MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

2021 Endeavour Round Successful Projects

SUCCESSFUL 2021 SMART IDEAS

Organisation	Title	Science Leader(s)	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
AgResearch Limited	Novel infant formula emulsions	Simon Loveday	3	$999,999	This Smart Idea "New Infant Formula Emulsions" will develop infant formula ingredients that mimic breast milk better than existing infant formulae. Breast milk supports the growth and development of babies better than infant formulae (IF), partly because IF contains vegetable fats, which are less compatible with a baby's digestion, leading to loss of dietary calcium, constipation and gut discomfort. We have recently discovered a novel, natural source of nutritional oils with similar structure to the fat in breast milk. Recent clinical evidence shows that babies' brains develop better when their diet includes phospholipids, a type fat that coats the surface of fat droplets in milk. Phospholipids can be extracted and concentrated from buttermilk, which is a low-value byproduct from the dairy industry. This raises the question: can novel nutritional oils, combined with dairy phospholipids, substantially enhance the 'human-ness' of infant formula? To address this question, we will combine novel oils with dairy phospholipids to form emulsions (a mixture of oil droplets in water) with similar properties to the fat droplets in human milk. The ability of new IF emulsions to mimic human breast milk will be tested using laboratory simulations of infant digestion processes, and this will indicate how well novel fat is absorbed, compared to the vegetable fats in IF. New IF emulsions will improve babies' fat and calcium absorption and supply phospholipids that crucial for brain development. IF products using this technology will enhance NZ's image as a source of advanced health-enhancing food products, provide economic opportunities for the NZ dairy sector, and build the foundations of a new nutritional oil industry in NZ.
Blue Carbon Services Limited	Quantifying Blue Carbon: kelp contribution to carbon sequestration in marine sediments	Scott Nodder	3	$1,000,000	Macroalgae are the most productive marine macrophytes at a global scale and have long been known to make a large contribution to global carbon sequestration. This proposed research will quantify the role of kelp-derived carbon in offsetting anthropogenic carbon emissions by quantifying kelp biomass and long-term kelp-carbon sequestration into deep-ocean waters and sediments, directly or via herbivorous marine life. This project proposes an alternative option to new forestry development to manage the projected shortfall (23.8 $MtCO_2e$) in Aotearoa New Zealand's 2050 net-zero-emissions target. Restoration and protection of natural kelp communities and the development of kelp-mussel/finfish co-culture could provide an important carbon offset that, unlike forestry, doesn't compete for the use of agricultural land whilst providing long-term carbon sequestration in the order of 1000 of years.
GNS Science	Agent models of tsunami evacuation behaviour to improve planning and preparedness	William Power	3	$999,999	New Zealand is among the nations at greatest risk from natural disasters. Our project focusses on our collective ability to swiftly and safely follow the 'Long or strong – get gone' advice. More than 430,000 New Zealanders live in tsunami evacuation zones, and many more work or play there. Comparisons of the impacts of recent large tsunamis overseas have demonstrated that well-executed tsunami evacuations can prevent many casualties. Our project will simulate the decisions and movements of individual people during a tsunami evacuation. We will consider the use of vehicles, such as cars and bicycles, as well as people evacuating on foot. The computer model will also simulate how people respond when they encounter obstacles, such as landslides and liquefaction, in their path when trying to reach safety. These realistic simulations will identify likely issues, such as insufficient suitable escape routes, so that additional infrastructure can be installed. A further goal is to identify problems that are likely to occur during evacuations, and to use simulations to explore the benefits of different potential solutions. We will also produce high quality animations that will enable people to experience what a large-scale evacuation would be like. We will develop Virtual Reality scenarios in which people can 'virtually' participate in evacuations and will assess their usefulness for making better decisions. Our work will involve 'citizen science' with local communities in tsunami evacuation areas. This will help to identify problems and solutions that are relevant for the diversity of people within their local environments. It is also an important step in educating communities on their specific risks.
	Assessing silent tsunami risk in the Tasman Sea/Te Tai-o-Rēhua	Suzanne Bull	2	$1,000,000	New Zealand is vulnerable to rare but destructive tsunami (up to 40m). Underwater landslides are the second most frequent cause of tsunami and New Zealand is surrounded by numerous examples of these underwater slips. Understanding past events is key to our resilience however NZ's tsunami hazard assessments currently only consider earthquake-triggered tsunami. We will investigate the largest underwater landslides ever found in NZ waters. A series of six events have been discovered in the eastern Tasman Sea, near the Taranaki-Waikato coastline. But they are unfortunately buried or "archived", hidden beneath the seafloor by younger layers of sediment and therefore unexplored from a hazard perspective. Our research will identify landslide frequency, size, causes, and impacts. This will inform the likelihood of a future landslide-tsunami recurrence and strategies for hazard risk mitigation. This evidence will be supplemented by pūrākau (historical stories) and mātauranga (traditional scientific knowledge) relating to past tsunami events in the impact regions. We will use a mixture of existing subsurface geological information and new data, including seafloor maps and sediment cores, that we will collect onboard NZ's research vessel Tangaroa The results will provide a clearer picture of the threat posed by landslide-triggered tsunami in the regions bordering the Tasman Sea, including eastern Australia, and will also improve our understanding of this hazard across the rest of NZ, contributing to enhanced hazard assessment and improved resilience.

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Landcare Research	Exploiting Fear for Integrated Pest Management	Not provided	3	$1,000,000	Our goal is to harness the power of fear to reduce the impacts of cat predation on native species. From grasshoppers to elk, all animals respond to predation risk by modifying their behaviour, yet fear of predators has never been applied to manage invasive species. Cats are both much-loved companion animals and devastating predators of native NZ species. Non-lethal methods are required to manage them effectively and protect NZ birds and other fauna. We will test the effects of deploying vocalisations and odours from dominant cat predators (dogs and humans) to deter cats from entering areas containing vulnerable native fauna. We will trial deployment of predator cues and non-threatening cues (e.g. sheep sounds and smell) at multiple sites over a period of 2 years. We will compare the presence of cats in areas where the two types of cues are provided, using systematically deployed camera traps. We will also deploy tracking collars on cats to determine changes in their behaviour driven by fear of dominant predators. Our methods, if proven, will be commercialised in NZ and deployed by pest control operators, as directed by central and local government or community groups. We will thus contribute to NZ's predator-free goals, protecting biodiversity, reducing pest damage, and helping Māori communities protect native species, strengthening their engagement with their taonga tuku iho through non-lethal, non-toxic pest management. Cat predation of native species is a major international problem, so our products will have export potential. Our methodology will also have potential for broad application to a range of pest species domestically and internationally.
	Pollinator management through floral microbe-mediated behavioural manipulation	Manpreet Dhami	3	$999,999	We will investigate the potential to use fungi and bacteria that live in flowers to attract pollinating bees to increase their pollination of valuable crops. Our world-first research leverages the recent discovery that floral microbes residing in nectar can produce microbial compounds that attract pollinators, thereby increasing microbe dispersal. As well as producing attractive compounds to lure honeybees, microbes can offer a range of additional nutritional benefits to bees. We hypothesise that microbially mediated attraction and (nutritional) reward can be used to alter the foraging behaviour of honeybees. We will determine which volatile compounds and microbial nutrients are most attractive to bees in controlled experiments and exploit this new knowledge to increase honeybee foraging by spraying 'microbial amendments' onto trees during blossoming. We will use mānuka as our test case, using microbial attraction to direct bees to forage in manuka, rather than other nectar-rich sources that are preferred by bees. This will increase yields of high-value monofloral mānuka honey and improve the economic returns of NZ's rapidly growing, $425M mānuka honey industry, while also protecting native pollinators in sensitive ecosystems by reducing competition with introduced honeybees. Our research has potential application to other high-value but difficult to pollinate crops, such as kiwifruit, almonds, apricots, and avocado. As global food production is heavily reliant of insect pollinators, our research could be extended to enhance pollination services and optimise crop yields worldwide, which are threatened by climate change, land-use change, and global insect pollinator declines.
Massey University	High-Resolution Underground Imaging with Airborne Ground-Penetrating Radar	Gabe Redding	3	$1,000,000	If we could use technology to quickly and accurately 'see' underground, it would preserve vital heritage and save New Zealand millions of dollars. There are currently thousands of underground structures around New Zealand that we don't know the precise location or dimensions of. This means that new construction projects risk damaging previously unknown archaeological sites; it also means that costly delays can occur on major projects. Another costly issue is water leaks in buried pipes: determining the exact location of a leak, especially in remote areas, currently costs millions in human labour-hours and wastes our precious water resources. This research aims to develop innovative new technology, the Airborne Underground Imager (AUI), which will allow structures below the surface of the ground to be rapidly and automatically reconstructed and visualised in 3D environments, including augmented and virtual reality. We will do this by mounting a unique combination of sensors on drones that are capable of exploring large areas, even in rugged terrain. We will also create new methods which enable the data captured to be interpreted and reconstructed visually, something that is currently difficult due to poor data resolution and a lack of data describing underground features unique to New Zealand. The proposed technology will represent a substantial advance over current technologies for below-surface imaging, which are cumbersome, expensive, and very difficult for humans to visualise. It is also expected that the Airborne Underground Imager will have broad-ranging applications beyond those targeted by the project, including the detection of historic landfills and contamination sites, the detection of landmines, and the rapid location of people in subterranean search-and-rescue operations.
	Enhancing legume nitrogen fixation to reduce fertiliser use	Paul Dijkwel	3	$1,000,000	Massey University researchers have discovered the key to dramatically reducing the NZ dairy sector's environmental impact, while maintaining optimum productivity, reducing farm expenses, and without any change to farming practice. This breakthrough will significantly cut synthetic nitrogen fertiliser application by making better use of a pasture's natural ability to produce free fertiliser in an environmentally-sustainable way. NZ dairy pastures consist of clover for its ability to fix atmospheric nitrogen and its nutritive value, and ryegrass, which produces high dry matter feed and is usually the cheapest feed available. Ryegrass requires more nitrogen to grow than clover alone can provide, so synthetic fertiliser is applied. However, this stops clover making fertiliser from air, so the benefits of the 'free fertiliser' are lost and even more synthetic fertiliser is required to maximise production. International research has been unable to break this robust inhibition mechanism, however, Massey researchers recently discovered a paradigm-shifting legume that still produces fertiliser from air even when excess nitrogen fertiliser is available. Through a series of carefully-crafted experiments utilising the latest genetic and laboratory techniques, together with premier NZ clover breeding lines, and AgResearch's Margot Forde Germplasm Centre, the science of nitrogen-inhibition will be illuminated and clover lines with this trait identified. New clover cultivars will save up to $588million/annum in fertiliser costs, dramatically reduce agricultural greenhouse gas emissions, improve water quality due to lowered nitrogen runoff, and reduce natural gas use, since synthetic fertiliser is made from natural gas. Clover also requires little ongoing expense and maintenance compared to frequent applications of nitrogen fertiliser. Furthermore, this trait could be bred into other internationally-relevant legumes (peas, beans, alfalfa, soybeans, peanuts, and lentils), giving a truly global impact.

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	BioWhere: Developing Methods to Georeference New Zealand's Biota from Text	Kristin Stock	3	$1,000,000	The BioWhere project is developing methods to determine geographic coordinates (e.g. latitude and longitude) of text location descriptions to unlock huge amounts of biological data. Accurate information about current and historical locations of biota are essential for the protection of endangered species, management of environmental pests and reduction of climate change impacts. Millions of records of species locations in biological collections, scientific reports and journal papers are in textual form (e.g. "South-east of Wellington, mouth of Orongorongo River, near coast"), lacking the coordinates needed to map species distribution. Our methods, using artificial intelligence to generate coordinates corresponding to descriptions of locations, are being developed in collaboration with both local (e.g. Te Papa Tongarewa) and international organisations (Kew Gardens, Natural History Museum, UK). Place names data is key to successful mapping of text descriptions, and the project is collecting data on Māori place names used by iwi/hapū (Rangitāne, Muaūpoko), including their origins, stories and geographic extents as they change over time, providing a foundation for interpreting phrases that mention place names (e.g. "mouth of Orongorongo River"). Historical biological collections data is also being used to extract new knowledge about place names to create a self-learning gazetteer (location-aware database), which is being co-designed with iwi/hapū. Through these activities, the project is exploring methods to promote digital engagement among iwi/hapū. The methods developed in the project have uses far beyond the biological domain, being applicable to any text data, from current and historical sources, enabling mapping of data from social media, historical archives, blogs, newspapers and diaries. For example, they may be used to map disaster impacts from social media posts, historical crime reports in newspaper archives and tourist itineraries from travel diaries.
National Institute of Water and Atmospheric Research Limited	RotoTurf – seeding freshwater restoration	Deborah Hofstra	3	$999,999	Many of New Zealand's shallow lakes are degraded to the point where they are permanently turbid and aquatic plants no longer have sufficient light to grow. Without the plants, wave action resuspends lakebed sediments, and a feedback loop is set up that traps the lake in the degraded state. Multiple restoration actions are required to reverse this process, including catchment management to reduce sediment and nutrient inputs, and management of invasive species. However, when plants have been lost from a lake for a long time, the native seedbank may not be healthy enough for plants to easily re-establish. We will develop and trial the use of native plants in "roto-turf" (roto is Te Reo for lake and turf refers to dense aquatic vegetation), to accelerate the re-establishment of submerged native vegetation and contribute to the restoration of degraded lakes. The research will examine a range of plant species, densities and propagule types, in combination with different types of biodegradable matting. We will use laboratory, tank and lake experiments to determine the net effects of the roto-turfs on lake processes, because while the plants will be beneficial in stabilising sediments, sequestering nutrients, and providing habitat for fauna, we also need to understand the effects of mat degradation as the plants establish. . Native plant mats could also be used in constructed waterbodies (e.g., reservoirs). The beneficiaries of our research include water managers, kaitiaki, the public and conservation agencies that support the restoration of native freshwater biodiversity.
	Transforming scallop fishing: Non-destructive surveying and harvesting for economic acceleration and kaitiakitanga	James Williams	3	$999,999	Seafloor dwelling shellfish (e.g., scallops) are harvested by towed dredges that scoop the surface of the seabed into a net or cage, retaining not only the shellfish but also other organisms that play important roles in ecosystem health and habitat stability. Fishery abundance surveys employ the same method. Repeated seasonal dredging over the same areas of seabed impacts valuable biodiversity that underpins essential ecosystem functions and contributes to destabilisation of the seafloor in vulnerable areas, especially those that are already affected by increased sedimentation and other impacts. Evidence of this can be seen in parts of New Zealand's largest scallop fishery, previously worth over $70M a year but now closed. Between 1987 and 2020, annual commercial harvests across New Zealand have fallen from over 1,000 to 30 tonnes. There is an urgent need to develop new ecologically sustainable methods of harvesting and surveying scallops that do not damage the seafloor. In this project, a highly experienced team of computer and mechatronics engineers, fisheries ecologists, Māori and industry collaborators will develop an innovative, cost-effective 'high-tech' solution to this problem. We will use advanced sensing and deep machine learning to develop (i) a remotely operated surveyor that can accurately measure scallop densities and sizes over broad areas, and (ii) a prototype harvester that differentiates scallops from other objects on the seabed, assesses whether they are of legal-harvest size, and picks them with minimal contact with the surrounding seafloor. Challenges to overcome include the scallops' use of sediment for camouflage, variable turbidity in scallop habitats, and the need to maintain the harvester at a distance from the seafloor that allows accurate scallop detection and sizing but avoids seabed contact.

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	Carbon sequestration via New Zealand's estuarine sediments: Implications for GHG budgets	Not provided	3	$1,000,000	Globally, there is increasing scientific and policy interest in the role that estuarine habitats can play in helping coastal nations achieve their greenhouse gas (GHG) emission-reduction targets. Estuarine habitats (saltmarsh, seagrass, mangrove, soft sediments) have high capacity to absorb carbon, yet carbon storage differs by habitat type and condition. Thus, even small shifts in the proportions of different habitat types within an estuary can lead to large shifts in its overall carbon storage. We hypothesise that estuarine habitat management offers New Zealand a large and previously overlooked opportunity to achieve its national GHG emission reduction targets. Our project will test this hypothesis and significantly advance the global state of knowledge on net GHG emissions in estuaries. In a global first, we will evaluate carbon sequestration and emissions using cutting-edge technology so that the differences in carbon sequestration and GHG emissions between habitats can be quantified. We will use advanced habitat mapping and modelling approaches to project changes in the proportions of estuarine habitat types in response to management actions, simulating national-scale opportunities for GHG reductions that could result from different environmental management choices taken by the country. We estimate that if habitat management could achieve a 2% increase in the amount of terrestrial organic matter that is stored in New Zealand's estuaries, it would remove an additional one million tonnes of carbon per annum that may otherwise be emitted as GHGs. These avoided GHG emissions would be valued at $37 million per year, based on current New Zealand unit pricing equivalent to a 2.6% reduction in the amount of overseas carbon credits that would need to be purchased to meet international climate obligations.
PlantTech Research Institute Limited	A 3D model of radiation transport to enable high yield photosynthetic efficient crops	Alvaro Orsi, Rajasheker Reddy Pullanagari	2	$1,000,000	Photosynthesis makes use of most of the solar energy absorbed, while the excess radiation is dissipated as heat or re-emitted as flourescence. The latter is tightly linked to the performance of photosynthesis, and thus it can be used to assess plant stress. This project consists of developing a rapid, non-invasive and robust monitoring system to reveal signs of plant stress within kiwifruit orchards. This will be performed by using an airborne hyperspectral imaging device to detect the signal of sun-induced fluorescence emitted by the vegetative canopy. The backbone of our technology is to develop a fully-fledged 3D radiative transfer and photosynthesis model of the canopy to perform a robust interpretation of the observed fluoerescence signal. Multiple data sources that include proximal and remote sensing devices will be used to construct a 3D virtual orchard to simulate the fluorescence signal. As a result, this model will deliver the spatial distribution of photosynthetic efficiency, plant stress in the orchards studied, and reveal the likely sources of plant stress (e.g. water, temperature, nutrient deficiency). We anticipate that this project will support increased horticultural production and resilience, with reduced environmental impact, by developing a state-of-the-art knowledge-based technology that delivers step-changes in crop yield and optimises orchard management. Contact details: Dr Alvaro Orsi Science Leader PlantTech Research Institute alvaro@pri.co.nz
Te Pou Tiringa Incorporated	Whakapakari whānau - realising the potential of Māori from early childhood and over generations	Mihi Ratima	3	$1,000,000	The early years of life have a large impact on the rest of our lives, and early learning through providers such as kōhanga reo and early childhood education centres are one of the earliest and most successful ways to set young children on course for a good life and the ability to contribute to the economy. Aotearoa New Zealand is a world leader in the provision of early learning for Indigenous children. Kaupapa Māori and mainstream early learning have many principles in common, but what are the ingredients of different forms of early learning provision that make the biggest difference for Māori children? Our research will find out what the key ingredients are for early learning programming that makes the biggest different for Māori children and kick starts a positive life today and throughout their whole lives. That is, that helps them to contribute to Māori society and wider society, get great jobs and live well as Māori. We also want to find out whether early learning centres that incorporate Māori principles deliver the best early learning programmes not only for Māori children but for all New Zealand children. Early learning opportunities that will make a big positive difference throughout their lives, and the lives of their children and future generations. We are taking an approach to our research that draws on the best of Māori knowledge and Western science, that reimagines research of global excellence that draws on both knowledge systems. We will share what we learn from this approach, so that other researchers can also unlock the potential of Māori knowledge in order to address the issues that are at the heart of New Zealanders' concerns.

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The New Zealand Institute for Plant and Food Research Limited	Te tipu o nga ngaro huruhuru: managed native bees for productive agro-ecosystems	Lisa Evans	3	$1,000,000	Aotearoa/NZ is home to 28 species of native bee, most of which are found nowhere else in the world. As opposed to honey bees, which nest in cavities (or hives provided by beekeepers), most native bees nest in tunnels in the ground. It has been recently discovered that these bees provide a critical contribution to pollination of valuable crops including kiwifruit, summerfruit, pears, and vegetable seed crops – however, growers are unable to rely on these insects for pollination because their populations are unmanaged and can be unpredictable. Some species of native bees may be in decline, and managers currently have few options for helping their populations. In this research programme, a multi-disciplinary team of scientists will unravel the factors that sometimes lead to large clusters, or 'aggregations', of native bee nests, under the right conditions. Working with iwi in Northland and Canterbury, scientists will test the use of odours produced by bees to attract bees to new nest sites, as well as discovering which soil properties are the best for bees. Scientists will also use genomics to test whether bees nest in family groups that return to the same site year after year. Results from this programme will be combined to test new methods for encouraging nesting of native ground-nesting bees and helping to grow their populations where needed. This will lead to development of new tools which can be used to help dwindling bee populations and secure pollination for rare plants in the bush, as well as for crops across NZ. It is estimated that the value of this native pollination to NZ horticulture will be at least $195M p.a.
	Rongoā Whatutoto - Advancing Rongoā Māori Therapeutic Applications through Innovative Technology	Garry Watson, Greg Sawyer	3	$1,000,000	The Rongoā Whatutoto - Advancing Rongoā Māori Therapeutic Applications research programme is a kaupapa Māori research project initiated by Nga Uri o te Ngahere Trust being advanced in collaboration with Plant and Food Research and Otago University. It takes a unique approach in the development of high-value health and wellbeing products based on the application of Mātauranga rongoā Māori, coupling this with advanced science research capability. A sea change in science research will occur through the development of a uniquely Aotearoa transcultural research methodology and novel high-value products for the health market, derived from indigenous plant species. Science in skin biology, phytochemistry, and wound pharmacology will be instructed by tohunga practitioners on Mamaku's mode of healing action, its symbiotic relationship within te Taiao [whakapapa] and its efficacy, to inform the research on Mamaku gel and its constituent gum and phytochemicals. The research expands on preliminary research undertaken and by Nga Uri o te Ngahere Trust via its co-owned company Trinity Bioactives Ltd, and it capitalises on the Trust's R&D relationship with A*STAR Singapore. The New Zealand economy will benefit from the development of unique indigenous products that meet high-demand/high-value market needs. Social, cultural and environmental benefits will result from the novel way the programme is designed, based on traditional knowledge around Mamaku. Decentralised production facilities in Gisborne, Rotorua, Kawakawa and Te Kuiti will stimulate localised employment. Raw material production will spur whenua Māori diversification and social enterprise development in remote rural Māori communities, forming a unique Māori wellbeing economy. The new knowledge from this project will underpin development of high-value indigenous bioactive products for the rapidly growing global bioactive wound-care market forecast to reach $US13.75 billion in 2027.
	The bite of the bumblebee: Biomimicry in flower synchronization	Saeedeh Afsar	3	$1,000,000	Recent research has demonstrated that bumblebees can accelerate plant flowering by biting the plant's leaves. How this works is not understood, and herbivore damage to leaves doesn't trigger the same response. This Smart Idea will unravel the insect-plant interaction that triggers this early flowering response, and synthesise compounds to replicate the effect on horticultural plants. Specifically, we will: Identify active compounds in bumblebee secretions such as saliva using analytical chemistry such as liquid chromatography-mass spectrometry Investigate phytochemical pathways of salivary compounds in leaf samples by microinjection and Raman imaging. If selected compounds have the anticipated effect on flowering characteristics in blueberry, apple and kiwifruit plants, we will begin to explore pre-commercialisation product development pathways. New knowledge and control of plant flowering would have a profound effect on horticulture. An early outcome could be the ability to induce continuous flowering of berries in breeding programmes, enabling faster release of new premium varieties. Climate change impacts could be mitigated by reducing the winter-chilling that apples and kiwifruit need to induce sufficient flowering and fruit set. Harvest timing could be manipulated to minimise industry's peak infrastructure requirements or for in-market benefit. Within the horticulture sector, some growers use hydrogen cyanamide (H 2 2
	Elucidating key mānuka genes determining honey value	David Chagné	3	$999,999	Mānuka honey is a strong growth export industry for Aotearoa-New Zealand, with a goal of growing to $NZ1.2B pa by 2028. Mānuka honey value is derived from the presence of the bioactive compound methylglyoxal (MGO). Our research aims to answer one of the biggest questions for the industry – why do some plants produce much more of the precursor for this bioactive in their nectar and so deliver more valuable mānuka honey? MGO is produced in honey by conversion of dihydroxyacetone (DHA) from mānuka nectar. Why DHA is only found in high amounts in nectars of mānuka, and why DHA production varies greatly between mānuka plants, has been a mystery. We may have found part of the answer – we have identified a specific gene that influences the chemistry of mānuka nectaries, the flower organs that produce nectar. Our research will investigate the role of this gene, and aim to create tools for rapid identification of high-DHA mānuka plants, enabling sustainable high-value honey production. This project will provide an exemplar for how to realise the potential in Aotearoa-NZ's native flora for generating unique high-value, culturally authentic products while also protecting the genetic diversity needed for a robust and sustainable plant-based industry. Our team combines researchers from Plant & Food Research, University of Waikato and University of Minnesota with Ngāti Porou partners. It includes individuals who helped create the strong local mānuka research capacity, international leaders in nectar biology and Māori innovators in the honey sector.

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	Stealth crops: A novel concept in pest management	Ashraf El-Sayed	3	$999,999	Insecticide use has significant impacts on the environment and human health. Each year the number of insecticides available to New Zealand growers for pest control is reduced by new regulations and environmental considerations. In addition, global demands for residue-free production for export are rising. This increases the risk of non-compliance for our agricultural exports and places constraints on organic crop production. This Smart Idea aims to develop a novel, effective pest control method with low environmental impact. This will enable the industry to reach its goal of providing pesticide-free, residue-free, high-value products for export. A research team at Plant & Food Research found that airborne chemical cues from apple trees infested with insect pests prime neighbouring healthy apple trees by "silencing" their emission of volatile organic compounds and altering their physiological status. This suggests a novel, previously undescribed mechanism used by plants to defend against herbivores. The Smart Idea will explore this novel mechanism and its potential use in pest management, by identifying the airborne chemical signals from pest-infested plants that prime the defence systems in surrounding healthy plants. In addition, the defensive metabolites and genes that regulate this process will be investigated for the potential of using a synthetic priming signal to enhance plant defence systems against herbivores and pathogens. This proof-of-concept project will be tested in two economically important agricultural sectors, pipfruit and brassicas. If successful this will generate a radical change in agricultural pest control based on mimicking plant signals for induced silence, by creating "stealth crops" essentially invisible to insect pests. The use of plant-derived compounds to control pests will enable the agriculture industry to reach its target with minimal environmental impacts.
University of Auckland	Making electroceuticals effective through targeted neuromodulation	Daniel McCormick	2	$999,060	Stimulating peripheral nerves using so-called electroceuticals is an attractive alternative to drug based therapies due to the potential for selective control and fewer side effects. The vagus nerve in particular is a key target because it has protective effects via projections from the brain to multiple organs that can be harnessed to treat a broad array of conditions including heart failure, obesity/diabetes, gastrointestinal diseases and inflammatory disorders. To achieve organ-specific effects, currently available devices must be implanted on distal branches of the vagus nerve close to the target, which significantly increases the surgical complexity and associated risk. Our technology on the other hand can be implanted with relative ease in the neck and stimulation steered onto subregions of the vagus to deliver therapeutic effects on downstream targets. This will enable new therapies for many untreated conditions, restoring quality of life to many thousands of New Zealanders.
	Piecing together our past: developing technology and skills to reconstruct broken cultural artefacts	Poul Nielsen	2	$1,000,000	Our history is important, laying the foundation for our culture and national identity. To understand how Māori transformed New Zealand between their arrival and following European colonisation we need to know about their movements, settlements, and regional interaction. We can learn this by combining knowledge derived from analysing taonga such as flaked stone artefacts with the rich oral history of Māori. However, the process of gaining information from these stone artefacts is laborious, requiring highly specialised knowledge currently limited to a few skilled archaeologists. Because of this bottleneck, most of these artefacts remain unanalysed, holding their secrets of the past. This project will integrate the specialised knowledge of archaeologists and a new imaging technology to tell us the shape and composition of stone artefacts, rapidly and accurately, matching the pattern against a large database of previously identified objects. The technology will mean we can quickly identify the stores of artefacts in museums and collections and draw on this knowledge to enrich the place of tāngata whenua in New Zealand history. The project will enhance our knowledge and cultural understanding of Aotearoa's history, and enable better management of the ongoing effects of development and climate change on heritage sites. The technology developed by this project will also be applicable to the analysis of artefacts from other places, filling a critical need in the international cultural heritage industry. They will lay the foundation for a knowledge intensive business which will generate revenue for New Zealand through sales of measurement equipment, analysis software, and/or services.
	Seismic strengthening of floor diapraghms with carbon fibre materials (CFRP)	Enrique del Rey Castillo	3	$1,000,000	Floor diaphragms transfer seismic forces between lateral-load resisting elements like columns and walls. However, floor diaphragms in existing concrete buildings are often inadequate to transfer the tension forces, making them vulnerable to earthquakes. The use of Carbon Fibre Reinforced Polymers (CFRP) is often used to improve the tension capacity of floor diaphragms due to their lightweight and unobtrusiveness. However, the use of CFRP materials in floor diaphragms has not been studied yet, resulting in unsafe and/or inefficient designs. We will study how to use CFRP for seismic strengthening of existing buildings, leveraging extensive co-funding with national and international partners and their knowledge and expertise. Our work will include small scale experimental testing of individual floor diaphragm components, computational modelling and large scale floor replicas. The main outcome will be a design methodology that engineers can use for safe, reliable and efficient design of CFRP ties for existing diaphragms. The methodology will be prepared in close collaboration with local and international engineers, and will be disseminated and implemented into the design process in partnership with the main industry organisations both in Aotearoa and overseas. The research will ensure the seismic resilience of our existing building stock, preventing the loss and disruption observed in previous seismic events and revitalising buildings and city areas. Finally, we will contribute to reducing the economic and environmental impact of demolishing and re-building by extending the design life of existing buildings.

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	Sulfate prodrugs for antibody-drug conjugates as anticancer agents	Moana Tercel	3	$999,999	Antibody-drug conjugates (ADCs) have recently become established as an effective type of cancer treatment. It has been known for a long time that certain antibodies can recognise markers on the surface of cancer cells and so selectively localise in a patient's tumour. In an ADC, an anticancer drug that is able to kill tumour cells is chemically connected to the antibody. After the ADC binds to its target it is taken up into the cancer cell and the drug is released, thus directing the toxic effects selectively to the tumour. Ten such ADCs have been approved as new antitumour agents and more than 80 different ADCs are currently being tested in patients around the world. In New Zealand the ADC Kadcyla was approved by Pharmac in 2019 for some types of breast cancer. Unfortunately most ADCs still cause significant side effects for patients. Usually these effects are associated with the drug component, suggesting that current designs do not deliver ADCs that are as selective or as stable as we would like. In this project we will explore a new way to mask the biological activity of drug types that are commonly used in ADCs. We will make and test examples of these 'prodrugs', and prepare ADCs containing the most promising examples to check that they can be activated in the target cancer cells. Ultimately we want to make ADCs that are just as effective, but much better tolerated, than current examples. Such an outcome would have significant health and economic benefits. For further information contact Dr Moana Tercel , m.tercel@auckland.ac.nz
	Sequentially knock out Phytophthora life stages: An effective solution to protect plants	Viji Sarojini	3	$1,000,000	This research will produce new compounds to tackle plant diseases caused by virulent plant pathogens, including kauri dieback that is devastating New Zealand's iconic trees. In addition, this research will protect several of our horticultural crops such as avocado that suffer from devastating plant pathogens. The compounds developed from this research will be environmentally friendly and help reduce environmental pollution from the use of chemical pesticides. Additionally, protecting our native forests will significantly contribute to reducing the impacts of climate change. This research integrates traditional Māori knowledge with new biochemical science to protect taonga species. The new environmentally friendly solution for plant protection developed from this research can be applied globally and will enhance New Zealand's reputation in biosecurity and clean green image.
	Novel device for delivering therapies to the inner ear	Peter Thorne	3	$1,000,000	This project will develop a novel device to deliver therapies to the inner ear to treat hearing loss. Hearing loss affects about 900,000 people in New Zealand and around 1.5 billion people globally. For many it is a debilitating condition, affecting communication, employment, education and mental health. The World Health Organisation estimates it costs our world economy US$650B annually from direct health care costs and lost productivity. Most of this hearing loss occurs because of disease or injury to the hearing sensory tissues of the cochlea in the inner ear, or because of aging effects. Current interventions depend on technology, like hearing aids and cochlear implants, but extensive research around the world, including at the University of Auckland, is developing drugs and molecular therapies to prevent the cellular damage and hence restore hearing or stop hearing loss happening in the first place. A major barrier to effective uptake of these therapies as they come on-stream is the difficulty of getting them into the bone-encased inner ear. We are developing a universal technological approach to deliver therapies directly into the cochlea through the eardrum and overcome the delivery problems. This will allow new therapies to be safely and effectively delivered to the inner ear to relieve hearing loss and recover hearing function. Contact audiology@auckland.ac.nz
	Harnessing biological materials to make biodegradable electronic devices	Jenny Malmstrom	3	$999,687	In this project we will develop fully biodegradable radio frequency identification (RFID) tags based on biological materials. There is a strong market drive to use electronic tags and sensors to monitor consumer goods and animals. RFIDs are expected to transform supply-chain management of food, in particular. However, there is an increased waste burden from the RFID tags themselves. Our biodegradable tags will limit that waste burden and simplify processes by removing the need to retrieve tags before processing steps. We propose that our tags, can simply be processed together with the raw material and that they will biodegrade to non-toxic materials if left in nature, which would occur in wildlife tracking applications for example. We have identified three industry sectors that will benefit directly from early adoption of biodegradable tags. These are, livestock management, wildlife tracking and food supply-chain management.
	Improving IVF success rates through machine learning	Nicholas Knowlton	3	$921,000	Our goal is to hugely improve the success rates of In Vitro Fertilisation (IVF) implantations. The current process of selecting embryos for implantation in the IVF process is based on little knowledge of the relationship between the parameters for embryo selection and the actual success rates post-implantation. Embryos are selected on the basis of the features in a single image taken at a single time. People are starting to apply artificial intelligence (AI) to selection of embryos, to consider multiple factors at once that make successful implantation and live birth more likely, but these schemes try to copy the current, and limited, approach of embryologists. We have evaluated the existing schemes, and realised that we can do much better; particularly given that none of them appear to improve success rates. Our team of an embryo quality specialist, a machine learning/AI expert, and a clinical embryologist/key opinion leader in embryology will use exclusive access to data regarding embryos and their parents to develop an AI-based approach to embryo selection. We will use information regarding a wide range of aspects of the embryo at different stages in its development, together with information regarding the parents. This knowledge will be embedded in a model, which will be made available widely in New Zealand and overseas, from a new company developed for the purpose. This enterprise will create new export returns from NZ, through selling access to the model, while generating significant social benefits in New Zealand by reducing IVF waiting times and increasing numbers of live births from IVF.

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	A Thumping Good Floor: Granular Metamaterials for Quieter Homes	Not provided	3	$999,843	Building codes and practices in New Zealand do not meet internationally recognised standards for acoustic comfort and privacy that are intended to preserve health and well-being in the face of increasing noise pollution associated with urbanisation and densification. Traditionally acoustic privacy has focused on speech privacy, underestimating disturbances such as the impacts on floors caused by things like scraping chairs, running upstairs and high heels on hard floors. The problem of impact noise has become more important, as evidenced by the growth in complaints with the rise in multi-family dwellings relative to single-family separated houses. The key to substantially improving acoustical separation lies in reducing impact pulse amplitudes as they propagate through the structure. The challenge is that floor impacts generate vibrations over a wide range of audible frequencies. One solution may be to use granular materials that are conglomerations of discrete solid, macroscopic particles, naturally occurring (sand, seeds) or manufactured (pills, Lego bricks). Vibrations travelling through such materials are reduced by dispersion and damping, particularly at low frequencies. We aim to integrate engineered granular materials into New Zealand floor/ceiling systems. Our research on impact noise transmission, together with recent advances in granular materials and mechanical metamaterials, can now be applied to significantly improve impact sound insulation while maintaining the benefits of existing building techniques. Our goal will be to enable the construction industry to meet emerging international standards, providing occupants with "A quiet atmosphere with a high level of protection against intruding sound", specifically thudding, thumping and footfalls. By providing a cost effective solution for raising NZ's impact insulation performance standards to more acceptable levels, we aim to lift the housing conditions in New Zealand.
	Mitigation of coastal wave impacts through innovative engineering and community engagement	Mark Battley	3	$999,654	The effects of climate change are causing significant harm to our coastal communities. Rising sea levels and the increasing frequency and severity of storms will exacerbate damage due to wave impacts around New Zealand's shoreline. Wave impacts can erode coastlines, damage infrastructure and cause flooding, resulting in large financial and social costs. Traditional responses to coastal wave impacts include either building large solid structures ("defend") or displacing communities ("retreat"). These approaches are typically very expensive, and can cause major social and environmental disruption. Further, existing levels of coastal protection may not withstand the types of wave impacts that will be experienced with our changing climate. Through close engagement with at-risk Māori coastal communities we will develop new knowledge of the intersections between scientific and indigenous knowledge, including perceptions of, and responses to, coastal hazards and culturally appropriate approaches to risk mitigation. Building on this knowledge, we will then develop and validate new predictive models of wave-structure interaction to enable solutions tailored to the requirements of specific coastal sites. These will enable the form and flexibility of the solutions to be designed to effectively dissipate and distribute wave energy and protect environmental and social assets. Our research will create methods for design of new approaches to coastal protection to enable prediction of how the shape, flexibility and positioning of coastal protection systems can be optimised. The project will develop new short term, flexible engineering solutions that reduce wave energy and enhance resilience to coastal wave impacts. This will allow time for intergenerational planning, and enable local authorities to spread expenditure over a longer period, for long term solutions.
	New chemistry to control kinase cell signalling in disease	Jack Flanagan	2	$1,000,000	This project will use an innovative type of chemistry we have discovered to develop a new class of drugs that can be used to deliver precision medicine to people suffering from gasrtointestinal and blood cancers driven by a protein called c-Kit/Stem Cell Factor. The new type of drug is designed to specifically target the mutated forms of the proteins found in cancer cells while leaving the normal forms of these proteins alone. This will allow drugs that are not only more effective but that have fewer side effects than the drugs that are currently used. If we are successful in developing this drug it would act as a proof of concept for using our innovative chemistry approach to develop a wide range of other kinase inhibitors. We would aim to make this approach the basis of a new drug discovery and development based in Aotearoa New Zealand.
University of Canterbury	Designing electrocatalytic electrodes to increase performance and lower the cost of redox flow batteries	Aaron Marshall	3	$1,000,000	The development of high-performance redox flow batteries will help support NZ's transition to a low-carbon economy. In NZ, the Government has set the goal of having 100% renewable electricity by 2035 and to be carbon-free by 2050. To achieve this, the intermittent renewable energy from solar and wind must be efficiently stored in batteries. Redox flow batteries (RFBs) are ideal candidates for this as they can store large amounts of energy for long periods, and have the longest lifetime of all the battery technologies. However, while RFBs have many advantages, the capital cost of RFBs is currently too high for wide-spread use. The size and cost of RFBs can be decreased by catalysing the electrode reactions which occur in these batteries. We will invent catalysts with the aim of increasing reaction rates of the most common RFB reactions. Unfortunately, there is limited understanding of how to best catalyse RFB reactions, so we will use advanced theoretical calculations to predict what catalyst will be best. Ultimately, the catalytic electrodes that we will produce, will lead to significant economic benefits by exporting these electrodes from NZ to international RFB manufacturers. The RFB market is growing very quickly and our catalytic electrodes have the potential to accelerate this growth further by making RFBs more competitive with other energy storage options. In addition to the economic benefits, less expensive RFBs will facilitate the further use and storage of renewable energy, and ultimately help NZ reach the Government's goal of having 100% renewable electricity by 2035.

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	Fungal biosynthesis of nisin for enteric methane mitigation	Emily Parker, Sarah Kessans,	2	$1,000,000	Thirty-five percent of New Zealand's gross greenhouse gas emissions are a result of methane production in our grazing sheep and cattle. The reduction of these agricultural methane emissions to meet our obligations under the Kyoto Protocol and Paris Climate Accord is a significant priority of the New Zealand government, with millions of dollars invested into methane mitigation research including improved livestock genetics, vaccines, and methane production inhibitors. New Zealand is at the forefront of research identifying compounds that can be used as inhibitors of enteric methane production, with currently known compounds providing up to 80% reduction in methane production in ruminant animals. Despite the potential of these compounds to reduce methane emissions when used as feed additives, the ability to deliver such compounds to our ten million hectares of dairy, sheep, and beef farms remains a critical challenge. Our proposal will make significant advances in providing dual manufacturing methods for natural methane inhibitor compounds - both in a fungal factory system as well as a significant step change in the form of a novel pasture-based delivery system.
	Building an integrative genomics framework to mitigate maladaptive reproductive traits in endangered species	Tammy Steeves	3	$1,000,000	Of the 266 recovery programmes around the world using intensive management to recover wild populations of endangered birds, including 16 taonga species unique to New Zealand, many report issues with early hatching failure (eggs that fail to hatch due to infertility or embryo death <5 days). Selecting appropriate individuals for breeding is vital, as the inclusion of individuals with low hatching success impedes species recovery. Current selection methods are inadequate because the genomic basis of disadvantageous reproductive traits, such as early hatching failure, are unknown and we lack standard approaches for mitigating these traits. We will combine new and existing genomic resources with an innovative cytogenetics approach to determine the genomic underpinnings of early hatching failure in highly endangered birds. We will integrate these discoveries into individual-based models to provide conservation practitioners with revolutionary breeding selection tools that will improve conservation outcomes for intensively managed endangered species. We will also co-develop an interdisciplinary programme with our Māori partners, targeted at rangatahi (Māori youth), to empower future conservation leaders to explore multifaceted issues in genomics and the emerging field of chromosomics. We will leverage our national and international networks in the conservation community–including iwi and hapū–to accelerate adoption of our integrative genomics approach as best practice by conservation practitioners in Aotearoa New Zealand. The impact of this work will fundamentally change the way we manage endangered taonga species and reinforce Aotearoa New Zealand's reputation as a world leader in recovering treasured species on the brink of extinction.
	Transforming New Zealand's ICT workforce using digital personalized interactive training	Tanja Mitrovic	3	$999,753	The growth of NZ's software industry is essential for NZ's vision of a productive economy. With 12,000 firms, 35,000 employees, a $5.3Bn contribution to GDP and a strong export focus, the software sector is a high value sector. Underpinning this economic value are highly skilled professionals. To build high quality software, "transferable" skills, including team and intercultural skills, communication, negotiation, empathy, are significant. However, many ICT graduates and professionals lack these skills and teaching them is expensive and time consuming. This research aims to develop an online, interactive and personalised learning approach for transferable skills based on "active" video watching. Novel scientific contributions are: 1) AI-based model to provide personalized support and learning during video watching; 2) an interaction model for engagement with video-based learning material that integrates interactive activities to ensure consistent, active engagement based on a learner's profile; 3) a computer-based training platform geared towards transferable skills relevant for different types of ICT roles based on scientific rigor and practical relevance. We will identify psychological and cognitive factors that facilitate video-based learning of transferable skills and define skills suitable for video-based learning. The research will enhance conventional passive video watching with novel mechanisms to increase learning experience, and push beyond a conventional classroom setting into professional development in industry. The research will help small and medium-sized ICT companies in NZ train employees in an effective and time-efficient manner, resulting in quantified gains in productivity and economic performance. In particular, it will extend reach and accessibility to more effective training and lower barriers to adoption. Our research will reinforce NZ's position as an international leader in AI in education, and software engineering research, science and technology.
	Non-invasive sap flow measurement and mechanisms for reliable tree syrup yield predictions	Matt Watson	3	$999,999	Tree syrup is produced by concentrating the sugars found in sustainably harvested tree sap, and there is evidence that the climatic conditions in NZ are sufficient to enable maple sap flow. However, since the mechanisms for sap flow are not understood, consequent sap yield predictions are unreliable, limiting investment into what could be a high-value export opportunity. We will deliver, for the first time, direct evidence of the mechanisms required for sap flow in maple, birch and selected native trees through enhanced imaging techniques, such as X-ray microtomography, magnetic resonance imaging and electron microscopy. We will create a first principles sap exudation model to predict sap yield under various climatic conditions and differing harvesting techniques. Armed with an evidence-based model, we will validate it against test plantations and existing trees, and determine the economic viability of establishing a tree syrup industry in New Zealand. Our vision is for 2,000 hectares of a tree sap row-crop and sap-to-syrup processing facilities, which will generate $60 million/year in export revenues, and create permanent and seasonal employment opportunities in NZ's provinces. Environmental spill over benefits include the potential to use the trees as a riparian buffer and to sequester carbon. For maple syrup, recent US-based research suggests that densely planted saplings can produce 3,000 litres of maple sap per hectare. At a wholesale price of $10 per litre, this corresponds to revenues of $30,000 per hectare annually. This compares very favourably to returns from plantation forests (~$2,500 per hectare). Birch syrup has an even higher value than maple syrup, while syrup derived from native trees will enable a protected geographical indication (like scotch to Scotland) and further support a nationwide tree syrup industry.

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	3D bathymetric modelling of shallow freshwater bodies with short-wave, small-footprint aerial lidar	James Brasington	2	$999,924	In the last decade, airborne lidar has transformed our understanding of floodplains and riparian environments. However, the near-infrared lasers used in these survey systems are absorbed by water, so that our ability to measure the underwater form of our river and lakes stops at the shoreline. A new class of airborne lidar utilizing a shortwave laser has the potential to transform our knowledge of the form, structure and dynamics of shallow waterbodies by penetrating through the water to delivering rich, 3D models of our underwater environments. Our research will assess the performance and optimize applications of this new, disruptive technology. Through a combination of robust field testing and data modelling, our research will facilitate the development of an improved evidence base for managing and restoring our waterways, giving effect to Te Mana o te Wai and supporting adaptive responses to the hazards posed by climate change.
	Distributed radio-localisation techniques to track flying insects with a UAV swarm	Steve Pawson	3	$999,705	New Zealand has more than 1,000 threatened invertebrate species with many species yet to be assessed. Reversing the decline of these small, cryptic, but vital elements of our ecosystems is impeded by a lack of understanding of how individuals interact with the environment. Bird conservation has benefited enormously from the ability to track individuals using transmitters, hence real-word behavioural/movement data supports the implementation of conservation operations. Our Smart Idea is an autonomous UAV mounted harmonic radar tracking system for flying invertebrates. The system relies on small (<10mg) tags that we can attach to the insect. Harmonic radar is a wireless technology whereby we transmit a signal on one frequency and the tag then processes the frequency to double its wavelength and re-emit this new frequency (2nd harmonic). Hence we can transmit a relatively powerful signal whilst simultaneously searching for low power 2nd harmonic signals amongst the clutter of reflections from the primary frequency that bounce off other objects in the environment. Essentially harmonic radar allows us to find that needle in a haystack. Mounting this technology on a group of UAVs creates a harmonic radar array that acts as an invisible virtual box in the sky that moves with the flying insect thus tracking its movement through the landscape. Our project aims to provide new tools that deliver vital information to conservation practitioners. In addition we utilise the novelty of our approach to engage with Māori to explore the myriad of opportunities that wireless technologies present for Māori businesses or communities. Final year UC engineering students will work with Māori organisations to identify needs and work together to co-design and trial solutions that deliver relevant outcomes using wireless technologies.
	Production of technology-critical, strategic metals using molten oxide electrolysis	Catherine Bishop	3	$999,999	The current systems for mining and processing minerals and metals are not always efficient, often polluting, geopolitically insecure and subject to increased social pressure and public protests. New processes are needed to address future supply needs. This is particularly relevant at a time when New Zealand, and the globe, is rapidly scaling up the deployment of renewable energy generation. Low emissions technologies require secure production of critical, and often rare, minerals and metals to build them (e.g. electric vehicles, batteries, superconductors and most modern electronics.) This research will design a near-zero emissions route to produce strategic metals from mixed oxides, leveraging high temperature (> 1000°C) experimental capabilities and predictive software to develop a molten oxide electrolysis (MOE) platform. The project seeks to overcome science challenges in the identification of suitable electrolytes, inert electrodes and operating conditions for particular metals. Two high-value, technology-critical elements, tantalum and neodymium, will be targeted as proof-of-concept. Each occurs in ores of mixed oxides with valuable, chemically-similar metals, and has different traditional processing routes. Tantalum is used primarily in capacitors; while neodymium is an essential ingredient in permanent magnets used in renewable energy generation and electric vehicle motors. These target elements have high value, small markets so domestic production will be viable. The research team combines expertise in ultra-high temperature experiments, electrochemistry, thermodynamics and MOE. New Zealand is ideally placed to lead this pioneering research area because we have an abundance of 'green' energy to use in metal production and are committed to innovation as a means to meet climate change objectives.
University of Otago	A metal isotope environmental toolkit for tracing emerging heavy metal pollutants	Claudine Stirling	3	$1,000,000	Heavy-metal pollutants are increasingly abundant in New Zealand's waterways due to mounting land-use pressures and their common use in transport, construction, agricultural and horticultural materials. This has led to the accumulation of heavy-metals in soils, streams and estuaries, exerting toxic effects on ecosystems, providing a pathway for adverse human-health effects, and tarnishing NZ's 'clean-and-green' export-image. Heavy-metal contamination is traditionally monitored by assessing the amounts of heavy-metals in waterways. However, the exact origin of the pollutant is not easily identifiable because there are multiple contaminant-sources contributing to the overall signature. This lowers the accuracy of heavy-metal contaminant-projections by NZ's regulatory-authorities and restricts the effectiveness of management practices. We aim to demonstrate the superior resolving power of metal-isotope 'fingerprinting' over traditional approaches for identifying and tracking individual heavy-metal contaminants from their points of origin to their ultimate 'sinks' of accumulation. Our study will target historic, current-use and emerging high-risk heavy-metal pollutants, such as copper, zinc, cadmium, lead and uranium, in this high-growth region. Our findings will be used to validate the new contaminant-model of Auckland-Council, and improve future contaminant-projections for heavy-metals. This will help prioritize management decision-making and incentivize sustainable urbanization and resource use to protect NZ's vulnerable ecosystems, internationally-renowned '100%-pure NZ' image, and major export industries of agriculture, horticulture and aquaculture.

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	Rapid, innovative monitoring of pest and native species using aquatic environmental DNA	Neil Gemmell	3	$1,000,000	Aotearoa New Zealand needs new game-changing tools to lower the cost of pest management, reduce the > $3 billion in damage mammalian pests do to our productive and natural sectors and achieve its Predator Free 2050 goals. Effective pest management requires ongoing surveys to discern the distributions, densities and movements of pest species before, during and after control. Current pest surveillance tools are laborious, expensive and perform poorly when pest densities are low. Here, we seek to test, develop and implement novel environmental (eDNA) pest monitoring methods to rapidly and accurately measure the distributions and densities of possums, rats, stoats, and potentially other parts of our biota, at low densities from local to landscape scales. eDNA, the assortment of genetic material found in the environment with no obvious signs of source material, has emerged as one of the most powerful new tools for investigating the diversity of living things in our environment. Recently, we demonstrated that eDNA surveys of water bodies might provide a cost-effective, efficient, sensitive and reliable pest surveillance tool. Here, using experiments that span the laboratory to field sites of increasing size and complexity, we will determine if aquatic eDNA surveys can rapidly and accurately measure the distributions, densities and movements of pest and other species, from local to landscape scales Cost-effective, efficient, sensitive and reliable pest survey tools based on eDNA will revolutionise pest management. Our work will provide new tools and approaches that will determine pest presence and abundance quickly and effectively, strengthening kaitiakitanga and providing new biodiversity information that supports mātauranga. In addition, it will spawn new technical capability, intellectual property and commercial opportunities in the high-value global pest control market.
	Novel Mānuka oil antibacterial medicaments to promote bone regeneration in oral wounds	Warwick Duncan	3	$999,500	Medical devices and medications are used by dentists for the preservation and/or regeneration of gum and bone after extracting teeth or following destructive gum disease around teeth (periodontitis) or dental implants (peri-implantitis). More than half of New Zealanders have lost one or more teeth due to oral diseases; many receive dental implants to replace these teeth. Periodontitis affects teeth in 10% of New Zealanders and 10% of dental implants. Treatment may include the use of slow-release antibacterial gels, followed by scaffold grafting materials and /or resorbable membrane. Mānuka is a New Zealand shrub with well-known internationally-recognised antimicrobial properties, knowledge embodied within tikanga Māori as a rongoā rākau (traditional botanical medicine). In collaboration with our industry partners Tairawhiti Pharmaceuticals Ltd. and New Zealand Bovine Pharma, we plan to develop natural plant-based antimicrobial products for use in oral therapeutics.
	Enhancing seed inoculants with bacteriophages to enable more sustainable agriculture	Simon Jackson	3	$1,000,000	Much of Aotearoa-NZ's pastoral farming relies on synthetic nitrogen fertilisers that have substantial environmental downsides. To protect our waterways and support long-term environmental and economic sustainability, we must urgently reduce their use. A proven alternative are legumes, such as white clover, paired with bacteria that naturally obtain nitrogen from the air. Globally, the use of nitrogen-fixing bacteria called rhizobia reduces fertiliser requirements by > 70M tons annually, representing substantial greenhouse emissions reduction compared with fertiliser production and application. More widespread use of rhizobia in agricultural systems, particularly pastoral farming, will increase these emissions savings and reduce nutrient leaching. However, not all rhizobia strains perform the same and the key to realising the benefits of legumes is in ensuring that the best nitrogen-fixing rhizobia strains are used effectively. 'Elite' rhizobia strains are typically applied via clover seeds coated with high amounts of the desired new inoculant. The performance gains of these elite rhizobia inoculants rely on the new versions establishing themselves in pasture soils. Unfortunately, inferior rhizobia that are already present in soils often outcompete the desired new rhizobia, resulting in poor performance. Overcoming this 'competition problem' is critical to unlocking the major potential value of elite agricultural seed inoculants. Here, we will develop a natural probiotic seed coating that helps boost the growth of elite rhizobia. Our technology will have multiple future applications for diverse bacteria that benefit plant growth, such as phosphate-mobilising bacteria and biopesticides. With the global agricultural bacteria market worth > US$430M per annum and increasing consumer and government demand for alternatives to synthetic agrichemicals, increasing the performance and use of bacteria in agricultural systems represents a major economic opportunity.
	Sterilization of pests for conservation of native species using a cell-targeting approach	Greg Anderson	3	$1,000,000	The decline in New Zealand's biodiversity is rampant. Introduced pest species such as rats, possums, stoats and ferrets have caused half of the surviving indigenous plant and bird species in New Zealand to be at risk. Clearly, improved eradication technologies are imperative. We aim to develop a novel, single-application humane approach to permanently sterilise pest animals. This approach would serve as a potential replacement for 1080 poisoning (which doesn't kill all predator species, can potentially kill off-target species and engenders significant community opposition). The effects of our method are permanent and, importantly, it only acts on mammals so native birdlife would remain fertile.
	A transformative DNA diagnostic test for early-stage cancer detection	Augustine Chen	3	$1,000,000	The rising incidence of cancer is driving the urgent need for innovative solutions to address the absence of effective early detection in the global diagnostic market. Current molecular diagnostic tests either lack sensitivity, specificity or reliable early-stage biomarkers. Here we outline new core technologies designed to transform the state of the art for molecular diagnostic testing by overcoming major technical and equity barriers to early cancer detection and monitoring. We will develop a transformative, sensitive and flexible pan-cancer diagnostic test to detect cancer onset and monitor progression.

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	Controlling damaging invasive pests by learning from successful biocontrol	Peter Dearden	3	$999,999	New Zealand's primary production and conservation estates are threatened by invasive species, some here already, and many currently being intercepted at our borders. These pests threaten our productivity and conservation efforts, but also our ability to improve the use of our landscapes, requiring new pesticides, and more costly and damaging pest management. One solution often applied in these situations is biocontrol, where a predator or disease of an introduced pest is imported to spread through the environment and control that pest. Biocontrol can be an effective, pesticide-free, non-GMO method of controlling damaging invasive pests, but new biocontrol agents are often ineffective. Importing ineffective biocontrol agents is costly, time-consuming, and dangerous. Biocontrol can fail due to the biocontrol species not spreading well in its new environment or worse finding native species that it can attack. Such biocontrol agents could also contain non-native viruses and microbes that could trigger environmental damage. Biocontrol is an important tool but we need to be able to better predict when it will work well before we release a biocontrol agent and to be sure that we are not introducing damaging species. We aim to leverage a remarkable 35-year experiment carried out in New Zealand biocontrol to identify factors in biocontrol species genomes, microbiomes and viromes (hologenome) associated with both biocontrol success and failure. We will use this information to study biocontrol agents that are slated for release in New Zealand, developing tools to predict their effectiveness. By finding hologenomic correlations of successful biocontrol, we will improve biocontrol systems already present in New Zealand, reduce uncertainty around biocontrol systems being proposed, and ensure that effective methods are available to control future pests without increasing pesticide use.
	Space-ready radiometers for climate monitoring: using light to detect thermal radiation	Harald Schwefel	3	$1,000,000	Weather prediction and green-house gas monitoring require satellite-based radiometers that can pick up the minute thermal (microwave and terahertz wave) radiation of molecules such as atmospheric Ozone. The current generation of instruments on NASA's EOS-Aura satellite are so heavy, bulky and energy hungry that they don't fit on the increasingly popular smaller and cheaper CubeSats. With the Aura satellite phasing out later this decade and no plans for full-sized follow-up missions, the future looks very bleak for global monitoring of green-house gases. Our project will improve upon the current radiometers being used for such applications by avoiding the energy hungry cryogenic environment required by conventional devices. Our design, converts the microwave/THz radiation first into the optical domain, for increased measurement sensitivity. Together with our international collaborators and our industry partners we will build upon the laboratory study to design, build, and investigate a compact, portable version of the radiometer that fulfils the requirements of our atmospheric and climate research collaborators and partners. Thereby providing the path for space-ready hardware for future deployment through NZ/Aotearoa's space agency onto vessels from NZ companies such as KeaAerospace.
University of Waikato	An ecosystem modelling platform to assist New Zealand lake management	Deniz Ozkundakci	3	$999,999	New Zealand lakes are under increasing pressure from land use intensification, urbanisation, and invasive species proliferation. Models are the best available tool to assess, manage, and protect NZ's essential freshwater resources. Lake ecosystem models distill scientific knowledge of lake processes (and external forcing such as weather and climate) into computer-coded equations. Lake water attributes including temperature and currents (hydrodynamics) are then simulated, both for the present day and future scenarios or aspirations. Decisions with respect to protection, management, and restoration of lakes rely on ecosystem models to select appropriate and effective management actions to achieve desired outcomes. Such models are currently not accessible due to the complexity and effort required to create models for individual lakes. Our Smart Idea involves the use of advanced computing technologies (including supercomputing) and software to generate models for all New Zealand lakes based on knowledge gained from automated models generated for 100 lakes with known water quality. Our research will enable better management of lakes by providing councils and iwi the tools needed to simulate pathways to aspirational water quality targets.
	Quantifying past rainfall and climate extremes in New Zealand	Adam Hartland	3	$1,000,000	Records of rainfall in New Zealand extend only to the period of post-colonial development when instrumental records first began. Beyond that time, the past climate and rainfall patterns of New Zealand remain unknown except for broad trends in relative wetness or dryness over the last few thousand years. This inexact understanding of New Zealand's past rainfall means that we have limited information on the degree to which rainfall may shift due to the large-scale changes anticipated due to man made climate change. This research aims to deliver precise records of rainfall and flooding in New Zealand with which to test assumptions about future climate states and to plan investments in infrastructure such as hydroelectric power generation. Our approach uses cave deposits such as stalagmites to quantify past rainfall through a combination of cave monitoring and state-of-the-art geochemical and magnetic methods. This research will extend our records of past rainfall from decades to millennia, massively increasing our understanding of the severity and frequency of droughts and floods. Furthermore, we aim to investigate time periods when climate changed rapidly providing analogues of near-future climate states.

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Victoria University of Wellington	Optics-based distributed magnetic field and temperature sensor for enhanced power infrastructure reliability	Shen Chong	3	$999,999	The move to a greener society utilizing more electric transportation will place increasing strain on existing power generation and distribution systems. New methods are urgently needed to ensure their reliability. The key to mitigate potential equipment or power lines failure, prior to the point-of-no-return, is to monitor two parameters concurrently – magnetic field and temperature at multiple locations. Any anomalous behaviour in either one can signal a potential failure is about to occur. We propose a new multi-functional distributed sensor system using optical fibres that have both composites that change their colour in a magnetic field for magnetic field sensing and nanoparticles for temperature monitoring. Our sensor system will be an optics-based distributed magnetic field and temperature sensors that will monitor the electric current and temperature along the entire length of a fibre optic cable. Wireless is required because the environment can have high voltages that can damage wired sensors, e.g. in substations, in a potentially flammable environment (e.g. transformers), or in areas not easily accessible to other sensors. Our novel magnetochromic composite will work by a magnetic field inducing a stress in a magnetic phase that is transferred to a mechanochromic phase, leading to a change in colour and intensity of the reflected light that can be directly related to the magnetic field. Luminescence from doped nanoparticles will enable distributed temperature monitoring using the same optical detection system that will reduce the cost and complexity. The development of these next-generation distributed magnetic and temperature fibre optic sensors is essential to ensure reliability of New Zealand's electricity generation and distribution systems, and related infrastructure. It will also create new export opportunities for NZ-based high-tech companies.
	Better models of human emotions for interactive media	Hedwig Eisenbarth	3	$999,999	Making interactive media characters look natural and behave natural and in a way we can identify with is currently not possible. The emotional world of such characters is limited to a small set of emotional facial expressions based on either single actors or algorithms derived from Western samples. How can we represent emotional states for interactive media, and allow Māori interactive characters to visibly change embodied emotional states? This project advances our understanding of human emotions by observing humans in natural interactions, using a holistic approach that includes recording of body movement, facial expressions, body reactions such as heart rate and breathing. We will use a multi-dimensional space to represent emotional experiences rather than emotion categories. This allows us to describe an infinite variety of emotional states rather than being limited to simple categories such as sadness or anger. Based on these data we will generate computational models that reflect embodied emotion and can be implemented in interactive media design. This will allow interactive media companies to implement emotional states in the flow of the process, responding to the momentary need and to represent Māori characters appropriately and holistically. Our project will therefore enable New Zealand's interactive media industry to share cultural stories and representing emotions in a new way.
	Three-dimensional fluorescent optical memory for long-term data storage and preservation	Shen Chong	3	$999,999	In the modern world, digital information is generated at an ever-increasing rate. The bulk of the data is currently stored in data centres that house massive banks of digital storage devices, including conventional hard drives. Conventional devices are not well suited to long-term storage, having lifetimes of 3 – 5 years, and requiring a great deal of electrical energy to operate. These limitations are of great concern when considering the vast quantities of information that require long-term storage, including health, cultural, and financial records. We aim to develop a new class of digital storage media using luminescent materials. Data will be optically written through the volume of the crystals, producing a new form of three-dimensional optical memory. Our devices will be capable of very long-term data storage and therefore ideal for applications in data archival. We aim to produce a device capable of retaining data for over 100 years in the absence of any power supply. We hope to solve the issues with current conventional data storage techniques by developing a technology that massively reduces the power consumption and electronic waste generation associated with the operation of modern-day data centres.
	Transformational Methods for Assessing Subaqueous Volcanic Hazards in NZ and Beyond	Ian Schipper	3	$1,000,000	Much of New Zealand's volcanic and hydrothermal activity is hidden beneath bodies of water. Some of NZ's volcanic lakes host degassing vents rivaling those on our largest terrestrial volcanoes. Whakaari/White Island has vents ≤ 200m deep in the Bay of Plenty. Analysis of gas and fluid emissions from these vents could be a fruitful way to assess their activity and hazards, but this potential remains untapped because of a critical inability to access them. Over 90% of the world's volcanoes are under water, yet only two submarine eruptions have ever been observed, and sudden CO 2 In collaboration between NZ scientists, engineers, and technology companies, we will create the world's first portable ROV-based instrument and sampling systems to investigate underwater volcanism. We will apply these to measure gas fluxes in Central North Island lakes, illuminating hazards and providing iwi with high-tech complements to traditional Mātauranga. We will then push our systems' limits to Bay of Plenty vents, targeting Whakaari's hydrothermal system. This work will yield new tools and methods for characterizing underwater emissions in NZ. It will also place NZ companies and scientists at the forefront of a shift toward economical and nimble underwater exploration, with technology that can be exported and adapted to far-reaching applications.

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Cawthron Institute	*Fish futures: preparing for novel freshwater ecosystems	Jane Kitson, Joanne Clapcott	5	$12,071,874	Freshwater fish are a cornerstone of freshwater values in Aotearoa including biodiversity and ecosystem health. They help New Zealanders sustain their cultural identities and to care and connect with the natural world. However, we are failing to protect fish and the values they support, and so we are failing to protect and nurture healthy freshwater ecosystems and healthy people. There is an urgent need to address the increasing pressure on our native fish from pressures like human activity, climate change, and threats from other species. This research aims to transform the way we think about and manage freshwater fish through the co-development of new knowledge. One of the key challenges in doing something about the pressures on native fish are the differences in values and interests of the various groups of people who care for New Zealand's freshwater environment. This is why three place-based studies and a national policy working group will work toward fostering a shared understanding, respect and reconciliation of different values for fishes. Co-designed studies that investigate both social and environmental issues will help us understand how freshwater fish and fisheries can be enhanced and effectively managed in response to future climate change pressures. Studies will draw on expertise in fundamental and applied fish ecology, biophysical modelling, mātauranga Māori, environmental values, qualitative and quantitative social science methods, science-policy relations, and applied and critical policy analysis. A policy working group, made up of New Zealand's leading fish management agencies, will be tasked to develop new planning tools and responsive policies grounded by Treaty principles to better integrate the management of native and introduced fishes in Aotearoa.
	*Ngā Punga o Te Moana: Anchoring our Open Ocean Aquaculture Future	Kevin Heasman	5	$10,980,925	Open Ocean Aquaculture (OOA) is a globally recognised opportunity for sustainable food production. It is a NZ government priority, industry is poised to grow, but NZ's advancement of multi-species aquaculture into the open ocean is handicapped by extensive knowledge gaps and lack of proven technology. Cawthron's programme of OOA research will address these impediments enabling acceleration and transformation of primary production in this new frontier. The Cawthron led team of scientists, industry, iwi and international collaborators have previously revolutionised NZ's approach to the design and testing of OOA structures. This programme will build on established knowledge, relationships and capability to enable reliable and cost-effective shellfish and seaweed OOA. We will use computer simulation tools to test thousands of structural designs, without the high costs and risks of a trial-and-error approach. We will take the best designs and create physical small-scale models that will be 'challenged' in specialised wave tanks to see if they are able to cope with high energy conditions. Those that perform will be built at scale as prototypes, deployed on open ocean farms and test sites, and monitored for real-world performance. Sensors will gather information to refine our simulation models and design process. Customized sensors and technology will be built to improve automation and monitoring, reducing on-farm visits and vessel/fuel requirements. Husbandry methods to farm our species on new structures in this new environment will be developed, adapted and improved. We will enable the capability and capacity for the massive scale-up that is needed from pilot research to commercial production, and address social, environmental and te ao Māori perspectives, to ensure the widest social and environmental benefits to NZ from OOA.
GNS Science	Beneath the Waves: Preparedness and resilience to New Zealand's nearshore volcano hazards	Craig Miller	5	$13,300,000	The hazards from New Zealand's near-shore volcanoes - Tuhua and Whakaari – will be explored in depth under a new research programme led by GNS. The programme was under development before the tragic eruption of Whakaari on December 9 2019, which GNS scientist Dr Craig Miller says gives the research a new urgency and is a stark reminder of the volcanoes' potential to do serious harm. Dr Miller, who will lead the research, says relatively little is known about the underwater extent and internal anatomy of the volcanoes and the threats they present to life and property. "The risks come not only from eruptions which have previously impacted as far as Auckland, but from under-sea flank collapse, which has the potential to send destructive tsunami onto nearby shores containing major ports, settlements and popular beaches." Dr Miller says given the scale of risk there is an urgent need to better characterise and forecast island volcanic hazards. The programme will undertake detailed underwater geophysical exploration and conduct large scale experimental work and computer simulations to understand the potential for ashfall and tsunami. The programme integrates a range of stakeholders, including iwi and national agencies who will guide the research to deliver outcomes relevant for Auckland, Bay of Plenty, Waikato and East Cape communities. The research will deliver improved understanding of island volcano hazards and their impact as well as improve forecasts of their occurrence. "Given the population density of the Bay of Plenty/Waikato region, the presence of New Zealand's biggest port, and the horticultural and tourism industries in this region, the knowledge we gain will be of considerable value in safeguarding future development and nationally-important assets ", Dr Miller says. Contact:media@gns.cri.nz

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Landcare Research	*Te Weu o te Kaitiaki – Indigenous regeneration pathways	Johanna Yletyinen, Phil Lyver	5	$15,950,000	Our research will use te ao Māori worldview 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 wellbeing, and deliver sustainable economic growth for communities. We will embed our research within Iwi-specific cultural learning institutions which will support the training and development of new kaitiaki and tangata tiaki. Our research will be embedded within four case studies: (1) Sequences of wetland plant communities that support mahinga kai aspirations, led by Awarua Rūnaka, (2) Breaking arrested forest succession through economic development, led by Tūhoe Tuawhenua, (3) Biocultural regeneration of Moehau, led by Pare Hauraki, and (4) Tītī by-products and weka management enhance biodiversity and community wellbeing, led by Rakiura Māori. We will use both te ao Māori and scientific knowledge systems to develop whakapapa frameworks and social-ecological networks and test how the impacts of kaitiakitanga interventions and economic activities cascade through ecosystems and our human communities. To facilitate this process, we will leverage new and existing data sets and network theory to explore the myriad of connections between human values, practices, and metaphysical and biophysical elements in ways that can be used in decision-making and cultural impact assessments. We will then determine how individual components and the entire architecture of studied social-ecological systems relate to well-being outcomes. The Iwi-entities use this information to achieve outcomes related to restoring biodiversity, promoting sustainable business ventures, improve community wellbeing, and reconnect people with their lands and seas.
	*Moving the middle: empowering land managers to act in complex rural landscapes	Suzie Greenhalgh	5	$13,190,000	Aotearoa-New Zealand (A-NZ) has ambitious environmental goals, and the commitment to these has been reaffirmed in A-NZ's COVID-19 economic recovery priorities. The primary sector underpins A-NZs economy and land managers are integral to achieving these environmental goals and leading A-NZ through its economic recovery. However, many land managers are not achieving the scale of action necessary to improve environmental performance. Conversely, they are 'overwhelmed' by the complex issues they face. Our research will address this issue and provide the systemic changes needed to enable land managers to act, which 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 disruptors such as COVID-19 and climate change. Past research has often assumed the problem is an 'information deficit' and focused on understanding and influencing '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 system leverage points that will enable the middle cohort of 'overwhelmed' land managers to respond proactively to the environmental, market, and societal challenges they face. We partner with Crown Research Institutes, universities, government, and industry to research the agency of land managers, the systems affecting them, and the influence of (a) public and private narratives; (b) debt loading and investment practices; (c) policy signals and perceptions; and (d) traditional and new agents of change in empowering rural land managers to respond proactively.
Lincoln Agritech Limited	*Novel cellulose fibres regenerated from New Zealand plant resources for textile use	Rob Kelly	5	$8,292,825	We propose to revolutionise the global fibre industry through development of a completely new, and environmentally low impact, approach to extracting cellulose from plants grown in New Zealand, such as harakeke, totara and Pinus radiata to produce regenerated cellulose fibres for textile use. Understanding the novel science of cellulose dissolution and regeneration will underpin the development of this manufacturing solution and will provide an environmentally superior alternative to current synthetic and cellulose fibres, well established as being of high environmental cost. Our goal is to develop the basis for a new industry exporting a substantial volume of regenerated cellulose fibres derived from dedicated plantations and diverting current streams of lower value or waste cellulose material, and to foster the development of high-end textiles made by New Zealand designers with embedded mātauranga Māori. The new industry will support regional economies which will produce and process the bioresource and manufacture the fibres. Mentored by Dr G A Carnaby (CNZM) and using well established connections to the global textile sector, our team of scientists from Lincoln Agritech Ltd, The Ferrier Institute, SCION and AgResearch will work in partnership with Ngāti Whare and Ngā For more information, contact Dr Rob Kelly at Lincoln Agritech Limited (rob.kelly@lincolnagritech.co.nz).
Massey University	Smart Bioplastic food packaging to extend shelf-life and reduce pollution	Eric Altermann, Nigel French	5	$9,265,324	The SmartBioplastics team will use innovation and challenging scientific hypotheses to bring New Zealand to the forefront of a green plastic revolution. This innovative programme will deliver ground-breaking new food-packaging materials made of biodegradable, compostable and/or edible materials that are cleverly functionalised to actively inhibit food-borne pathogens and spoilage microbes. These next-generation materials will increase shelf-life and provide improved food safety for New Zealand's fresh foods. The multidisciplinary SmartBioplastics team unites eminent scientists in microbiology, bacterial fermentation, biotechnology, and polymer and material sciences to leverage one of New Zealand's key strengths: the primary sector. Shelf-life limitations on fresh agricultural products are one of the most critical factors currently restricting our export markets. Microbial contamination, most notably by Clostridium and Campylobacter, shortens product shelf-life, increases health risks, and causes significant wastage. At the same time, global consumers are demanding a shift towards sustainable and environmentally-friendly packaging materials, prompting a move away from commonly used petroleum-based plastic packing materials due to the pollution they create. The SmartBioplastics programme will create world-first fully-compostable and/or edible functionalised packaging materials and coatings able to keep food fresher for longer by killing harmful bacteria, initially focussing on protecting fresh meat products against food-spoilage by Clostridium and food-borne disease by Campylobacter. This will add value to the New Zealand primary sector both domestically and internationally by extending product shelf-life, while benefiting all of New Zealand by protecting human health and reducing environmental impact.

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National Institute of Water and Atmospheric Research Limited	*Transforming coastal lowland systems threatened by sea-level-rise into prosperous communities	Scott Stephens	5	$13,600,000	Aotearoa-NZ's coastal lowlands are threatened by ongoing relative sea-level rise (RSLR). New Zealanders and our decision-makers need to know how RSLR will affect lowland freshwater systems, wetlands, coastal marshes and estuaries, and the social, cultural and economic systems that depend on them. Knowledge is needed for adaptation governance and planning, including managed retreat. This knowledge includes identifying thresholds (of RSLR) at which a particular land-use is no longer viable, and new actions are therefore necessary, and when and where those thresholds may be reached. This national-scale programme will identify and provide free access to visualisations of what and where natural habitats and productive lands are exposed to RSLR, and how adaptation thresholds can be determined. This includes new methods and assessments of groundwater rise and salinisation, estuarine habitat evolution as a function of sediment supply and human interactions, and building national maps and datasets of environmental, land-use and asset exposure in coastal lowlands with RSLR. The project will fold this evidence base together with economic evaluation tools into a dynamic adaptive planning and decision-making framework that transparently compares adaptation approaches in terms of costs, benefits, consequences and opportunities across our complex lowland systems. Uptake of this research will enable integrated adaptation of Aotearoa-NZ's coastal lowlands to RSLR by quantifying values at risk, identifying opportunities to improve well-being, identifying local adaptation thresholds, and uncovering community tolerances and preferences for adaptation. The programme will enable adaptation planning that increases resilience across socio-economic and cultural systems and natural environments. This research will contribute to a future in which coastal lowland communities continue to prosper in the face of RSLR, ensuring sustainable protection and value from natural habitats alongside built and productive environments.
Scion	*Seeing the forest for the trees: transforming tree phenotyping for future forests	Michael Watt	5	$9,627,500	Planted forests are an essential component of New Zealand's transition to a carbon-neutral bio-economy. However, our ability to grow radiata pine and other species successfully is at risk due to uncertainty around our changing climate. One approach to ensuring our planted forests remain productive is to use a tree's phenotype (characteristics), which is a product of the interaction between genetics and the environment, to identify trees that grow particularly well in specific environments. Work identifying trees with outstanding phenotypes has already begun, but there is a lot more to be learned about our planted forests. New ways of collecting and analysing data about tree volume, height, shape, carbon content and form – that consider trees in three dimensions – will enable us to identify exceptional trees rapidly. This research programme is focussed on delivering high throughput forest phenotyping using remotely sensed data and advanced concepts in data science. Combined with genomic data, we will be able to select and breed trees with desirable traits such as high carbon storage and resistance to disease and drought exacerbated by our changing climate. The programme also extends to indigenous forests, with the aim of combining data with mātauranga Māori to explore the cultural linkages Māori have to forests and taonga species. This "cultural phenotyping" is expected to lead to modern applications of traditional forest-based economic opportunities including diverse forests capable of delivering a wider range of benefits and to the reinvigoration of Māori customary practices. Forest-scale phenotyping of millions of trees will enable forest growers to optimally site different genotypes under current and future climates, increasing plantation productivity, health and resilience and contributing to economic, environmental and social gains.
	Extreme wildfire: Our new reality - are we ready?	Not provided	5	$11,250,000	Extreme wildfire is accelerating much faster than predicted—research and operations worldwide are struggling to keep ahead of the fire-front. Even in NZ, what was once rare is now the norm. The changing climate is increasing the frequency and severity of wildfires, and escalating the risks, especially for those living within the Rural-Urban Interface (RUI, Lake Ōhau is a tragic example). We have no wildfire code—decisions made today will constrain homeowners' options for decades. Our indigenous forests, once considered "safe" from fire, are under threat. Today, the annual average direct impact of rural fire on NZ's economy is ~$140M, with indirect 'costs' estimated to be at least 2-3 times the direct cost, plus indirect impacts as much as 30-60 times direct costs. The direct costs alone are predicted to rise to ~$550M/annum by 2050 under a likely climate-change scenario. A world-class international team from Scion, US Forest Service Missoula Fire Science Laboratory, San Jose State University, US Forest Service Pacific Northwest Laboratory, Karlsruhe Institute of Technology, RMIT, USFS-Colorado, Canterbury and Lincoln University, will challenge existing understanding of the transitions between linear (predictable) and extreme (unpredictable) fire, especially in relation to fuels. Predicting the physical processes driving fire-spread is central to all fire readiness; without that knowledge, it is not possible to develop effective tools and strategies to keep firefighters and communities safe. We address the Government's investment priorities for the environment by enabling NZ to better manage the impacts of fire. All rural fire stakeholders will benefit from this programme, including Fire and Emergency NZ (FENZ) Department of Conservation (DoC), rural landowners, RUI residents, and in particular Māori with their role as kaitiaki of our indigenous forests.
	Vive la résistance - achieving long-term success in managing wilding conifer invasions	Thomas Paul	5	$12,850,000	Wilding conifers are an economic and environmental disaster that already cover 1.5M of NZ, including Māori land. A further 7.5M ha of productive or iconic conservation land are threatened by invasion in the next 30 years. In response, the Government established a National Wilding Conifer Control Programme to deal with this serious and growing problem. Existing populations are being treated but current control efforts do not consider that cleared land is more likely to be re-invaded due to incomplete initial control, soil legacy effects, seed banks and other causes. We must develop effective strategies to create long-term resistance to re-invasion on treated land – Vive la résistance! Re-invasion processes differ significantly from those of initial invasion and a critical international knowledge gap exists on how various factors interact to drive re-invasion. We will disentangle the multiple drivers of re-invasion to overcome this gap and address the devastating problem of wilding-conifer re-invasion in NZ. The outcomes of this programme will transform current wilding-management practices by breaking an otherwise inevitable cycle of treatment/re-invasion/re-treatment. Benefits to NZ from this research include securing $6.3B of projected benefits by 2050 from the current > $100M investment in wilding control and generating substantial benefits of ~$750M (benefit-to-cost ratio ~54:1) by reducing treatment costs and by avoiding multiple re-treatments. Increasing participation of Iwi/Māori in management of wilding re-invasions and restoring Māoritanga and landscape aesthetics are also key research outcomes.

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The New Zealand Institute for Plant and Food Research Limited	The Flowering Crisis: Confronting a changing climate's threat to NZ's tree crops	Andrew Allan	5	$14,500,000	New Zealand's plant-based economy relies heavily on temperate conditions to deliver high quality fruit, vegetable and forestry products to local and global markets. These plants are being affected by the climate crisis due to warming climate, loss of cold nights, as well as extreme weather events such as heatwaves. Flowering is a key parameter for New Zealand's horticultural and forestry industries, determining yield and quality of its products. Heat reduces flowering in temperate perennials, thus the climate crisis is beginning to threaten horticultural sustainability as New Zealand experiences warmer temperatures. Our research team is world leading in their study of flowering and the genes that control plant response to the environment. This research programme will use kiwifruit, pine and other plant models as research tools to study flowering. New knowledge will be used to generate variants in commercial crops and to develop 'climate-ready' cultivars. This will enhance the country's fastest growing sector, and protect its competitive advantage as a supplier of premium plant products. Through our new exemplar plants with increased flowering, we will engage the public in discussion around how climate change may affect New Zealand's crops as well as how new genetic technologies are one tool to address these issues. The programme will also co-develop new strategies for plant breeding with Māori partners that integrate indigenous knowledge with new selective breeding methods and gene technologies. Public engagement will be a key part of the project, identifying and developing ways for the New Zealand public to positively engage with the scientific concepts.
University of Auckland	*Wirelessly Powered Transport Infrastructure for a Low-carbon Future	Grant Covic	5	$13,507,911	In order to achieve our goal of net zero greenhouse gas emissions by 2050, New Zealand must tackle the difficult problem of weaning itself off fossil fuels for transport. The bigget single barrier to uptake of electric vehicles is wirelessly charging their batteries – safely, simply, and fast. But there is no technology yet invented that can deliver sufficient charge to heavy vehicles without limiting payload or range. Despite the advice of the Climate Change Commission that we need to switch much of the freight fleet to electricity by 2035, it is unclear how we can do so. This research programme adresses that challenging problem. It will develop the necessary technology to wirelessly power the full range of vehicles on the move, and to deliver very high power quickly to heavy vehicles at off-road locations – without imposing impossible loads on the electricity grid. The science that makes this possible was invented by New Zealand researchers 30 years ago. The science is challenging, but the team is internationally respected for its work in these fields. The outcomes will provide the vehicle-side and in-road charging technology including magnetics, power electronics, and road materials, as well as the traffic and economic data necessary for their deployment in New Zealand roads. Our work will give confidence to fleet owners to invest in EVs and to NZTA and local authorities to invest in the new roading infrastructure. We are partnering with rural and urban iwi groups to ensure our technologies are appropriate for them. This research will help to create the safe, clean future that we want our children to inherit – and create economic opportunities for NZ firms to commercialise the technology.
University of Canterbury	A new electromagnetic imaging method for advanced food process optimization	Bill Heffernan	5	$5,225,040	Food processing is one of New Zealand's most important economic sectors. Food safety and quality control are at the core of all government and industry food strategies. We will develop a new imaging technique, referred to as "electrical admittance tomography". By detecting and digitally processing the variations in electric and magnetic fields within food mixtures flowing through our sensors, we will be able to "see" into the food as it is being processed and in motion. These variations arise due to the differences in electrical conductivity of different materials passing through – for instance metals are very conductive, plastic and rubber are non-conductive, while foods occupy a range in between. The new technology will provide a multifunctional, economical, viable detection system to enhance product quality, safety and efficiency in the food processing industry. The core research team is based at the Universities of Canterbury and Auckland, and Lincoln Agritech. This team has expertise ranging from computer modelling, electronic sensing and digital signal processing, through to food process engineering. In addition we are working with overseas experts in electrical imaging and food processing. Our programme will produce many benefits for a wide range of end users, including milk, cheese, ice-cream and sausage producers. In addition to improved food safety, reduced waste and increased efficiency, will be the creation of jobs in manufacturing to produce and sell the sensing and imaging systems based on our technology. We are working with NZ-based manufacturing and process design partners, to produce and market the products, and with seven well-known major NZ food producers, in the dairy and meat processing sectors.
	Enabling unmanned aerial vehicles (drones) to use tools in complex dynamic environments	Richard Green	5	$9,837,002	Robotics has revolutionised a wide range of industries over the past decades. Unmanned aerial vehicles (UAVs/drones) are revolutionising surveying and inspection tasks that once required manned aircraft, and becoming a standard tool for a wide range of applications. However, one glaring omission our project will solve is UAVs as flying robots, which are able to accurately use tools to perform precision tasks at high and hard-to-reach locations. Our novel solution is to design, build and demonstrate a compact UAV with precise 6 degrees-of-freedom positioning capability enabled by new control methods, airframe designs, aerodynamic models, and position estimation (visual odometry) in dynamically changing (windy) environments. We have assembled a leading drone research team, including a wide network of international collaborators to tackle these challenging tasks. We designed our implementation for fast uptake and maximum impact in a wide range of industry sectors. For NZ UAV manufacturers, a new product class of UAVs able to use precision tools will open new national and huge international markets increasing export earnings. For users in arboriculture, silviculture, electricity industry, agriculture and construction sector our technology will help to increase productivity, decrease costs and substantially improve worker's health & safety. In summary, our programme will help to redefine how and where we are able to use UAVs as aerial robots to perform tasks. This will move humans out of harm's way and increase productivity for a wide range of different industry sectors and end users, ultimately benefiting every New Zealander.

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MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

2021 Endeavour Round Successful Projects

SUCCESSFUL 2021 RESEARCH PROGRAMMES

Organisation	Title	Science Leader(s)	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
University of Otago	*Natural carbon sequestration in our southern fjords – a pathway towards carbon neutrality	Christopher Moy, Gary Wilson	5	$8,605,643	Fjords play a critical role in the global carbon cycle by storing large quantities of terrestrial organic carbon. Across all aquatic systems, fjords represent carbon cycle 'hotspots' that bury the largest amount of organic carbon per unit area in the world, thus representing a crucial ecosystem that regulates climate. Fiordland is likely one of New Zealand's largest carbon sinks, but its storage capacity is threatened by climate change and catchment management practices, potentially resulting in significant economic and environmental consequences. We presently don't know the sensitivity of the carbon sink to environmental forcing. Nor do we know the crucial tipping points that, once crossed, will dramatically reduce the efficiency of carbon sequestration, leaving more emissions in the environment. These unknown aspects limit our ability to undertake effective environmental management strategies, determine how the system will respond to future climate change, and as more pressure is placed on the Manapouri Power Station (MPS), to meet our 100% renewable electricity ambitions, determine how variability in introduced freshwater threatens carbon loss in Doubtful Sound. Our multi-disciplinary team of scientists, iwi and environmental conservation partners will address how key environmental parameters, future climate change and human activities will impact the sensitivity, efficiency and capacity of the Fiordland carbon sink. Through a unique observation and modelling program, our work will provide the scientific basis to determine how future changes in fjord circulation, driven by changing climate and changes in MPS generation capacity, will impact the fjord carbon sink.
University of Waikato	Restoring Urban Nature	Bruce Clarkson, Martin Breed, Shaun Awatere, Stephen Hartley, Yolanda Van Heezik	5	$10,069,140	Excitement about returning native biodiversity to towns and cities is growing rapidly due to the many benefits it provides and because 87% of New Zealanders live in urban centres. However, urban ecosystems present challenges differing from national park and rural conservation. Hence, research that reveals how native biodiversity can be maintained in existing, and created in new, urban greenspaces is vital for ensuring healthy cities. Our research team will develop best-practice guidelines for optimal urban ecological restoration through world-leading evidence-based science and strong collaboration with iwi, communities, and councils. Our four research aims are: Residential Design for Biodiversity, Retain & Restore Urban Wildlife, Restoring Health-Promoting Soil Biodiversity and Whanake rākau, whakatipu mātauranga, poipoia te tangata: Growing trees, enhancing knowledge, nurturing people. Our team's approach is built on empowering kaitiakitanga, encouragement, and reconnecting urban dwellers with nature to restore native wildlife and create high-quality greenspaces resilient to climate change. This new approach to restoring nature in towns and cities will play a major role in preserving Aotearoa's native biodiversity for future generations. Beyond protecting our present biological and cultural heritage, we will recommend how to create high-quality urban greenspace that maximises the wellbeing of humans and native species (e.g., restoring plants important to Māori culture), recreation, and ecosystem services. This will help achieve national policy objectives such as meeting the UN Sustainable Development Goals. By expanding our team's existing urban biodiversity networks and using international methods to track progress, we will contribute to global efforts to treasure biodiversity and enhance city liveability and sustainability. Our team has co-developed this research through 19 partnerships, including 15 councils, iwi/hapū, national agencies, and flagship projects. To learn more about this programme, please contact peoplecitiesnature@gmail.com

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