widespread across the country, in habitats including coastal areas, farmland, forests, riverbeds, sub-alpine environments and islands.

Cats of all three types are a major ecological problem worldwide – they are opportunistic broad-spectrum predators that contribute globally to biodiversity loss. In AoNZ, household, stray and feral cats prey on rabbits and hares, rats and mice, but they also take bats, lizards, birds and bird eggs, wētā and other insects.

But cat management to enhance ecological outcomes is controversial, especially any form of lethal management, because cats are highly valued as companion animals. As a result, a suite of non-lethal approaches to reduce cat impacts on native biodiversity is needed, as well as the careful development of public support (also known as "social licence") for such approaches.

To address this need, as part of an MBIE-funded Smart Idea research programme, scientists at Manaaki Whenua have tested whether sound cues can deter cats from specific locations. The

researchers played sounds of human voices, dogs and cats to test whether these induced fleeing and avoidance behaviours in cats and kept them from exploiting areas where food was placed. The first part of the trial used cats in an enclosure, and the second part of the trial was done in an open suburban area, where cat presence was measured using trail cameras.

In the enclosure trial, human playbacks protected the greatest proportion of food patches, were more likely to reduce time cats spent feeding, and induced more fleeing responses and spatial avoidance than competitor dog and cat playbacks. Cat and dog playbacks were effective in protecting food patches but induced fewer fleeing and avoidance responses. In the open area trial, cat and human playbacks were effective, and these are promising for further testing. The researchers are currently integrating playbacks into a management tool to repel cats from areas where they are not wanted but lethal control is not feasible.

Additionally, work has been done at Manaaki Whenua to establish cat owners' willingness to adopt new cat control measures. Keeping cats indoors at night is an often-cited solution to the problem of cat predation on native species, but is it a realistic suggestion to make? A survey of 2000 cat owners across the country suggests not – at least, not yet: cat owners will mostly or always keep their pets indoors at night only if they have high involvement with cat welfare and a strongly favourable attitude towards keeping cats inside. The survey also showed that concern for cat welfare must be built-in to any cat control solutions. Owners were unlikely to keep cats inside in the long term if promotional material focused solely on the harm that cats do to wildlife, but they might be more prepared to do this if cat-friendly, inexpensive, practical, and easily maintained devices are available that enable cats to be kept inside.

Similarly, whether cat owners put collars on their cats depended on their attitude towards protecting wildlife from cats and their beliefs about the effectiveness of protective devices. If protective devices such as bibs attached to collars are effective, or their effectiveness can be improved, they may offer an inexpensive and practical alternative to keeping cats indoors at night. A campaign promoting the use of these devices would need to offer persuasive evidence that they work and are safe for cats to wear – again, highlighting the importance of cat welfare in the public mind.

These studies are important foundations for understanding the motivations and beliefs of cat owners. The aim of developing non-lethal cat-control tools with built-in social licence to operate is ambitious, but herding cats is perhaps not as difficult as the phrase suggests.

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A little-appreciated ecological problem caused by cats

Toxoplasmosis, caused by an intestinal parasite called *Toxoplasma gondii* has been confirmed as a cause of death of endangered Hector's dolphins and critically endangered Māui dolphins. *T. gondii* reproduces only in cats. The egg-like oocysts of the parasite spread from cat faeces into the environment, and can travel via surface water run-off to the sea. Toxoplasmosis causes abortions in infected sheep, goats and pigs, and vaccinations and lamb losses can be a significant cost to the farming sector. Dolphins can become infected when parasites from cat faeces end up in the marine food chain. The parasite can also affect humans, and if a pregnant woman gets infected via contact with cat faeces, birth defects are possible. Researchers from Manaaki Whenua have modelled the potential spread of toxoplasmosis by feral cats on farmland, and are currently modelling the transmission of toxoplasmosis by feral cats in the catchment area affecting the Māui dolphins.

A cat-astrophe for native species

Studies have shown feral cats have a devastating effect on native species. Here are some examples (from the Department of Conservation).

- In 2020, a feral cat caught in Canterbury had 17 skinks in its stomach.
- In 2010, a feral cat in Ohakune killed 107 bats/pekapeka in just one week.
- From 2019 to 2021, feral cats caused the death of 20% of monitored kea in Arthur's Pass.

Here, there and everywhere: Vanuatu welcomes the beetles

Another milestone for Pacific weed biocontrol was passed in November 2024, with Vanuatu receiving the pico beetle (*Leptinotarsa undecimlineata*) to tackle the spread of the invasive weed prickly solanum (*Solanum torvum*), known as pico weed in Vanuatu. This release follows another successful release – the hibiscus bur lace bug (*Haedus vicarius*) in July 2024, and is part of ongoing efforts to restoring pasture lands overrun by invasive weeds in Vanuatu.

Zane McGrath, Senior Technician at Manaaki Whenua (left), and the Vanuatu Biosecurity team conducting foliage assessment survey at the pico beetle release site in Efate.

Prickly solanum is a thorny shrub or small tree with broad, hairy leaves. It overtops most herbs, grasses, and shrubs, limiting the growth of other species. The weed produces attractive berries that are rapidly dispersed by birds. It has long posed a serious problem for farmers, particularly in cattle-grazing regions, where its thorny structure and toxicity make it unsuitable as fodder. The plant's rapid spread has forced some farmers to reduce livestock numbers or abandon parts of their grazing land.

The pico beetle, native to Jamaica, is the first natural enemy ever released globally to target prickly solanum. Both the adult beetles and their larvae feed on the leaves, effectively stripping the plant and allowing pasture to regenerate. Our researchers have spent five years studying the beetle and determining its suitability to deploy. "This release is of great significance for Vanuatu, where it was recently estimated that 34 percent of grazing land is lost to weeds. The most important pasture weed is prickly solanum, which was ranked the worst, or second worst weed on 81 percent of farms," says Dr Quentin Paynter, who leads the Vanuatu Weeds Programme. "The release of the pico beetle will mean a natural enemy has now been released for three of the four worst pasture weeds in Vanuatu."

This release builds on previous introductions, including the nail grass psyllid (*Heteropsylla spinulosa*), and the hibiscus bur lace bug, which was released on Efate in July 2024, Santo in November 2025, and Malekula in April 2025. The pico beetle was also released on Malekula in April. Work on wild peanut (*Senna* spp.) is still in progress. The PRISMSS NENS team has recently conducted follow-up monitoring at the release sites on Efate and Santo, reporting some promising results particularly for the pico beetle. At multiple sites, significant feeding damage both from adults and larvae was observed, with the invasive weed heavily defoliated. At the hibiscus bur release sites, early indications of lace bug presence were also recorded. White specks at the centre of the leaves made it easier to spot eggs, larvae, and adults on the underside.

Further follow-up surveys are planned for November 2025 to assess the level of establishment. If successful, the project could serve as a model for other Pacific nations facing similar challenges, strengthening the region's resilience through sustainable biocontrol solutions.

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Pico beetle larvae, Leptinotarsa undecimlineata.

Natural Enemies – Natural Solutions (NENS)

Manaaki Whenua is the technical lead for the Secretariat of the Pacific Regional Environment Programme's (SPREP) Pacific Regional Invasive Species Management Support Service's (PRISMSS) Natural Enemies - Natural Solutions (NENS) programme. NENS reduces the vigour of widespread weeds through reuniting them with safe natural enemies from their original homeland. The NENS programme initiatives empowers Pacific communities by improving the health and well-being of all living things and ecosystems.

PRISMSS is a coordinating mechanism designed to facilitate the scaling-up of operational management of invasive species in the Pacific. PRISMSS brings together experts to provide support within the Pacific region with a focus on protection of indigenous biodiversity and ecosystem function. As a service provider, PRISMSS provides a comprehensive suite of support services in a cohesive, effective, efficient, and accessible manner to Pacific Island countries and territories.

PRISMSS

SPREP PROE

NATURAL ENEMIES - NATURAL SOLUTIONS
Biological control of widespread weeds

Psyllid answer: a new biocontrol weapon for Tuvalu

Heteropsylla cubana *psyllid.*

In April last year, Tuvalu released its first-ever natural enemy on the atoll of Funafuti to control their number one weed, *Leucaena leucocephala* (known locally as *tamalini*). A sap-sucking psyllid, *Heteropsylla cubana* feeds on the new leaf tips of Leucaena, stunting plant growth. The psyllid is known as a major pest of Leucaena in agroforestry and is expected to help control Leucaena in Tuvalu.

In November 2024, two team members returned to Funafuti, bringing more psyllid natural enemies to combat Leucaena on Vaitupu, Tuvalu's largest atoll. Vaitupu is one of nine islands that make up the nation of Tuvalu, and is 129 km north-northwest of Funafuti. This work is also part of Manaaki Whenua's Natural Enemies - Natural Solutions (NENS) programme. This release was also of particular significance to one of the weed biocontrol group's newest members, Indigo Michael, who joined in July 2024 as a NENS Pacific Programme Coordinator and whose family hail from the Tuvalu islands of Nukufetau and Vaitupu.

"I'm the first in my family to return to Tuvalu for two generations," says Indigo. "My great-grandmother was born in Vaitupu and would tell me stories of her motherland growing up. But I only heard about Tuvalu and read about it in books. To be able to come to the fenua for such meaningful and important work, and to serve the community that I feel such a strong connection to, was rewarding."

Leucaena has become an aggressive invader in many tropical and sub-tropical regions and is listed in the top 100 of the world's worst invasive plant species. It is considered a major weed across the Pacific, spread both accidentally and intentionally for its beneficial properties such as leaf fodder for animals, nitrogen fixing for agriculture, wood for building materials and fires, shade, and soil stabilisation.

Once touted as the 'miracle tree', Leucaena can quickly outcompete and replace other vegetation, forming dense, impenetrable thickets, impacting nutrient cycling and soil chemistry and disrupting natural successional processes. It quickly colonises disturbed ground, meaning it is expected to be an increasing problem under more turbulent weather systems brought about by climate change.

With a land area of only 5.6 square kilometres and a population of just 1,184 residents, improving the islands' resilience to invasive plants is paramount. Touching down in Funafuti on November 25, the psyllids had flown 3,180 km, but the journey wasn't over yet. Vaitupu doesn't have an airstrip, so the trip had to be coordinated with the timing of the very infrequent inter-island boat that was leaving to pick up the Funafuti children that go to boarding school in Vaitupu. On 28 November, the team handed over the psyllids to staff at the Department of Agriculture to make the last leg of their journey, a 6-hour boat ride from Funafuti to Vaitupu, where they would be released. The release was a success, and the team hopes this will give the island another tool to help in their fight against climate change.

"It's confronting going to Tuvalu and seeing the reality of a small island nation facing the impacts of climate change in all areas of life," says Indigo. "Equipping Tuvalu with long-lasting, sustainable solutions to invasive weeds will not only increase resilience against climate change, but free-up resources once used for managing these weeds that can now be used for improving the health and well-being of Tuvaluans and their fenua."

The Vanuatu project is funded by New Zealand's Ministry of Foreign Affairs and Trade (MFAT) as part of the Vanuatu Pasture Weeds Project. The Tuvalu project is funded by MFAT through the Restoring Islands Resilience programme administered by SPREP, and previously through the MFAT-funded Managing Invasive Species for Climate Change Adaptation in the Pacific (MISCCAP) programme, as well as by the GEF-6 Regional Invasives Project.

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A new partnership building capability in the Pacific

Climate change poses an existential threat to food production, food and nutrition security, biodiversity, livelihoods, and economic resilience in Pacific Island Countries (PICs). Reduced economic resilience and food insecurity also poses risks to domestic security and social stability.

Manaaki Whenua and its predecessor the DSIR have provided government ministries and research stations of Pacific Island countries (Vanuatu, Samoa, Tonga, Fiji, the Cook Islands, and Niue) with climate-resilient agriculture and sustainable land-use support for over 50 years.

We are proud to have been awarded a new contract by MFAT in April 2025 for a regional Pacific partnership with Samoa, Tonga, Fiji, Vanuatu, Cook Islands, and Niue. We will support Pacific-based peer-to-peer networks across countries with links to regional and international science organisations and networks. Under the partnership, we will work alongside PICs' Ministries of Agriculture and Environment, as well as agricultural research organisations to strengthen their capacity for climate resilient:

- land-use science, data analysis, and decision-making tools: building PICs data collection and analytical capacity to enable more accurate and effective climate resilient soils, seeds, and land-use-management assessments, and decision-making;
- on-farm trials for soils, crops, and indigenous plants: undertaking harvest, cultivation, and on-farm research to trial more climate resilient soils, crops, and culturally and commercially significant indigenous plants;
- provincial seed storage and distribution: developing provincial seed centres to improve seed storage and distribution capacity to farmers across Vanuatu – to support food security after cyclones and other climate-change induced disasters; and
- agriculture and land-use lab infrastructure and associated processes: filling infrastructure, systems, and skills gaps for labs that determine climate-resilient seeds/soils/crop/plant traits and protect against climate-induced pests and diseases.

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Preserving the Desert Road: the battle against invasive legumes

The Central North Island Desert Road tussock-lands are special, containing unique landscapes and ecosystems with cultural significance. Yet this special environment faces a persistent threat from invasive species such as broom, gorse, and yellow tree lupin. These fast-spreading plants displace native flora, disrupt ecosystems, and diminish the road's scenic beauty.

In response, Project Yellow was initiated in 2014 as a collaborative biosecurity initiative. A strong collaborative framework was formalised and signatories included central government agencies (Department of Conservation and New Zealand Defence Force), local authorities (Horizons and Waikato Regional Councils), state-owned enterprises (Transpower and Genesis Energy), and iwi organisations (Lake Rotoaira Forest Trust).

To help oversee this project and assist these parties to work closely together to protect 23,000 ha of the Desert Road corridor, the Desert Road Invasive Legume Control Group was developed.

Although significant progress has been made, challenges remain. Harsh alpine conditions can limit fieldwork, and sustained community involvement is essential for long-term success. However, through remote sensing technology a breakthrough in the legume control effort has been achieved: Paul Peterson and Dr James Shepherd working together with external colleagues, including Horizons staff, have used high-resolution imagery and data analytics to transform how invasive legumes are managed across the Central Plateau.

With remote sensing now helping guide decisions and fostering efficient strategies, Project Yellow is well-positioned to meet its 2025 goal of significantly reducing invasive legume populations.

In November 2024, members of the group met to discuss submissions for a MOU (memorandum of understanding). This agreement, replacing the original version, aims to guide efforts from 2025 to 2037. The new MOU will incorporate iwi perspectives and cultural significance, welcoming Ngāti Tūwharetoa and Ngāti Rangi as signatories. It will also reflect findings from the remote sensing work, which highlights the need for strategic shifts in management strategies to achieve the overarching vision:

"The unique natural environment, iconic vista, and cultural significance of the Desert Road area is protected from invasive legumes."

This MOU is not just about preserving the Desert Road; it is also setting a standard for innovative and collaborative biosecurity efforts across New Zealand. With the New Zealand Defence Force and the Department of Conservation poised to adopt weed control strategies inspired by this remote sensing work, the impact extends far beyond its original scope, helping to ensure that the Desert Road's alpine vistas and unique ecosystems endure for future generations.

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HTTPS *doi.org/10.3390/rs16132503*

Are birds always on the menu for rats in New Zealand's beech forests?

A recently published study has shown that native birds are always on the menu for invasive rats in New Zealand's beech forests, regardless of how much other food might be available. The study delved into the DNA inside rat stomachs and showed that one in five rats in a remote Fiordland forest had been eating birds.

The research – a collaboration between researchers at Manaaki Whenua – Landcare Research and the Department of Conservation (DOC) – aimed to understand how rat diet may change over different years. Ship rats have a field day during beech "megamasts" (mass seeding events), when the flood of extra food in the forest leads to a population spike. These increased numbers of rats spell trouble for our native birds, but a crucial question remained – is it just the extra rats that are the problem, or are birds also a bigger part of the rat diet when the seed runs out?

"Answering this question is important to enable the best timing of predator control efforts for bird conservation," explains lead researcher Dr Jo Carpenter. "If rats do end up eating birds more often when beech seed runs out and they begin to starve, that suggests pest control should be timed just before that happens. However, if they eat birds at a similar rate all the time, that suggests we need to always be keeping their numbers down."

But, until now it's been very difficult to tell exactly what rats eat, partly because they chew their food up so finely. The researchers got around this problem by using genetic techniques to illuminate the "ghosts of past meals" by screening the DNA of over 200 rat stomachs. These stomachs came from rats trapped at Lake Alabaster in Fiordland over three years following the megamast of 2019.

The results were sobering – the rats were eating 15 different native and introduced bird species (with a particular fondness for native silvereyes and introduced blackbirds), as well as 40 different plant species (mostly silver beech and broadleaf species, but also mosses and orchids). The proportion of rats consuming birds was surprisingly high – nearly one in five rats overall had bird DNA in their stomachs, with more birds eaten at lower altitudes where birds are more abundant. However, this proportion didn't change over the three years – one in five rats ate birds all the time, suggesting that most rats did not switch to eating more birds when the beech seed bonanza finished.

"We were surprised by how frequently the ship rats were eating birds," comments co-author Dr John Innes, "because most other studies have found birds are only an occasional part of ship rat diet. However, those studies have all had to pick through rat stomachs to find tiny fragments of eggshell or feathers, so it could be that bird consumption was under-estimated."

So what does this mean for conservationists? "Our findings suggest that it's the sheer number of rats in a mast year that are the problem for our native birds, rather than those rats also eating birds more frequently than usual," explains co-author Dr James Griffiths, a science advisor at DOC. "This means it's critical for rats to be kept at low densities where possible, while also timing that control to best protect birds when they are particularly vulnerable, such as during nesting."

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HTTPS *doi: 10.1007/s10530-024-03522-z*

The summer the Southern Alps turned red

Dr Phil Novis on the Fox Glacier. Image: John Hunt.

When snow on the Southern Alps turned from white to red in the summer of 2019/20, ash from Australia's bushfires was blamed. But researchers studying the event now say the real culprit was desert dust storms that sent massive amounts of red dust across the Tasman Sea. These storms are likely to occur more often as the climate warms.

"Media reports in 2020 generally assumed the blanket of red on the mountains was caused by ash swept across the sea from Australia's devastating New Year bushfires. But the red dust that led to the dramatic colour change actually arrived well before New Year," says Dr Holly Winton, an environmental scientist at Te Herenga Waka – Victoria University of Wellington and lead author of a new study about the event.

Time-lapse photography of the Southern Alps' Brewster Glacier, taken by the University's Associate Professor Brian Anderson, showed the red dust arriving on the mountains in late 2019.

Using geochemical fingerprinting, the researchers analysed samples of the dust from the Fox, Franz Josef, and Tasman glaciers and pinpointed its origin as south-east Australia where it was stirred up by desert dust storms. Fuelled by high winds that were also driving bushfires, these storms saw an estimated 4,500 tonnes of red mineral dust dumped on top of snow and ice in the Southern Alps. Most of it fell during two weeks in late November 2019.

"Fresh snowfall quickly buried the dust, but this surface snow melted away in early 2020, coinciding with spectacular skies over New Zealand associated with the Australian bushfires. Not surprisingly, the red mountains and the fires became linked in media reports," says Dr Winton. While the dust storm event lasted only a short time, it could have long-term effects.

"The huge amount of dust dumped reduced albedo – that's the ability of snow to reflect sunlight. The dust particles absorb sunlight. This in turn will raise surface temperatures and increase snow and glacier melt, adding to existing pressures on this environment," says Holly.

The Southern Alps may well see more of these massive dust dumps in coming years as the climate warms, says project leader Dr Phil Novis, a senior researcher at Manaaki Whenua.

"Climate change is expected to result in increased desertification and dry conditions in many areas so these storms – as well as wildfires that can be driven by similar weather patterns – are likely to occur more often.

"The 2019/2020 event is at least the ninth such event recorded in Aotearoa New Zealand since 1902 and surely one of the most dramatic. We are in the firing line from dust blown across the sea when these events occur in Australia," says Phil.

Results of the research are published in the journal *Geophysical Research Letters*. The work, funded by a Marsden Grant from the Royal Society of New Zealand, is part of a wider study looking at the effect of airborne particles on snow and glacier melting. These particles increase melting rates of snow and ice, as do the microbes that live in these habitats, the growth of which may be affected by the deposited particles.

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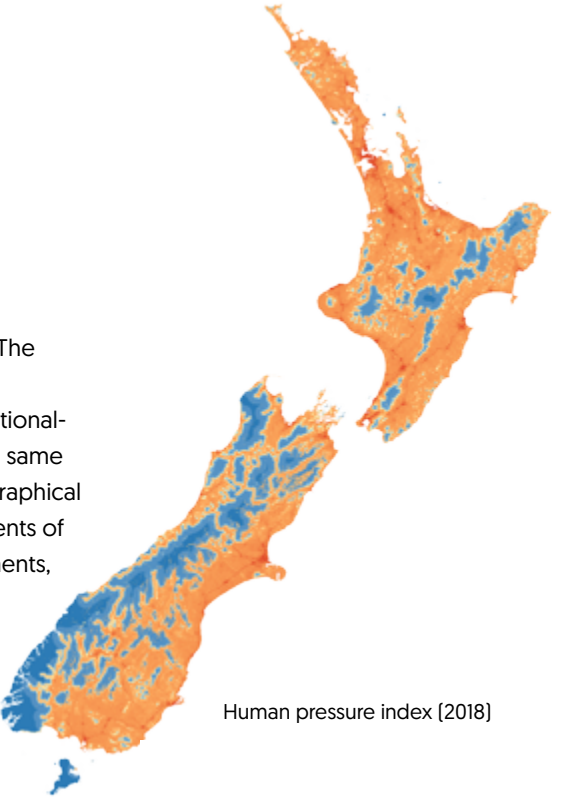
HTTPS *doi.org/10.1029/2024GL112782*

Where the wild things are



Human pressure index (2018)

Low High

In 2002, landscape ecologist Dr Eric Sanderson and colleagues at the Wildlife Conservation Society Institute and Columbia University, New York, wrote an influential paper introducing the Human Footprint Map, a global measure of human pressures on the environment. One of the original aims of the paper was to find and document the "last of the wild" – the most pristine, most natural areas remaining on the planet. They also identified the wildest 1% of each biome (the "seeds of wilderness").

Since then, the Human Footprint Map has been revised and upgraded several times, increasing its capacity to map global threats to biodiversity and to assist with conservation planning and research. It has been used to understand losses of intact ecosystems, changes in species extinction risks, and to quantify the contribution of Indigenous lands with low human pressure to terrestrial mammal conservation.

However, the map resolution is quite coarse (minimum size 1 km^2) and it also uses a map projection – the Mollweide projection – which is good for showing global patterns but distorts the appearance of mid-latitude countries such as New Zealand.

To make the map more useable in a national and regional New Zealand context, Dr Olivia Burge and Richard Law at Manaaki Whenua – Landcare Research, with Sandy Wakefield at the University of Canterbury, have added a new map layer to create a New Zealand human pressure index. The new layer is at higher resolution (100 m), which matches other national-scale datasets, and also uses the same map projection as official topographical maps. It includes eight components of human pressures: built environments, cropland, navigable waterways, pasture, population density, rail, roads, and visible night lights, comparing data for 2012 and 2018.

The local layer revealed that 28% of New Zealand's terrestrial area can be classified as "wilderness" while 60% is "highly modified" by human pressures. This is consistent with the global wilderness estimate of 28% in 2018, although much wilderness elsewhere is tundra and boreal forests/taiga, neither of which is found in New Zealand. By contrast, temperate broadleaf and mixed forests dominate New Zealand's wilderness areas, which also have more montane grasslands and shrublands, temperate grasslands, savannahs, and shrublands than the global average. Total human pressures on the environment between 2012 and 2018 remained much the same, following the pattern shown by other higher-income countries.

To test the usefulness of the new human pressure layer to support conservation-based land-use planning, the researchers then investigated specifically whether it could explain or predict the survival of freshwater wetlands in New Zealand. Wetland conservation and loss are critical in the face of the increasing frequency of extreme climate events and the services wetlands provide in terms of flood mitigation.

Between 2012 and 2018, 1,681 ha of wetlands were lost nationwide. The mapping showed that the biggest pressure on all wetlands was proximity to roads, but the better resolution of the new human pressure map layer enabled the researchers to see that the lost wetlands were additionally within 100 m of land recently converted to pasture. This is a useful finding, because it shows the power of the new layer, even given limited time-series data, to differentiate between pressures on the environment and to predict likely patterns of habitat disappearance if those pressures are not mitigated – both essential tools for effective conservation management.

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HTTPS *doi.org/10.20417/nzjecol.49.3580*

Endless possibilities for fungi specimens returned from Kew

The excitement in the containment room was palpable as a trove of 654 specimens of fungi were welcomed home. Manaaki Whenua staff from the New Zealand Fungarium – Te Kohinga Hekaheka o Aotearoa held a welcoming ceremony for the specimens, recognising the journey they had been on and their return home, before opening the boxes to find out exactly what might be inside.

The specimens, which were being held at Royal Botanic Gardens, Kew, in London, formed the private collection of Dr Greta Stevenson (1911 – 1990), a New Zealand botanist and mycologist renowned for describing many new species of Agaricales (gilled mushrooms). She and the collection moved to England where she completed her taxonomic work and prepared a five-part series on the Agaricales of New Zealand, published between 1962 and 1964.

As the team opened the boxes and started a preliminary sorting of the contents, the true value of the collection started to emerge. The specimens are old, with most collected between 1940 and 1960. Despite their age, it appears that most have been immaculately preserved, from fungal parasites complete with insect hosts to a *Russula* collected in 1949 with its pink and orange colours still apparent. The locations noted on the collection cards show a strong focus on the Wellington region, where Greta lived and worked for a long time, but also a surprising breadth of representation across New Zealand. This will give researchers new knowledge of past landscapes.

Another snapshot the collection provides is one of social landscape. The specimen labels identify a mix of collectors. Several of the collectors' names are well known to the Fungarium team – Marie Taylor, Lucy Moore, and AP Druce. Others are unknown to the team or appear to be collected by students in classes that Greta taught.

The next step for the team is to record a catalogue of the specimens and the other material in the collection, which include original paintings and notes by Greta and others. They will then be rewrapped into archival packaging and added to the national collection.

"Once they're available online, people will be able to request them for research and for things like species revisions," says Dr Maj Padamsee, curator of the New Zealand Fungarium. "The possibilities are endless."

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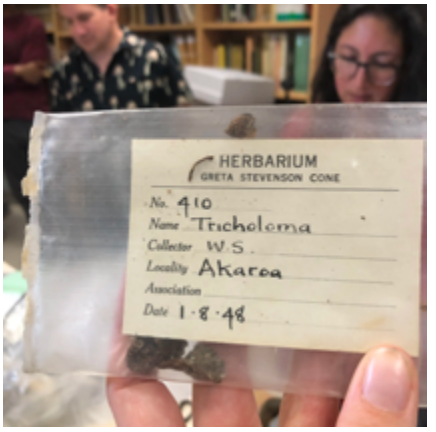

Unboxing fungi specimens from Kew (UK) at the New Zealand Fungarium.

Ancient poo proves moa were key dispersers of colourful truffle-like fungi

In a curious case of finding something unexpected whilst looking for something else, Manaaki Whenua's palaeoecologists have discovered that ancient moa were fond of fungi, particularly colourful truffle-like species that mimic fruit. This discovery, in turn, has helped to advance our understanding of present-day and likely future native forest resilience.

The story begins with two ancient bird coprolites – fossilised poo – collected several years ago from dry caves in two remote locations in New Zealand's South Island beech forests. Coprolites can be carefully picked apart and analysed for DNA and microscopic remains to find out what species of birds deposited them and what they ate. Studying ancient bird coprolites helps to reconstruct what ecological roles extinct birds used to play in shaping New Zealand's ecosystems before they died out.

Initially included in a study of kakapo droppings, the ancient poo turned out to be from the upland moa. Weighing less than 50 kg, this species was one of the smaller members of at least nine species of moa (the larger members reaching over 3 m tall and 250 kg in weight). This guild of birds was flightless, herbivorous and ground-dwelling, and all went extinct around 600 years ago.

Rather than put the coprolites back in the specimen box, the scientists took the opportunity to fully analyse them, with some surprising results.

Truffle-like fungi have fruiting bodies that never fully open and lack a way to eject their spores. Whereas other fungi do this by wind, the truffle-like fungi rely on animals to consume them and disperse their spores. Overseas such fungi – including "true" truffles – are generally drab, strong-smelling and highly appealing to mammals. By contrast, those in New Zealand are often brightly coloured and look much like fallen berries on the forest floor.

It is likely that these fungi depended on fruit-eating birds for their dispersal, yet there is little evidence that any present-day native birds eat them. Ecologists have long debated that their original dispersers must be extinct birds, but this has not been demonstrated before.

Previous work on coprolites has already shown that the extinct moa ate brightly coloured fruits and other plant matter, but the new analyses revealed that moa were indeed consuming these colourful truffle-like fungal species. This finding adds weight to the idea that these fungi had evolved specifically to be attractive to fruit-eating birds. Moa would have been good at dispersing the fungal spores, too. Comparison with their distant cousin the ostrich, which retains

Noah Siegel.

Gallacea scleroderma, *Arthurs Pass.*

food for some 36 hours after eating it, shows that moa could have carried spores in their gut over long distances.

But given the large birds are extinct, what if anything is now driving the dispersion on which these fungi once depended? What will eventually happen to these evolutionary anachronisms – species that rely on other species to establish and thrive that are no longer there? Further, how is this loss likely to affect current native forest resilience and its capacity to regenerate and expand?

The scientists say it's unlikely that remaining species of herbivorous ground-dwelling birds, such as weka, can make up for the loss of moa in dispersing these fungi. In turn, this may be having knock-on effects on overall forest resilience. Forest species such as New Zealand beeches have evolved symbiotic relationships with native fungi, such as the ones detected in the moa poo, to benefit their regeneration and resilience, so fewer or less widespread native fungi in the mix may decrease forest resilience overall.

Are non-native mammals such as possum or deer able to take the place of the moa? No, say the scientists: scent-driven mammals are not so interested in non-odorous, fruity fungi that evolved to catch a ground-dwelling bird's eye, and native fungal spores also don't survive so well in the mammal gut. Instead, non-native mammals tend to disperse non-native fungi, which in turn promote symbiotic relationships with non-native forest species, at the expense of native ones, with possible flow-on effects on native forest resilience.

More study is needed as this gradual turnover of fungal communities continues. What is clear, the scientists conclude, is that the long-term consequences of moa loss on the overall health of native ecosystems are still very much unfolding, some 600 years down the track.

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News in brief

Using overseas plant specimens to protect our biosecurity

Xylella fastidiosa (Xf) is one of the most important plant biosecurity threats to New Zealand. It affects more than 500 plant species, including economically important agricultural crops such as grapevines, summerfruit, citrus and olive, but it is not currently known to be present in New Zealand. As part of the Better Border Biosecurity (B3) collaboration, researchers at Manaaki Whenua screened collections of New Zealand indigenous plants in arboretums and botanical gardens overseas for plant pathogens from the *Xylella* genus. This work is helping scientists to assess the risk of Xf to New Zealand's indigenous flora and the potential spillover to agricultural crops. As a result of the study, MPI has updated its list of indigenous plant species that are confirmed hosts of Xf.

Xylella fastidiosa *on an olive crop.*

A new rapid camera system for insect specimen imaging

Staff at the New Zealand Arthropod Collection, led by entomologist Dr Aaron Harmer with contributions from Dr Darren Ward and Leanne Elder, have created two new semi-automated imaging tools for quickly capturing label images of pinned insect specimens for digitisation. Known as the Raked Pinned Insect Imaging Device (RAPIID), the hardware for these image systems is modular and customisable to user needs. The team has also developed a scaled-down version, RAPIIDlite, and software to run the devices, allowing them to be used by non-experts and volunteers. Initial testing shows that these tools make the imaging process around four times quicker, as well as standardising the processes and reducing error rates.

Pinned specimens.

Celebrating our achievements

The annual Science New Zealand Awards celebrate the people whose research and innovation makes real-world differences. The theme of this year's awards was 'Impacts for Aotearoa New Zealand', recognising the research driving innovation and tangible outcomes that benefit New Zealanders.

Dr Nikki Harcourt was a joint winner in the Te Tohu Tūhura (Charter a Course for Impact through Partnering with Māori) category. Nikki collaborated with external partners from the Hikurangi Bioactives Limited Partnership, Dr Damian Skinner and Manu Caddie, on a programme of research to support the ongoing development of a market for kānuka products in AoNZ. Our other finalists were:

Graeme Rogers - Lifetime Achievement
Graeme recently retired after 50 years of service as a technician at Manaaki Whenua and its predecessors. It is near impossible to cover all the work that Graeme has been a part of during his career. However, those who have worked with him have benefitted from his wide array of MacGyver-like skills, know-how, innovation, and enthusiasm to help others.

Dr Sam McNally - Early Career Researcher
Since completing his PhD in 2016, Sam has had more than 20 papers published in high quality journals. He is the co-lead on the Trees in Landscapes programme, working with a diverse range of stakeholders, to generate new knowledge about how rural landowners can increase biomass and soil carbon stocks, and directly contribute to the mitigation of greenhouse gas emissions.

The S-Map and S-Map Online teams - Success in Innovation/Commercialisation
This team, co-led by Dr Sam Carrick and Dr Linda Lilburne, is behind S-map, the digital soil map for New Zealand. Begun around 20 years ago and ongoing, as of August 2024 S-map coverage stood at 41.2% of all New Zealand soils, with 73% of the most capable land (horticulture, cropping, and intensive pasture systems) covered. The S-map online website supports smarter decisions and investments, and now has over 13,000 active users.

The Whitiwhiti Ora 'Data Supermarket' team - Collaboration for Impact
Dr Linda Lilburne and Dr Nikki Harcourt co-led the Data Supermarket project and Matarau tool, as part of the collaborative Our Land & Water (Whitiwhiti Ora) programme. The team developed a free public website, hosted by Manaaki Whenua, containing a single-format data repository of spatial information on social, environmental, and economic costs and benefits for a range of land use options, including information on vegetable, fruit, arable, animal, plant and tree crops sourced from grower, sector and research entities. Matarau is a user-friendly interactive tool designed to make the data accessible and meaningful for end-users, specifically Māori landowners.

CEO James Stevenson-Wallace & Nikki Harcourt.

Graeme Rogers.

Sam McNally.

Sam Carrick & Linda Lilburne.

Whitiwhiti Ora 'Data Supermarket' team.

How do we know that we have searched enough, when we do not find what we are looking for?

This is a question that most managers face when attempting to ascertain the presence of a pest or a pathogen in an area, so that management actions can be planned accordingly. But what is the point at which researchers can stop looking, knowing with confidence that an area is pest- or pathogen-free?

Dr Dean Anderson and M. Cecilia Latham, researchers in Manaaki Whenua's Wildlife Ecology and Management team, in collaboration with Dr Nari Williams at Plant & Food Research, and Māori colleagues, have designed and published a method to address this issue for the microscopic soil-borne pathogen *Phytophthora agathidicida* (PA), the cause of kauri dieback.

They adapted the Proof of Absence framework, a Bayesian statistical model developed to guide surveillance efforts with the aim of proving freedom from TB in wildlife, to the problem of planning surveillance for a microscopic plant pathogen.

PA surveillance is largely done by taking and lab-testing soil samples, as kauri trees can develop kauri dieback-like symptoms from multiple factors. On the other hand, if PA is not detected during surveillance, the question then becomes how confident can we be that PA is not in that area given that absence of evidence is not evidence of absence?

It was important to investigate how Proof of Absence modelling can help answer two main questions that communities face in the management of kauri forests:

1. If PA and associated disease symptoms are detected in a surveyed area, the immediate management priority is one of containment: to delimit the disease front where PA is present, and apply actions that limit future spread of the pathogen to uninfected neighbouring sites.
2. If PA is not detected, then it is important to determine the surveillance effort required to be confident that PA is absent from a high-risk zone in the forest.

Part of the modelling exercise included developing a risk of pathogen presence map which is based on relationships between the likelihood of PA presence and five environmental variables that are known to influence pathogen ecology. Importantly, it does not preclude the inclusion of other factors considered to be of local importance.

The researchers say that the mapping method is simple and easily transferable between locations and different pathogens of cultural and ecological significance. It should prove to be an effective tool to target trees for surveillance, monitoring and protection, and for local communities and rangers to plan their on-the-ground activities, for example ensuring that monitoring is done exclusively within high risk or low risk areas, but not crossing between levels of risk without the proper hygiene measures.

Results from Proof of Absence analyses showed that many samples are needed to achieve 95% confidence in pathogen absence, but this varied between forests and sectors of each forest. However, these analyses are valuable to guide field efforts as well as to ensure realistic expectations among practitioners.

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