MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

2018 Endeavour Round Successful Projects

SUCCESSFUL 2018 SMART IDEAS

Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
AgResearch Limited	Enhancing early-life development and immune protective function using milk exosome-enriched dairy foods.	3	$999,999	Every parent wants to provide the best possible nutrition for their children. This nutrition is particularly important in the first 1,000 days of life, when the foundations of a child's abilities to think, reason, capacity to fight infections, and other aspects of a healthy life are established. Mothers are not always able to breast feed for the recommended first 180 days, so there is a need to ensure that mothers have nutritional solutions using complementary foods to maximise a healthy start to life for their children. Our Smart Idea provides a unique opportunity to discover why and how milk exosomes could be harnessed to develop infant complementary foods for mothers to ensure a healthy start to life for their children. Milk is a truly remarkable food that has evolved to meet the nutritional demands of mammals in early-life. Exosomes are naturally enriched in milk and we think they provide vital sharing of biological information between the mother and infant to maximise the infant's start to life and future potential. We will uncover the key scientific knowledge on how milk exosomes enhance gut and immune cell development leading to a better start to, and supporting a higher quality of life. This will be translated into new food solutions by NZ food companies to provide a nutritional solution to highly motivated parents seeking to ensure the wellbeing of their young infants and to provide them with the best possible start in life.
	Engineering robust nano-protein delivery vehicles for tailored insect pest control	3	$1,000,000	Nature has developed a protein-based nano-machine able to transport insect-lethal proteins through the insect gut to a pre-programmed target site. This nano-machine is termed the anti-feeding prophage (Afp), a DNA-free phage-like particle. Several naturally occurring Afp variants with altered host ranges have been identified. The goal of this research is to produce a new generation of biological insecticides to provide specific and environmentally sound control of insect pests in agricultural and horticultural sectors, overcoming the problems of pest resistance and non-target toxicity inherent in current pesticide controls. Our research will develop a range of scalable, biological eco-friendly insecticides. Afp and its variants are cell- and DNA-free and protein based, meaning they are biodegradable within a few weeks after application. The non-replicative and protein-based nature of the Afp and its derivatives will confine it to the site of its application, and ensures heritable genetic material is not present. Results of the research program will allow the development of a blueprint for the tailored construction of a range of Afp delivery modules and specific toxins to target any invertebrate pest species. The beneficiaries of this research will be biotechnology producers in New Zealand and exporters of biological alternatives to chemical pesticides in all forms of agriculture, horticulture and forestry with the knowledge extending to *non-insect* targets such as animal parasites. Within 3 years we expect to produce prototype Afp variants that can be evaluated for development.
	High-throughput phenotyping of biological nitrogen fixation and metabolism to improve forage legumes	3	$999,999	Fertilizer application in the form of urea is a non-renewable input across farms in New Zealand and urea is a petroleum-derived fertilizer which is tied to petroleum prices. Nitrogen leaching from farms is also a major conservation concern for waterways and protected areas. All of these facts pose environmental and economic issues for the country. Some legume plant species are used as forages and others as cropping species and all have the ability to capture free Nitrogen gas (N2) from the atmosphere and "fix" it through their roots to form compounds necessary for growth and development of plant parts of critical importance for agricultural production. The biological nitrogen fixation (BNF) process is complex and involves a myriad of interactions, but there is evidence that indicates that it can be improved. However, genetic improvement of complex processes such as BNF involves the generation of potentially tens of thousands of genetically distinct plants via conventional breeding to detect the best individuals within populations that have improved BNF performance. This causes a bottleneck in the improvement of BNF as current methods of assessing BNF are slow, time consuming, destructive and require specialized facilities and laboratories and highly trained personnel. Our objective is to use existing and generate new knowledge, on BNF in association with engineering skills and sensor technology to develop a cheap and versatile device that enables breeders, scientists, farmers, environmentalists and anyone in society that could potentially gain from collecting information on the BNF status of a legume.
Bodeker Scientific	Inferring city-scale particulate matter emissions sources through inverse modelling	2	$999,100	There are many cities around the world that suffer from extreme pollution with harmful impacts on public health. Poor air quality in New Zealand typically occurs in winter when wood-burners are used for home heating. As a result, particulate matter (particles small enough to be suspended in air) can accumulate in the air close to the ground, and fossil fuel burning from industrial activities and road traffic can add to this burden. The best way to reduce urban air pollution is to identify where it is coming from and eliminate or reduce its source. We aim to develop a novel way to create maps of pollution sources as a service to town and city officials. The method uses measurements of particulate matter in the air around a town or city, a state-of-the-art computer model that can simulate the distribution of air pollution for given emissions, and a smart mathematical technique to infer emissions from measured concentrations. We will demonstrate our technology by generating particulate matter emissions maps for Timaru through the winter of 2019. Timaru currently experiences some of the highest wintertime pollution in Australasia - last year it experienced 48 nights with particulate matter levels above World Health Organisation recommended limits. After testing and proving our new technology in New Zealand through this project, we will export it globally through a newly established commercial entity as a service to megacities around the world that are hampered by poor air quality. In this way, in addition to tackling a domestic problem of winter-time particulate matter pollution in local towns and cities, New Zealand ingenuity will be exported globally to address an increasingly urgent global problem.
	Near real-time assessment of climate change impacts on extreme weather events	3	$999,932	Our climate is changing. While average temperatures are expected to increase by a few degrees over the 21st century and beyond, this alone may be little cause for concern. Far more concerning are the expected changes in extreme weather events that climate change will bring e.g. hot spells, droughts, extra-tropical cyclones, intense rainfall and associated floods. Few extreme events are caused exclusively by changes in climate; there is almost always some chance that an event of that severity would have occurred anyway. However, knowing to what extent a recent extreme event was made more severe and/or more likely because of climate change, will allow New Zealanders to better anticipate and prepare for extreme events to come, and will sharpen awareness of the necessity for reducing greenhouse gas emissions that drive climate change. We will develop a capability where, soon after an extreme weather event, the contribution of climate change to the likelihood and severity of that event will be quantified in a scientifically robust way and widely communicated to New Zealand society. Achieving this goal requires the combined skills and expertise of a team of researchers that will build on multiple lines of existing research and operational capability. To diagnose the contribution of climate change to an extreme event, we will perform simulations of the event using a weather forecast model, identical to that used by New Zealand MetService, under present day conditions and under conditions prevalent at pre-industrial times. Careful comparison of those two sets of simulations provides deep insights into the contribution of climate change to the severity and likelihood of occurrence of the event. *Contact Bodeker Scientific at 03-4488118*.

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Cawthron Institute	Rationally designing a 'smart' marine antifouling biocide based on novel synthetic peptides	3	$1,000,000	Biofouling – build-up of marine organisms on surfaces submerged in the sea – causes major financial and ecological issues for most maritime industries. When surfaces are covered with biofouling: fuel usage and greenhouse gas emissions dramatically increase for ships and other vessels; underwater structures deteriorate faster; and biosecurity risks are exacerbated if invasive species are present. Antifouling coatings are the primary tool to counteract biofouling but most leach toxins into the marine environment. Active and looming bans on current antifouling products necessitate innovative new approaches to effectively control biofouling without harming the environment in the process. Biocide-free foul-release approaches continue to be developed but they are only applicable to a defined subset of the market – industry needs better biocides to be developed. This project will rationally design and synthesise a 'smart' antifouling biocide using a combination of cutting-edge medicinal chemistry approaches and pragmatic biological 'ground-truthing'. We aim to produce a fit-for-purpose 'smart' biocide that is: potent against the range of problematic biofouling organisms when applied to artificial surfaces in the sea; benign against marine life, including biofouling organisms on natural surfaces, if released into the environment; and cost-effectively synthesized at an industrial scale. Designing an entirely new class of 'smart' biocide from the ground up will place New Zealand at the forefront of antifouling technology development. Formulating the 'smart' biocide in traditional antifouling coating systems or novel biomaterials will protect existing manufacturing in New Zealand and develop new high-value export opportunities. The wide-scale availability of an effective yet safe antifouling formulation will improve productivity and social licence to operate for end users, whilst reducing environmental contamination and biosecurity risks in accordance with Māori principles of Kaitiakitanga.
GNS Science	Geologic sub-surface modelling of an active fault system: Cape Egmont fault zone	2	$728,628	The movement of tectonic plates generates earthquakes on faults developed in the Earth's crust over thousands to millions of years. Faults, along with the earthquakes they generate, are complex systems comprising many interacting elements that behave in unpredictable ways. Earthquake science aims to understand the factors that contribute to this unpredictability and to help reduce the impact of these events by providing information about the risks posed to our society by these natural hazards. The information available for traditional earthquake hazard assessment is generally incomplete and typically focused on the properties of single faults described at the surface. Since the Christchurch and Kaikōura earthquakes, it is now as important to understand how these systems of active and concealed faults link and interact from the surface to depths where earthquakes nucleate. We will investigate the three-dimensional sub-surface geometry of a large active fault zone (comprising numerous faults) to better understand the factors that control earthquake behaviour. The Cape Egmont Fault zone is close to or beneath communities as well as nationally important energy and industrial infrastructure extending offshore from the Taranaki Peninsula. Petroleum exploration data will be used to examine the three-dimensional structure and evolution of this complex active fault system using state of the art sub-surface mapping and modelling techniques. We will experiment with methods of numerical earthquake simulation to demonstrate the utility of the fault and rock property model with the aim to develop new avenues of research for future earthquake hazard estimation. Information from this study will contribute to national and global efforts in understanding earthquakes and their hazards along with the resilience of local communities and critical national infrastructure to these powerful natural forces.
	Energy harvesting from ambient heat using transparent thermoelectric materials	3	$999,999	A global population that is growing in numbers and prosperity is increasingly exacerbating the world's energy problems and associated air pollution. About half of the residential and office energy demand arises from heating and cooling indoor air, whose temperature is thus modified to be different from the outdoor air. This indoor/outdoor temperature difference can be exploited with suitable materials, called thermoelectric materials, to generate electricity, which in turn can steer a household towards energy independence and certainly lower energy costs. An ideal place to take advantage of these temperature differences are windows. Windows provide the right thickness across which the temperature changes to incorporate our technology. Windows cover a significant area of buildings around the world and this technology can be installed in new and old buildings alike. However, suitable thermoelectric materials to be coated onto glass must be transparent, but no transparent and efficient material is currently available. We aim to develop this elusive thermoelectric material that is both transparent and efficient to provide a viable alternative energy source. We propose a two-stage approach that increases thermoelectricity in optically transparent semiconducting materials. We hypothesise that by doping this material with suitable elements into specific locations, we will be able to individually increase parameters such as thermoelectric conductivity without compromising transparency. We will draw on the team's expertise in semiconductors, nanotechnology, material science, and ion beam engineering for material modification. Our goal is a proof-of-concept coating material for 'smart windows', which are capable of creating a viable voltage for electricity generation. We will seek advice from New Zealand manufacturers to encourage uptake of this new technology by New Zealand stakeholders for global commercialisation.
Massey University	Functional carbon nanomaterials from harakeke fibres for sustainable energy applications	3	$999,978	Global demand for efficient energy storage devices provides a great opportunity to develop a high performance supercapacitor system for applications such as consumer electronics (smart watches, communications, health care sensors, bendable displays), transport (cars, bikes, buses, trains and aircraft), portable electrical devices of all kinds, and power tools. The performance of the supercapacitor is largely determined by its electrode material and architecture, for which harakeke fibre is a good potential candidate due to its inherent porous structure and excellent fibrous properties, such as length and strength. The goal is to develop a novel hybrid electrode material, a functional nanocarbon material, with controlled meso/micropore ratio and hierarchical structure allowing excellent electrical properties. The electrode material will also be used to develop a flexible supercapacitor that can be woven into fabric. The team will work with Carbon Valley Ltd, a New Zealand company that has committed to invest in this development and commercialise the technology. Key Māori stakeholders will ensure that mātauranga and tikanga are respected, and will provide a conduit for translation of the research outcomes to iwi/hapu, and to entrepreneurial Māori business enterprises. Harakeke is an important taonga for Māori, having significant symbolic meaning and many practical uses. This research will develop new high-tech applications for harakeke fibres, and will be underpinned by mātauranga Māori. Outcomes of this research will help establish a New Zealand plant fibre processing industry, pioneer research in sustainable and clean energy, and put New Zealand on the global technology innovation stage.

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Massey University, contd	Airborne hyperspectral remote sensing for establishing New Zealand's baseline environmental and mineral indicators	3	$999,000	This research program will enable New Zealand to better utilise remote sensing tools and resources for cheaper and environmentally friendly mineral resource mapping and environmental management. Society is rapidly transforming towards a carbon-neutral, green economy that requires increased resources of metals (e.g. for the production of electric cars, solar panels, wind-turbines, lithium batteries). This transformation puts pressure on science to deliver new techniques to increase the efficiency and decrease the cost of mineral exploration. Our research program utilises hyperspectral imaging that detects reflected light from the Sun at wavelengths that are outside of the human vision. Hyperspectral imaging involves image capture over >100 spectral bands that are highly sensitive to the physical and chemical properties of surface cover. Since vegetation is highly sensitive to chemical element abundances within the soil and underlying substrate, spectral reading using airborne hyperspectral imaging can provide a new opportunity to develop advanced methods for mineral resource mapping and detailed environmental imaging studies. Our approach combines ground sampling, hyperspectral datasets, topography and existing aero-magnetic datasets to provide datasets for analysis by machine learning algorithms, producing mineral maps to identify untapped resources. Our research program is focused on developing a method to integrate hyperspectral remote sensing in the environmental management and resource mapping using aircraft-mounted sensors. However, a national-wide expansion of this technology would use data from satellites. There are several upcoming opportunities (e.g. German EnMap satellite mission) to sustain and manage New Zealand's diverse environment and natural resources through analysis of digital imagery from space. The proposed approach also has application in forest management, agriculture and fertilizer industries and mapping and detection of environmental pollution, along with improving the technological infrastructure of New Zealand.
National Institute of Water and Atmospheric Research Ltd	A reliable ocean forecast tool for managing marine disasters in New Zealand	3	$1,000,000	New Zealand manages the eighth largest marine domain in the world and a marine sector currently valued at $4 billion. For a nation familiar with natural disasters such as earthquakes, being prepared is the best way to minimise the scale and costs of a disaster. It makes sense then, to build defences against the risk and impact of marine disasters such as the spread of disease and invasive pests, oil spills and search and rescue operations. Having a NZ-specific ocean forecast tool is an essential element of preparedness if we are to maintain and grow a vibrant Blue Economy. Ocean models inform us about how the ocean behaves. We will extend existing capabilities in ocean modelling into a real-time ocean forecast. Below the ocean's surface are layers of different temperature and salinity -- ocean stratification -- that vary over days to weeks and geographic location, just like the weather. Providing ocean forecasts that reflect reality requires subsurface data to be generated and incorporated into the models in near-real-time. Ocean weather is one of the big unknowns in understanding how the ocean transports and disperses materials such as pollutants or sediments. To overcome this unknown, we will 1) develop new technical skills of data assimilation and ocean forecasting, and, 2) resolve ocean weather dynamics in real-time from ocean gliders. Having a more accurate ocean forecast tool will ensure that NZ has the capability to respond quickly to any future marine disaster. The benefits of a data assimilating ocean forecast extend well beyond marine disaster scenarios.
	Machine Learning approaches to downscale seasonal climate forecasts for New Zealand	2	$740,000	New Zealand's climate is extremely variable as a result of its maritime surroundings and its physical geography. Key economic activities—especially in the primary sector—are directly or indirectly dependent on climate. Long-term deviations from normal climate conditions have led to severe economic impacts, such the 1997/98 and 2007/08 droughts driven by El Niño and La Niña, respectively, and the 1993/94 "Auckland Water Crisis". Better knowledge of forthcoming climate conditions (for example average temperature and rainfall) over time-scales of one to three months resolved at relevant spatial scales (e.g., region, catchment, site) could assist in better management of risks associated with climate variability. Likewise, it would offer prospects to better capitalise on the economic opportunities climate variability presents. The accuracy and local relevance of seasonal climate forecasts that are currently available for New Zealand are hampered by the relatively coarse spatial resolution of present climate prediction models, which do not account for important orographic effects highly relevant to New Zealand. This project will refine seasonal climate forecasts provided by global climate prediction models to the town and farm scale within New Zealand. This will be achieved for the first time by leveraging recent cutting-edge advances in Machine Learning, a sub-field of artificial intelligence devoted to the development of algorithms that can learn from data and make predictions. It will provide better and more useful seasonal forecast products for Aotearoa. This project is expected to result in significant benefits for multiple sectors of New Zealand's economy that are dependent on climate guidance. We will trial this with partners in the agriculture, energy and water management sectors.
	Drone flow: Aerial monitoring system for better river management	3	$1,000,000	Drone flow is a research project developing methods for measuring river flows from the air. It provides an efficient and cost-effective way to collect high resolution data of water depths, velocities, and volumetric flow rate. Using drones enables measurement of flows where existing methods are inadequate or dangerous, such as during floods. River flows are measured to manage rivers, quantify floods and evaluate physical habitat. This information is used to set minimum flows and limits on water take (e.g., regional council regulation of hydro-power and irrigation industries), and by central government to monitor the state of New Zealand's waterways. Existing methods of measuring river flows struggle in shallow channels (e.g., summer low flows, braided rivers), or during large floods due to floating debris, safety risks, and rivers overtopping their banks. These problems result in missing or inaccurate data, particularly at low and peak flows. It is critical to improve flow measurement capabilities now, since flow variability is expected to increase with climate change. The drone flow system uses a pair of drones flying in formation. An upstream drone releases biodegradable tracer particles, while a downstream drone records particle motion to resolve river surface velocities. Depth is then calculated from surface waves, turbulence, through-water imagery, and spectral attenuation. Physical habitat maps are generated by combining information on river velocity, depth and substrate. Development of the drone flow system positions New Zealand as a world leader in river remote sensing and provides a valuable tool for river managers tasked with maintaining or improving the health of New Zealand's river ecosystems. *Contact Hamish.Biggs@niwa.co.nz.*

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National Institute of Water and Atmospheric Research Ltd, contd	Reducing the impact of LED streetlight conversions on cultural and ecological values	3	$999,000	Most of the nearly 400,000 streetlights in New Zealand will be converted from largely high-pressure sodium lamps (HPS) to more energy efficient light-emitting diodes (LEDs) by mid-2021. This conversion is estimated to save $10 million/year and improve road user safety. However, LEDs emit more blue light than HPS lamps, which reduces night-sky visibility and has adverse effects on marine, terrestrial and freshwater ecosystems. There has been minimal research effort focused on understanding and mitigating impacts of such widespread streetlighting changes, particularly in New Zealand. Our research develops two tools that can be used to visualise different streetlighting scenarios, from the fine-scale (Tool 1: drone-mounted sensors) to the city-scale (Tool 2: interactive lightscape maps). We will use experimental tests of operational streetlight types in the Christchurch Residential Red Zone to identify options that minimise impacts on cultural (night-sky visibility) and ecological (freshwater insects) values. Experimental results will populate an interactive map depicting lighting scenarios across Christchurch City, overlaid with areas of cultural importance identified by the Ngāi Tahu Cultural Mapping Project (Kā Huru Manu), to determine the impacts of LED streetlights on night-sky visibility and freshwater insects. Interactive maps will allow councils and developers to identify areas of cultural importance and areas where lighting impacts on ecological and cultural values are likely to be highest. These areas can be prioritised for assessment for the more appropriate lighting scenarios identified in the experiments. Together the tools will allow lighting project developers to realise economic and safety benefits associated with LED conversions while minimising impacts on important cultural or ecological values. We will trial the Christchurch Residential Red Zone but our methods will be transferable both nationally and globally.
	Refining the spawning sites and larval dispersal routes of eels using isotopic landscapes	3	$954,000	This research address one of the most mysterious and fascinating aspects of New Zealand's taonga eel (tuna) species life cycle: where do eels spawn and what oceanic routes do they take to our coastline to enter lakes and rivers? Longfin and shortfin eels have a complex life cycle. Adults leave freshwater habitats to swim thousands of kilometres to spawn somewhere in the Western Pacific Ocean for reproduction. The larvae are then transported via ocean currents to New Zealand to grow and mature in fresh waters. The specific spawning areas and larval dispersal routes of our tuna are unknown, presenting significant knowledge gaps in their life cycle. The marine environment that eels use for reproduction, larval growth and transport is changing, and is affected by the El Niño Southern Oscillation and global climate change. These oceanic changes are highly likely to result in increasing variation in larval survival and glass eel recruitment to fresh waters. However, these inter-linkages are unknown creating significant uncertainties for scientists and managers about the drivers of eel population declines currently being observed. We will use chemical signatures in eel otoliths (ear bones) and tissues to retrace eels' marine origins and larval movements. To do this, chemical signatures are linked to satellite-derived environmental information (e.g., sea surface temperature) and known biogeochemical spatial variations. Statistical analyses are then used to map the location of longfin and shortfin eel spawning grounds and larval migration routes calculated based on the associations between chemistry and environment. This approach is novel and cost effective; research expeditions to the Western Pacific Ocean are not required. Results will be used by DOC, MPI and Māori for the management and conservation of New Zealand eels.
	Freshwater bioremediation using native mussels (kāeo) - focussed on shallow eutrophic lakes	3	$999,999	We will harness the filter-feeding capacity of native freshwater mussels (kākahi/kāeo) to assist lake restoration through 'biofiltration'. Many of our shallow lakes are degraded to the point where they are permanently muddy and aquatic plants no longer have sufficient light to grow and stabilise the lake bed. Without the plants, wave action resuspends lake bed sediments, and so a feedback loop is set up that traps the lake in the degraded state. Many restoration actions are required to reverse this process, including the removal of bottom-feeding pest fish, and reduction of nutrient inputs. We will trial restoration of degraded freshwater lakes using aquaculture rafts to lift the mussels out of low oxygen bottom-waters and soft sediments. We will examine substantially increasing their numbers to boost their filtration capacity. We will use a combination of lake modelling and laboratory, tank, and field trials to determine the net effects mussels have on water quality because, as well as absorbing nutrients and filtering out sediment, algae and organic particles, mussels excrete nutrients, and deposit faeces. The fact that they are found in large numbers in clear, low nutrient lakes suggests that their net effect on water quality will be positive. We will also develop protocols to eco-source and culture large numbers of mussels to stock the rafts. There are many potential benefits, as mussels are relatively tolerant of toxic cyanobacteria and can degrade some pathogenic bacteria that cause human illness. In the long-term these techniques could also be applied in situations like stormwater treatment ponds. The beneficiaries of our research will include water managers, kaitiaki and the public and conservation agencies that support the restoration of iconic native species.
	Rivers as dynamic transport vectors of plastic pollution to the ocean	3	$999,000	Plastics are significant pollutants in the NZ environment, as is increasingly observed around the world. Large items, notably plastic bags, are a visual blight both on our streets, river banks and beaches. Plastic pollution blocks stormwater infrastructure and entangles aquatic life and birds. Small fragments (microplastics) can be taken in by plankton and are potentially passed up the food chain. Much of the plastics found in marine waters is discharged by rivers, particularly from urban areas, yet river transport of plastic pollution is poorly understood. This project will study plastic transport in an urban-affected river, the Kaiwharawhara, which discharges to Wellington Harbour. We will survey the sources and types of plastic, changes in the nature and size of plastic, the storage of plastic in sediments, and discharge of plastic pollution into Wellington Harbour. Mana whenua and community volunteers will be engaged to help quantify plastic pollution in the water and sediments of this typical urban stream, including before and after flood events – thus providing more spatial and temporal coverage than would be tractable for the research team working alone. We will demonstrate how plastics are degraded by bacteria and sunlight exposure and are fragmented (broken down) as they travel downstream. The resulting plastic 'budget' will identify ways to reduce plastic pollution in Wellington Harbour and provide a tested approach that can be applied nationally. Mana whenua, community and industry partners will provide their perspectives on a variety of potential plastic management options. This research will provide a unique opportunity to discuss this growing issue across our partnerships, with potential co-benefits that include improving waste management infrastructure, reducing plastic use, and reducing littering and illegal dumping.

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Scion	New Zealand seaweeds: unique cellulose nanocrystals for use in high-value products.	3	$987,249	New Zealand's oceans may well be hiding the solution to unwanted heat build-up in electronic devices. Seaweeds contain 'giant' cellulose nanocrystals, natural nano-sized heat conductors that are stronger than steel. They contain significantly larger cellulose nanocrystals than their land-based plant counterparts, we will test the hypothesis that larger nanocrystals provide increasingly better heat conductance properties. Manufacturers of electronic devices are racing year on year to decrease product size, whilst improving speed and functionally. Coupled with the requirement for higher energy density batteries to keep them powered longer, overheating has become a real problem. High profile cases of flagship smart phones and laptops exploding and catching fire has in part been due to the products' inability to manage heat build-up. If proven, the inherent heat conductance properties of seaweed nanocrystals, either as a standalone material or incorporated into new composite materials, could solve a whole variety of heat related product problems. These range from the examples above, to improving the battery life and safety of electric vehicles, to wicking heat away from our aircraft seats so that we can fly more comfortably. This unique cellulose nanocrystal material comes from seaweeds found around New Zealand's coastlines and can be obtained from the wastes streams of current sustainable industrial and food manufacturing processes. We will work with New Zealand companies, including Māori owned aquaculture businesses, to develop the fundamental science, technologies, and pathways needed to integrate the production of seaweed based cellulose nanocrystals into a sustainable aquaculture industry. We will then assess their suitability and use for a myriad of manufacturing industries and globally relevant products.
The New Zealand Institute for Plant and Food Research Limited	Are microbial partners the key to bioactive precursor production for high value mānuka honey?	3	$1,000,000	The nectar of mānuka, Leptospermum scoparium, yields honeys rich in methylglyoxal (MG), the unique mānuka factor (UMF) which governs the honey's commercial value. The precursor of MG is dihydroxyacetone (DHA), found in high amounts only in Leptospermum nectar. DHA nectar concentrations vary widely and the production mechanism remains unknown. Plants contain microorganisms (endophytes), and new understanding of whole-plant functioning has recently revealed that this microbiome plays important beneficial roles for the host plants. We hypothesise that endophytic microorganisms within the nectary of mānuka plants drive the biosynthesis of DHA and are responsible for variation among plants. Our smart idea is to understand the mānuka nectary microbiome, to deliver ways to increase honey UMF content, enabling NZ's honey industry to grow sustainably. Our science will: reveal microbial associations crucial to DHA production by mānuka, recover microorganisms from nectaries, and test their ability to augment DHA production following inoculation into plants. This research will deliver two key benefits: firstly, a direct economic benefit from driving growth of the NZ mānuka honey industry; secondly, to Māori supporting industry leadership and sustainable development of their own resources (human and natural) sustainably. Higher-value honey will increase returns from mānuka–covered land, much of which is owned by Māori, thereby providing a solid economic foundation for Māori leadership of this industry. We will work with both Ngāi Tahu and Ngāti Porou to implement the findings from this research. Longer term, transmission of nectar endophytes could be used to add to or augment other bioactive production functionality in other plant species. It also offers the potential to manipulate nectaries for other purposes, such as increasing their attractiveness to bees, or enhancing plant resistance to diseases. *Contact: Hayley.Ridgway@plantandfood.co.nz*
	Developing an artificial bi-trophic ecosystem maintained in dynamic equilibrium for sustainable control of a serious pest within honeybee hives, and a new paradigm for addressing other intractable pests in productive systems	3	$1,000,000	We will develop self-sustaining predator-prey ecosystem within honey bee hives to provide long-term control of varroa mites and their associated viruses. Virus-vectoring varroa mites are a threat to apiculture world-wide. Reducing varroa infestation levels results in healthier bees by reducing the viral load of the honey bee colony. Current chemical controls lack long-term viability because varroa develop resistance to the treatments and may leave undesirable residues in honey. Our smart idea is to develop sustainable biocontrol of varroa by creating an artificial ecosystem inside hives that facilitates population suppression of varroa by the generalist predator, Chelifer cancroides. We've shown that when correctly positioned and protected, chelifer adults actively feed on varroa without harming bees, but disappear from the hive when food runs out. Our novel ecosystem approach includes booklice which feed on bee detritus and sustain the chelifers when varroa densities are low. We will model the biological requirements of each member of the ecosystem (bees, chelifers, booklice, varroa, and viruses), and develop specially-designed modular structures for fitting into standard hives to provide habitat for the chelifers and booklice. We will optimise internal hive designs to maximise chelifer efficacy and reduce viral load on bees, thus creating a new ecological balance beneficial to the bees. The systems will be validated under real-world field conditions in commercial beekeeping operations. Success of the chelifer system will allow for chemical control of varroa to be replaced with a sustainable control option in hives worldwide. The insights gained in using the artificial ecosystem approach will have application elsewhere for addressing other pest problems that have proved impossible to overcome at present. *Contact: Dr Ron van Toor, Plant & Food Research, ronald.vantoor@plantandfood.co.nz*
	Novel process for making low glycaemic load starch ingredient for healthy innovative food products	3	$1,000,000	Consumers are demanding simpler, healthier foods, with fewer ingredients and increased wellness attributes. Currently 1 in 4 people would consider switching brands for one with fewer ingredients, and 2 in 5 for one that is "better for you". Manufactured foods sometimes require a number of additives, such as modified starch, stabilisers and gums, to ensure a pleasant eating experience and preserving product shelf life. However, many of these additives work in best as a group, increasing the numbers of ingredients listed on packaging, which is unpopular with consumers. In addition, many of these produce a peak in blood sugars after eating. This research will develop a patented process for manufacturing a unique ingredient for use by the New Zealand food industry. This ingredient will replace certain additive groups in foods, reducing the number of ingredients without disrupting the food's taste or the consumer's eating experience, but with a low glycaemic load that reduces blood sugar peaks after eating. In addition, the ingredient is likely to have a beneficial effect on gut bacteria, improving gut health and overall consumer wellness. This new ingredient will support the development of new foods for consumers, both in New Zealand and for export to high-value markets, with fewer ingredients and with added health benefits. The knowledge will also support development of new processes for other manufacturing sectors, such as packaging and pharmaceuticals. *Contact: Dr Deborah Le Corre-Bordes, Deborah.LeCorre-Bordes@plantandfood.co.nz*

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University of Auckland	Building a sustainable gender budgeting strategy for New Zealand	3	$859,815	Gender inequality in economic and social wellbeing remains a pressing policy problem in New Zealand. This is particularly the case for Māori, Pacifica, disabled and older women. International evidence indicates that gender budgeting is a valuable and effective policy initiative to advance gender-related goals. However, New Zealand has yet to trial such an initiative. This project takes up this challenge by undertaking gender impact assessments of fiscal policy and developing a gender budgeting tool that draws on the combined expertise of government agencies, non-government organisations and academics. Using a multi-phased approach, the project will undertake a 15-year retrospective gender analysis of budget forecasts and outputs, to build an evidence-base and identify the data, templates and assumptions required to support ex-ante, prospective budget processes that incorporate gender-relevant indicators and allocations. By pursuing a non-legislated, cross-sectoral partnership approach, this project will ensure that the needs of women from diverse backgrounds, including Māori women, are taken into account. This approach will support the development of new methodologies to assess the impact of fiscal and related policies on women and men, and to design inclusive, gender-sensitive budget allocation models. Finally, capacity building is key to effective gender-budgeting. To this end, we will create training modules for delivery to relevant public servants, experts, civil society partners and consultants. The results of this project will have numerous economic and social benefits. Based on international evidence we know that gender-budgeting initiatives help to increase labour supply and human capital and ensure the allocation of public spending is financially efficient, while also being effective in advancing gender equality and enhanced economic wellbeing.
	Photonic Device for Rapid Prostate Cancer Detection and Mapping	3	$999,999	Prostate cancer is the second most common male cancer worldwide with growing incidence. NZ has among the world's highest incidence. Loss of life and economic impact on NZ exceeds $60m p.a. Prostate cancer diagnostic accuracy ranges 20-80% and requires expensive invasive biopsies, increasingly alongside costly MRI. Typically, 12 samples are taken in the first biopsy. Despite the relatively large amount of samples taken, about 30% of patients, especially for early-stage (isolated) cancers, no cells from a tumour are picked-up. Consequently, a second, or third, biopsy is required several months apart, with up to 20 samples taken each time, but only improving the detection rate by 20 to 30%. Current in-situ prostate cancer detection methods lack precision and diagnostic power. The technology developed thanks to this Smart Idea funding will be capable of differentiating cancer cells from healthy surrounding tissues in situ, and hereby output, in real-time, mapping of the prostate with unprecedented accuracy. The technology will dramatically reduce the need for invasive biopsies and MRI screenings. Our optical probe will use the latest technology available in the field of fiber-lasers, Raman spectroscopy and advanced computational techniques to better existing systems. Overlapped to standard ultrasound images, our light-based multi-sensor will enhance, to few millimetres, the accuracy of the 3D mapping of the prostate. When successful, surgeons will be able to more readily identify suspicious regions of the prostate in situ in real time and thereby realise improvements in diagnostic and staging ability for prostate cancer. Economic benefit to New Zealand will derive from (1) reduced medical costs and loss of productivity from more accurate and timely diagnosis, and (2) through high-value exports. In Patient outcomes also will be dramatically improved.
	Growing NZ optometry device industry, through developing novel technology for screening blindness	2	$999,757	The current model of eye health care used to diagnose and treat vision-threatening disease in New Zealand is expensive and is concentrated around eyecare clinics or private optometry practices, which require a range of expensive instruments to examine the eye. This model has led to inequities in the delivery of eye healthcare, where both accessibility and affordability can be a problem; disproportionately affecting poorer communities that live in more rural areas. We propose to address this shortcoming in vision care through development of a novel device, which can replicate the function of several ophthalmic devices, and can screen for four common causes of blindness (i.e. cataracts, glaucoma, macular degeneration and uncorrected refractive error). Our device (MyIScope) will be inexpensive to manufacture compared to existing technologies, portable to reach remote communities, and simple enough to be operated by a trained primary health provider. We believe that community engagement is critical for eyecare delivery, regardless of the technology in use. We are engaging on three levels: We are actively engaged with independent optometrists and primary health care providers In the future, we will train nurse\community care providers to operate MyIScope in their local communities We will seek user feedback on the operation and design to optimize our technology platform. We believe that there is a strong value proposition for MyIScope, which will help grow and diversify New Zealand's emerging MedTech sector, valued at $1.5B in 2017. At present, there are only 5 New Zealand-born ophthalmology technology companies, and of these, only Objective Acuity is in the high-value disease detection space. This project will enable us to deliver new knowledge intensive and high value-add ophthalmic imaging device products to international markets.
	Experimental approach for reducing eruption risks in New Zealand Geothermal Fields	2	$926,000	Many of New Zealand's electricity-producing geothermal fields and highly visited touristic sites are located within or near explosion craters produced by hydrothermal eruptions. Amongst them, the Rotokawa Geothermal Field is a valuable power resource (174 MWe capacity) with an uncertain hazard future. We know that up to thirteen large hydrothermal eruptions have occurred over the last ~20,000 here. However, we cannot currently recognise the conditions that would presage the next eruption. Rotokawa, with its well-exposed eruption deposits and drill-samples of subsurface geology, is an ideal exemplar to investigate the triggers and dynamics of hydrothermal eruptions and to develop a generalizable hazard model that can be applied to the 22 known geothermal fields of the central North Island. Hydrothermal eruptions are caused by near-instantaneous vaporization of pressurised hot water trapped in pores and cracks within the upper parts of geothermal fields. Host rock properties (porosity, permeability and strength) along with the rate of pressure/temperature change, controls the explosive "potential" of a geothermal system. By triggering a series of hydrothermal explosions of rock from Rotokawa in a specialist laboratory in Munich (Germany), we will test why this area is so prone to large explosions. By establishing the conditions promoting different types of eruption, we will take a step toward monitoring for and mitigating these hazards. Methods and partnerships developed over the course of this project will be used to promote a broader understanding and awareness for other sources and styles of hydrothermal eruption hazards in the 22 geothermal areas throughout the central North Island, and enhance world leading research based in New Zealand that supports the sustainable power generation, tourism and communities within active geothermal environments.

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Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
University of Auckland, contd	Titanium Foam Thermal Shielding - Returning Small Payloads from Space	3	$999,714	To enable deeper science and technological innovation in space systems it is often desirable to recover payloads that have been launched into orbit. However, as these objects re-enter the Earth's atmosphere they are exposed to extremely high temperatures and can be destroyed. Existing methods for protecting objects returning to earth use large amounts of expensive brittle ceramics or heavy metal composites. These methods are not suitable for small objects or satellites. In this project we will develop a lightweight metal foam that will create a shield to protect a small object returning from orbit. We will create a range of foams made from titanium alloys, sourced and manufactured in New Zealand. We will undertake testing to understand their ability to provide protection from heat. We will also use numerical modelling to simulate what happens to the forces and thermal stresses when a satellite re-enters the Earth's atmosphere. This will help us to design the right shape and structure for the metal foam shielding. This research will enable the recovery of high value payloads from orbit for subsequent analysis. It will also contribute to the development of the titanium industry and the high value manufacturing sector in Aotearoa/New Zealand. The new metal foams will be useful not just for space applications, but also in the manufactured consumer goods sector where lightweight thermal insulation is needed, for example to provide protection from electric battery fires.
	A Wave and Finite-Element Method for Calculating Sound Transmission in Lightweight Buildings	3	$999,999	As New Zealand's cities grow and intensify, multi-tenancy buildings are becoming more prevalent. These buildings are usually constructed from lightweight materials (e.g. timber) for which current state-of-the-art methods for predicting sound transmission contain a large degree of uncertainty. This uncertainty leads in some cases to conservatively built structures with good sound insulation, but which are more expensive than necessary; or worse, to structures which do not meet the required noise insulation standards and to which expensive remedial treatments must be applied. Cross-Laminated Timber (CLT) is a novel building material which is well-suited for rapidly constructing large volumes of high-quality multi-tenancy housing in New Zealand. Because CLT is a relatively new material, the acoustic performance of CLT structures is not well-established. This inhibits the uptake of CLT as developers perceive this unknown performance as a risk. This research project will develop a software tool to model how sound transmits through lightweight building materials, using CLT as a case study. Using this tool, we will also assess technologies for reducing sound transmission, such as novel CLT panels with damping layers or resilient panel connection systems. The software tool we develop will be used by Acoustical Engineers to ensure that multi-tenancy buildings are designed with appropriate sound insulation. Manufacturers of lightweight construction materials will benefit from increased use of their products due to increased certainty and improvement in acoustic performance. Construction companies will benefit from reduced costs associated with retrofitting sound insulation in buildings. This research will generate knowledge and develop methods for designing quiet, economical housing and thus will also benefit society through the improved availability of good-quality affordable housing.
University of Canterbury	Sustainable and cost-effective seismic-isolation foundation-soil systems for medium-density low-rise buildings	2	$1,000,000	The current rate of waste tyres production in NZ is over 5 million per year and is expected to grow over time with increased population and number of vehicles on the road. An estimated 70% of such waste tyres are destined for landfills, illegally disposed of or otherwise unaccounted for, posing environmental concerns and urging the reuse of waste tyres through large-scale recycling engineering applications. We propose to reuse/recycle waste tyres to deliver an innovative eco-rubber, seismic-resilient foundation system to enhance the seismic performance of medium-density, low-rise buildings across NZ. This will be achieved by combining two critical elements: • a seismic-dissipative filter made of rubber-gravel mixtures placed underneath the foundation structure, and • a flexible raft foundation made of fibre-reinforced rubberised concrete. To achieve our goal we will use a combination of: • geotechnical and environmental engineering investigations to identify optimum rubber-gravel mixtures having excellent mechanical properties and minimal leaching attributes; • structural engineering tests to design flexible fibre-reinforced, rubberised-concrete raft foundations with satisfactory structural performance; and • numerical and physical models to prove the concept, evaluate the seismic performance of the entire foundation system, and quantify the level of reduction in the seismic response of prototype buildings. The successful completion of this research will result in significant environmental and socio-economic benefits (new jobs, improved products, increased revenues) for NZ, and will contribute to the reduction of seismic risk in NZ. Multiple end users will benefit from the research, including government agencies (MfE, MBIE, EQC), Waste Management NZ, cement makers, geotechnical structural and environmental consultants, building designers and developers, builders, companies dedicated to the collection and shredding of waste tyres, granulated tyre rubber cement and gravel suppliers, Māori communities, researchers, insurers and private owners.
University of Otago	Bees as Biosecurity Biomonitors - using pollen testing to identify and monitor new plant incursions into New Zealand	3	$964,620	New Zealand's world-class biosecurity system aims to protect the environment, primary production and human health from harmful invasive organisms. Implemented through comprehensive surveillance, eradication and management programmes, government costs reach $248 million annually. Recent invasions of the velvetleaf plant and myrtle rust highlight that once such species are discovered, they are tough to contain and require significant resources to eradicate or manage. The success of these strategies can be exponentially improved by early detection of new invaders, and in turn, enhanced by proficient monitoring. However, this remains poor for weed species with reliance on fortuitous observation. Our research will make novel use of honey bees as biosecurity monitors, to detect and locate the presence of noxious plant species in New Zealand. We will deliver an efficient and cost effective end-to-end surveillance, diagnostic and discovery system by combining the foraging behaviour of bees, with cutting edge DNA technology to identify plant species from bee-collected pollen, and remote-data modelling to narrow the search area for the invasive plant. We will optimise and adapt each aspect of our technology to produce a single integrated system for testing in collaboration with the Apicultural Industry and MPI. This landscape-scale approach to monitor for noxious plants will be trailed in both rural and urban areas, including high risk sites for exotic weed seeds. Success would provide a new component in the biosecurity toolbox to better support government and Māori aspirations to protect our unique environments and value of our primary industries. The science is also anticipated to underpin unrelated biosecurity issues, using pollen to monitor for exotic plant diseases and infer the geographic origin of high-risk insect pests. Contact: Dr Andrew Cridge, andrew.cridge@otago.ac.nz

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Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
University of Otago, contd	Long distance connectivity for superconducting quantum-bits	3	$999,519	The goal of this project is to develop the technologies need to efficiently, coherently and reversibly convert individual microwave photons into individual optical photons. The motivation for this work is communicating and performing calculations using inherently quantum mechanical states. There has been spectacular progress towards this end using devices based on superconducting qubits. Superconducting qubits are small resonant circuits made of superconductor. One of their key advantages is that they are manufactured in a similar way to today's computer chips with the same benefits of robustness and ease of manufacture at reasonable cost. One of the downsides is that they have to be cooled to only a fraction of a degree above absolute zero. These extreme operating temperatures mean that it is very hard to send quantum signals to and from the computer and currently there are no technologies that work. This lack of a quantum interface means superconducting qubit computers cannot be connected together to form quantum network. Severely limiting their application to super-secure quantum cryptography and to powerful distributed quantum computation. In this project we will improve the efficiency of the conversion of microwave photos to optical photons. For additional information contact: Dr Harald Schwefel, harald.schwefel@otago.ac.nz
	Highly efficient solar-to-hydrogen energy conversion based on innovative nanophotonic platform	3	$999,959	This project will develop an innovative platform to highly enhance water-splitting efficiency, providing a cost-effective solution for large scale production of hydrogen gas. For some time, the scientific community has been actively seeking alternatives to fossil fuels - the main source globally of man-made greenhouse gas emissions. Hydrogen gas is a promising option to replace fossil fuels for its clean nature, earth-abundant reserves and high energy density by weight. In addition, hydrogen gas is also an important chemical for fertiliser, semiconductor and chemical industry. Hydrogen production is currently dominated by steam reforming of natural but that produces significant greenhouse gas emissions. Electrochemical splitting of water offers a clean pathway to replace this, but it is currently tens of times more expensive even when electricity is available. This project seeks to significantly improve the water-splitting process. This research will significantly reduce the hydrogen production cost, having significant value as the world seeks out clean energy carriers to replace fossil fuels and clean industrial hydrogen. Our manufacturing techniques fit with NZ's capabilities. This and other related developments could in time deliver a significant NZ high-value research-based manufacturing industry. For additional information contact: Professor Richard Blaikie, richard.blaikie@otago.ac.nz
	Understanding pollen abortion in female kiwifruit to create bisexual flowers	3	$999,720	Kiwifruit differs from most crop plants as it has separate male and female plants. This means that pollen must be transferred from a male to a female plant for fertilisation and subsequent fruit development. As a result, over 10% of the plants in current kiwifruit orchards are non-fruiting males required for pollen production. Additionally, as the size of fruit depends on a high rate of pollination, kiwifruit growers spend resources on managing bees (kiwifruit flowers are not attractive to bees), and some growers resort to artificial pollination. Interestingly, flowers on female kiwifruit plants initiate pollen development, but the pollen aborts before maturity. We aim to understand what causes this pollen abortion, and use this knowledge to provide tools to restore male fertility in female kiwifruit plants. Having females that can also produce pollen in orchards means the male plants could be removed and growers would no longer need to manage bees and pollination. This would reduce costs, increase yields and improve land-use efficiency. For extra information contact: Dr Lynette Brownfield, lynette.brownfield@otago.ac.nz
	Superhydrophobic lenses – Merging water droplets for fast surface ejection, preventing ice-formation	3	$999,677	Icing constrains many engineering systems, from aircraft to domestic appliances. It is a particularly major problem in energy generation and conversion systems such as wind-turbine blades and heat-exchangers, leading to system damage and reduced availability and efficiency. Anti-icing coatings can be applied, demonstrating ice-formation delays of 3-5-fold on heat-exchangers or wind-turbines, however these are a temporary measure. Removing condensed liquid remains an unsolved technical challenge for hydrophobic anti-icing coatings. This project will demonstrate new classes of surfaces that prevent ice-formation even under extreme conditions. These novel surfaces will be trialled under real-world conditions of high airflow-rates and condensation-icing typical of heat exchanger and wind turbine operation to demonstrate fast and continuous surface rejuvenation. We will test our systems with NZ heat exchanger, wind turbine manufacturers and metal and composite-fibre industry. For additional information contact: Dr Sam Lowrey, sam.lowrey@otago.ac.nz
University of Waikato	Eye on lakes: national monitoring of cyanobacterial blooms	3	$1,000,000	Cyanobacterial blooms are increasing in NZ lakes. Many blooms contains toxins that pose a health risk to humans and animals. Signs advising against contact are familiar at popular recreational lakes, but the scale of this issue is likely under-appreciated. A recent assessment of NZ's lakes suggested that most lowland lakes outside of national parks might experience cyanobacterial blooms but, at present, only 40 lakes are monitored routinely for cyanobacteria. We will develop a remote-sensing technique to detect cyanobacterial blooms applicable to more than 1000 lakes in NZ from satellite images, at weekly intervals (cloud permitting). This will allow the dynamics of bloom development to be monitored both, over time and across the surfaces of lakes. The techniques developed in this project will allow lakes to be graded as low, medium or high risk. This project will advance other remote sensing water quality applications where optical properties are affected. Spin-off benefits will include the ability to monitor total phytoplankton, as chlorophyll-a, and suspended sediments in many more lakes in NZ than current tools allow. This will provide a national inventory of both trophic condition and the prevalence of cyanobacterial blooms. Together, the evolution of these two indicators of lake water quality over time will allow a far more comprehensive evaluation of the state of NZ lakes, and restoration effectiveness, than is currently possible. Assessments will be available via web-based tools, providing a near real-time monitoring of cyanobacterial biomass from which health risks can be assessed. Stretch goals include using high-resolution monitoring of bloom development to guide research and the development of a smartphone-based tool for monitoring lake quality to facilitate citizen science.

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Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
University of Waikato, contd	An isotopic toolkit for cadmium management: from agrisystems to ecosystems	2	$999,808	Cadmium is a biotoxic element present in fertilisers used extensively in New Zealand agriculture. This project will deliver new understanding on the fate of cadmium in soils, waters and cropping plants. We will test how cadmium mobility can be minimised and determine the extent to which cadmium has left the soil zone and entered in groundwater and natural ecosystems. We will also develop a new tool to allow Regional Councils and farmers to manage cadmium in the most pragmatic and sensitive way.
	Reduction of force transmission to buildings from vertical and horizontal seismic motion	3	$993,612	New Zealand is vulnerable to seismic hazard, including earthquakes that cause significant vertical ground acceleration. While there are excellent protection systems, such as Lead Rubber Bearings, to isolate buildings from horizontal ground motion, protection against vertical motion remains a challenge. Isolation means introducing some flexibility and permitting movement to reduce forces that can cause damage. An everyday example is the shock absorber in vehicles. When we drive on bumpy roads this allows the wheel to move relative to the body of the car. Without this we would feel the force from the uneven road. It is not so easy to protect buildings from earthquakes with such shock absorbers, because allowing too much motion would affect day-to-day use. So what is the solution? The answer may be a foundation that can change its stiffness, so as to remain rigid except in the event of an earthquake. This poses a significant research challenge. Inspired by a plant called Mimosa pudica, or the touch-me-not plant, which becomes completely floppy and flexible when it is touched or shaken, we sought an adaptive foundation that changes its stiffness in response to ground movement. After initial trials with water-filled tubes to mimic the touch-me-not's mechanism failed to produce the necessary change in flexibility, we approached the problem using another idea based on mechanical engineering applications. Preliminary work confirmed the potential of our proposed concept for use as a protection mechanism against vertical ground acceleration in an earthquake. If successful, this will be combined with existing systems that protect against horizontal motion. The resulting device will be designed for installation in new buildings and the same device (or a variant) for retrofitting into existing buildings.
	Identifying Solutions for Using Personal Monitoring to Support Workers in Hazardous Industries	3	$999,993	Finding a way of keeping workers safe in high-risk and hazardous environments is a top priority for New Zealand's outdoor-based industries. Current industry-standard monitoring systems cannot reliably predict fatigue and hazard risk as they do not capture any information about a worker's current activity and environment. They also have poor buy-in from workers who are unwilling to be monitored in this way due to the ethical dilemmas around data use and privacy.This project will develop an innovative, ethical and evidence-based wearable monitoring approach suitable for the New Zealand workforce. It is our hypothesis that data ownership and control will improve worker engagement, therefore improving workplace safety and wellbeing. We propose to empower workers with ownership of their personal data collected during workplace activities following the philosophy of Te Mana Raraunga (the Māori Data Sovereignty Network). Māori are disproportionately affected by work-related injuries; this research embraces and applies cultural philosophies and delivers health and safety benefits for all workers. The resulting increased worker safety will have significant economic benefits to New Zealand's high-risk industries. Our New Zealand-best science team is collaborating with major outdoor-based industries to address this hypothesis. Co-designed with workers, active Māori investigators and in partnership with Māori organisations ensures treatment of worker data that respects both its cultural (living tāonga) and its commercial value (data ownership). We will develop a solution that uses incoming data from wearable technology worn by workers which will be analysed along with contextual information to provide live feedback to the workers throughout the day. *Contact Dr. Judy Bowen (jbowen@waikato.ac.nz) or Associate Professor Annika Hinze (hinze@waikato.ac.nz).*
	Harnessing Marine Invasive Allelochemistry to Fast Track Bioactive Applications	3	$1,000,000	Increasingly new and returning diseases of humans and primary production animals and plants are creating risks to our health, the productivity of our ecosystems and our food security. We have spent significant effort over the last decades searching for new drug leads from marine natural products. The 'holy grail' was to find novel chemical compounds that have unique modes-of-action to counteract increasing drug-resistance. Unfortunately, many biodiscovery programs have randomly collected samples using "shotgun" approaches, requiring high collection and screening efforts but providing few relevant discoveries and resulting in low return on investment. These programs have however left a legacy of valuable bioinformatics – data that links the bioactive chemistry with the mode of action on cells, in turn linked to the species that produced the chemical leads in the first place. This information base is available to us for harvesting and to direct smart new approaches for development of useful, nature based bioactives that will have applications in other sectors. This research uses a hypothesis-driven approach linking successful marine invaders with their use of novel chemicals to outcompete native species. Marine biofouling (encrusting) invaders disproportionately contribute to coastal biodiversity, dominating resources and outcompeting native species for space. Although the key drivers of invasion success remain elusive, previous work has demonstrated that non-native species dominate space over natives. We propose that novel chemical ecology plays an important role in non-native species' competitive abilities and significantly contributes to their invasion success through biofilm modification and direct effects to overwhelm competing native species' defensive responses. Focusing on successfully invading biofouling species would therefore provide a mechanism to target new bioactive compound leads relevant to pharmaceutical, animal and plant health sectors.
	New approaches to detect invasive freshwater fish using scent and environmental DNA	3	$1,000,000	Invasive fish are a significant threat to New Zealand's freshwater ecosystems, damaging biodiversity and habitat. Detecting pests like koi carp and catfish can stop them becoming established, and allow eradication. However, current methods of detection such as netting and electrofishing are time-consuming, expensive, and poor at detecting low numbers of the fish. This research will provide an innovative solution to these problems: with scent-detection dogs. Pet dogs visit the University of Waikato's scent-detection laboratory, where they are trained to detect fish odour in water samples. Our preliminary results are promising, and show that dogs can detect koi carp at levels equivalent to one fish in an Olympic-sized swimming pool – but many unanswered questions remain. Part of this project includes comparing the performance of our scent-detection dogs against environmental DNA (eDNA) analysis. eDNA is a relatively new detection technology which involves analysing the DNA contained in water samples to determine whether a species is present. Our preliminary research suggests that dogs could be a more sensitive, and much cheaper, detection option. We will also analyse the water samples to learn what volatile chemical compounds the dogs are detecting, which will guide our training processes. This research will deliver a novel, low-cost biosecurity system that will allow organisations such as DOC, regional councils, and iwi to conduct more extensive monitoring of freshwater systems; users will be able to send water samples to our laboratory for the dogs to assess under controlled conditions. As well as delivering significant benefits to New Zealand's freshwater conservation, this detection system has the potential to be applied to many other detection problems, including other unwanted organisms and native species. *Contact: Clare Browne, clare.browne@waikato.ac.nz*

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Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
Victoria University of Wellington	An engineered RNA ligase system for unbiased sequencing of diverse microRNA pools	3	$1,000,000	Every organism can regulate expression of its genes. For example, some genes are switched on when you are a baby and switched off when you get older. Others are expressed in your eyes, but not in your ears. Turning genes on or off at the wrong time or in the wrong place can lead to many diseases, including cancer and neurological conditions. In the 1990s, researchers discovered a new way by which gene expression is regulated. This involves thousands of molecules called microRNAs, each of which is effectively a 22-letter word. One-third of all human genes are controlled by microRNAs. As you would predict, this means that mistakes in our microRNA system can lead to over 100 different diseases, including dozens of different cancers. There is huge interest in understanding how microRNAs work in all higher organisms. For us humans, there is also enormous potential in using the patterns of microRNAs that we produce to predict the onset, severity and likely outcomes of disease. The best way to achieve this is to read all of the microRNA 'words' in a particular sample (such as blood, or a tumour biopsy). Unfortunately, current technologies for doing this are severely biased. They misrepresent the presence or absence of different microRNAs, as well as their relative amounts. We hypothesise that this problem will be solved if a key step in the laboratory protocol for reading the words can be done at high temperatures (above 75°C). Our team of internationally-respected life scientists is going to develop the molecular tools required to achieve this. By being the first to demonstrate unbiased analysis of microRNAs, we will enable a new generation of microRNA-based diagnostics and therapeutics.
	Novel 3-dimensional sugar-based clusters for the treatment of metastatic breast cancer	3	$999,953	The spread of primary tumours to other parts of the body is the principal cause of death in breast cancer patients. An enzyme called heparanase is a key influencer in this deadly process. Heparanase weakens the 'glue' that hold cells together, and enables cancer cells to escape through tissue barriers. This means the primary tumour can grow faster, enter the circulation and spread to remote parts of the body, becoming very difficult to treat. This tissue invasion makes heparanase a promising drug target. Our research aims to combat heparanase by developing a new generation of anticancer drugs. Standard anticancer drugs kill rapidly dividing cancer cells but also affect normal cells and have adverse toxic side effects. Our goal is to produce a drug that is both more effective than existing drugs and considerably safer. This research on the production of 3D natural sugars has been 7 years in the making, and we can now focus on the development of the sugars to treat breast cancer. Our compounds have low toxicity and retard the spread of cancer cells in mouse models. Combining leading expertise in medicinal chemistry and cancer biology, we will select the best compounds for treating cancer. There are no therapeutically effective heparanase inhibitors currently available for use in the clinic. Our new manufacturing techniques give us an edge on competitors, whose syntheses are difficult and very expensive. By working with industry, we will take our lead compound to market. Our research is a new frontier that promises to save billions of dollars in treatment costs and to significantly improve the lives of breast cancer sufferers in NZ and across the globe.
	Synergistic pathways for remyelination in multiple sclerosis	3	$999,999	We aim to develop the first treatment to promote repair and recovery in multiple sclerosis (MS). There are approximately 2.5 million MS sufferers worldwide with 400,000 in the US and >3,000 in New Zealand. Over one third of people with MS suffer from moderate to severe disability characterised by impaired vision, coordination, and paralysis, and there is no cure. Disease-modifying drugs are available, but they are only effective in one of the three major forms of MS, and while they can reduce the immune-mediated damage, they do not promote repair. The principal goal of our research is to introduce urgently needed therapies that target repair and enable the remyelination of the nerves in MS. We have discovered that activating a specific neurological pathway leads to full recovery from MS disease in an experimental model. Furthermore, we have identified 1) currently approved medicines, which target this pathway and can be repurposed for MS, as well as 2) novel compounds (developed by our team) which are effective at promoting functional recovery. Our research will fully characterise the disease-modifying effects of our repurposed and novel compounds in preparation for clinical development. Furthermore, we will investigate if greater benefit can be gained by 1) targeting two different neurological pathways as well as 2) combining our therapeutics to promote repair with current immune-targeting MS drugs. Ultimately, this research will deliver a new (and first-ever) treatment to enable functional recovery during MS.
	Enhancing the efficacy of veterinary vaccines by skewing the immune response to a Th1/Th17 profile	3	$1,000,000	Veterinary vaccines for the prevention of communicable diseases positively impact animal health and productivity, and thus provide significant economic savings to the agribusiness community. Moreover, vaccinations have important public health benefits via the reduction of pharmaceutical (e.g., antibiotic) residues in the human food chain. Despite this, there are several pathogens for which there are no effective vaccines – a situation that is exacerbated by the global increase in antibiotic resistance and the corresponding emergence of new diseases. Effective vaccination needs to produce a strong immune response that generates immunological memory, as this is required for protection against future infections. To develop vaccines against animal pathogens, we will focus on a class of molecules, called adjuvants, which enhance the immune response. Specifically, we aim to prepare adjuvants that lead to a specific immune response that is critical for protection against a variety of diseases. As proof-of-concept, we will provide an adjuvant for a vaccine against Mannheimia haemolytica and Mycoplasma ovipneumoniae, pathogens that cause ovine pneumonia.1,2 This disease represents a major economic burden in NZ and there is currently no effective vaccine. In addition to novel vaccines, our adjuvant can be added to existing vaccines currently used by farmers so as to enhance vaccine efficacy and lower vaccination costs. Our new adjuvant will also work in vaccine formulations for pets. To realise our goal, we are leveraging off our patented vaccine technology and have brought together a multidisciplinary team of scientists with skills in chemistry, immunology and vaccinology.

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Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
Victoria University of Wellington, contd	Handheld, enzyme-based biosensors for monitoring grape quality, wine quality and fermentation	3	$1,000,000	New Zealand wine has an international reputation for quality and innovation. To make good wine, it is essential to monitor the levels of various molecules in grapes (pre- and post-harvest) and in wine as fermentation proceeds. However, the current tests for these molecules are too complicated to be carried out in most wineries. Instead, viticulturists and winemakers pay to ship samples to commercial testing labs and then wait days for the results. This is a source of frustration, especially when time-critical decisions on when to harvest and how to manage the fermentations must be made. Our vision is to provide winemakers with smart biosensor technology, to maximise the quality and value of their wine. We will construct handheld, enzyme-based biosensors that will allow winemakers to conduct biochemical tests in-house, in seconds, at prices at least 10-fold cheaper than current outsourced tests. We will focus on developing biosensors for two key parameters: the grape-derived nitrogen that wine yeasts use during fermentation; and malic acid (important in the winemaking process of malolactic fermentation). The first biosensor will be colorimetric – the presence of yeast-friendly nitrogen in a grape juice sample will lead to development of a blue colour. Ultimately, we anticipate implementing this biosensor in a format akin to a pregnancy test. The malic acid biosensor will be electrochemical, using the same technology as a diabetic's blood glucose monitor. We will also work towards making a generalisable version of the electrochemical biosensor, suitable for developing into a suite of other user-friendly tests. The biosensors will interface with smartphones, for real-time data analysis. Thus, this research will give NZ winemakers the tools they need to make better wine, more reliably and more cheaply.
	Reconstructing Baseline Ocean Data Around NZ for Marine Management and Forecasting Models	3	$987,366	New Zealand's oceans play a profound role in our cultural and economic heritage. They shape our climate and support a rich fishing industry. However, pressure to exploit our marine resources is growing, while at the same time we are facing profound climate and environmental changes. New Zealand has therefore made it a priority to develop tools to help us optimally, yet sustainably manage our natural resources in the face of global change. Our scientists are developing state-of-the-art earth system and ocean ecosystem computer models that can be used to forecast change and explore marine management strategies. The problem is models are only as good as the data fed into them. Oceans are naturally variable on timescales of decades to centuries, but quality instrumental records extend back only a few decades. How can models provide reliable results when our window of perception is so short? Our research will address this problem by generating baseline ocean data using a new natural archive: deep sea corals. In the same way that tree rings can be used to reconstruct climate on land, these deep-dwelling slow-growing corals capture ocean information in their tree-like skeletons. NIWA hosts one of the world's largest collections of deep sea corals, with specimens from all around New Zealand. By analysing the chemistry of their skeletons, we can reconstruct centuries of ocean circulation and phytoplankton productivity. A project of this scale and scope has never been attempted before and could revolutionize our understanding of relationships between long-term ocean circulation and phytoplankton productivity while providing invaluable baseline data for ecosystem management and climate prediction tools.
	Water purification using solar energy captured by natural photonic crystals	3	$999,992	We will develop a low-cost technology for the efficient small-scale purification of water to a potable quality by distillation. The scientific basis of this technology is direct steam generation by solar radiation. Using existing conventional heat-absorbing surfaces, the diffuse solar flux of about 1000 W m-2 is inadequate for steam generation from water because of very substantial radiative energy losses. Instead of employing capital-intensive concentration of sunlight with mirrors (US$200 m-2) to overcome this problem, our new approach will harness solar energy using an inexpensive solar selective absorber with a photonic crystal structure that captures/traps solar energy over a broad spectral region and crucially, also reduce parasitic losses due to re-emission of absorbed energy. This technology fills an important niche in harnessing solar energy and has advantages over photovoltaics in terms of the increased wavelength range of absorbed radiant energy and its direct conversion to thermal energy for steam generation. We will establish the transmission and reflectance spectra of assemblies of the novel photonic crystals. We will determine the efficiency of conversion of photons of simulated sunlight to thermal energy by assemblies of these photonic crystals. We will establish the nano-structural basis of the behaviour responsible for trapping solar energy that gives the most efficient conversion of solar to thermal energy.

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AgResearch Limited	Mapping the New Zealand Ruminotype Landscape – defining variation in the microbiome as a resource for fitness and adaptation	4	$3,588,899	Ruminant livestock such as cattle, sheep, goats and deer graze more than 30% of the earths land, mostly due to geographical constraints on other food production. Ruminants have evolved to exploit a wide range of often harsh environments by hosting microbes in their fore-stomachs to digest plants to gain energy. This collection of different species of microbes is termed the microbiome. Even though we depend on ruminants for sustainable meat and milk production, we know very little about the microbiome in the gut. We do have evidence that the animal can partly control which organisms inhabit the gut by creating an environment that favours the more useful microbes. Human studies classify gut microbiomes into three main enterotypes. There may be similar ways to classify groups in ruminants or "rumenotypes" and these may be associated with specific animal characteristics such as growth, behaviour or parasite resistance. If we understand this we may be able to choose animals with optimal gut microbiomes for health and productivity leading to better animal welfare. Our aim is to create a map of the microbiomes of 10,000 NZ ruminants and to combine this with information recorded on the animals. We have DNA sequencing programs advancing characterization of microbiomes, and highly monitored ruminant populations measured for multiple production, health and disease traits. Combined with our team's expertise, this put us in a unique position to identify linkages between microbiomes and important animal characteristics. This program will use this map to improve animal selection and identify rumen microbial communities benefitting animal productivity and health. Study of the host-microbe system will also inform other complex microbial ecosystems such as marsupials, termites and humans.
	Improved weed control and vegetation management to minimise future herbicide resistance	5	*$8,500,000*	*This programme will deliver critical knowledge and improved tools to farmers (in the first instance) threatened by evolving herbicide-resistant weeds. Our intended outcomes are: (1) the ability to warn stakeholders about management practices likely to produce resistant weeds and consequential risks to farm businesses and surrounding landscapes (including conservation estates) where resistant weeds may also accumulate, and (2) more effective and timely interventions with reduced reliance on herbicide inputs. Novel and uniquely NZ tools from this research will target the weeds' most susceptible growth stages, making use of natural aides (e.g. pathogenic organisms) and traditional Mātauranga Māori for managing weeds without chemicals.* *We will address the question: In increasingly intensive production systems, how can we overcome the threat of the evolution of weeds resistant to the herbicides used for their control? We will do this by: (1) developing a prediction tool that identifies the most at-risk forage and crop production systems and high-risk weed species, (2) mapping and overcoming systems that lock-in mechanisms that prevent change, (3) designing improved detection methods for resistant weeds, (4) finding novel control options and optimising interventions used to manage weeds and reduce the soil weed seed bank, and (5) identifying how resistance is spread and developing strategies to minimise this.* *The research is undertaken by a multi-disciplined and experienced team across a number of NZ research organisations and universities with connectivity to the top international experts in this field. This work aligns strongly with the weed research priorities of the NZ's National Science Challenges and primary sector strategies. Critically, the work has benefits beyond primary agriculture for weed management in urban and road-side settings, forestry and conservation land uses.* *Contact: Trevor James, AgResearch*
GNS Science	Optimising water management based on understanding of flow sources, pathways and lags	5	$9,500,000	New Zealand's groundwater resources are vital to our economy, environment, society and culture. Groundwater supplies drinking water to ¼ of the population, is an essential input to the primary sector, and maintains stream and river baseflows. Yet land uses and other pressures are causing degradation of groundwater quality and availability nationwide. Long-term monitoring bores show evidence of this, with 40% having nitrate concentrations above natural levels and 71% exceeding the safe drinking water thresholds for *E. coli* at least once during 2012-2014. If groundwater is so valuable, why is it not better protected? This is a global issue arising from inadequate scientific understanding. We can't directly observe complex groundwater flow pathways. Groundwater transit times through aquifers can extend from years to millennia. This means that we presently can't provide a definitive link between pressures (like nutrient leaching or groundwater pumping) and impacts on the groundwater system or interconnected surface waters. We will overcome the scientific limitations and determine *Te Whakaheke o Te Wai* ('the pathways of the waters'), nationwide. In a world first, we will develop nationally continuous maps depicting the age, source and destination of groundwater and baseflow from any New Zealand location. To achieve this ambitious goal, we will need to collect new data and build new models of groundwater flow. Research outputs will be used by iwi, hapū, regional councils and Central Government to make better policies and plans for land and water management. Example applications include iwi/hapū environmental management plans, regional plans for managing catchment-scale contaminant inflows to groundwater-fed rivers, and helping protect local potable water supplies. Thus, the uptake of our proposed research will enhance groundwater quality and availability, thereby benefitting all New Zealanders.
Institute of Environmental Science and Research Limited	Impacts of microplastics on New Zealand's bioheritage systems, environments and ecoservices	5	$12,536,205	Microplastics (including beads, fibres and fragments) are a globally significant environmental pollutant. They are found in a broad range of ecosystems, and consumed by a diverse range of animals. The potential impacts of microplastics range from risks to human health to ecosystem collapse. Research programmes in Euro, Australia and North America have confirmed the presence of microplastics in a range of environments, and their long-term impacts on organisms. In New Zealand, scientists, regulators and Māori are increasingly concerned about the impacts of microplastics on our unique scies and ecosystems, tāonga, and human health. While initial national data shows that New Zealand's coastal and freshwater environments and biota are contaminated, there is limited information to assess the risk microplastics pose. This project will undertake a rigorous assessment of the extent of microplastic contamination, advance research on the mediation of that threat, and will contribute to the long-term well-being of NZ's environment, ople and economy. It will ensure NZ remains current with international trade and food safety requirements, while also making a significant contribution to international microplastic research.
Landcare Research New Zealand Ltd	More birds in the bush: large-scale restoration across complex forests	5	$9,000,000	Native bird populations in large NZ native forests are still rapidly declining, mostly due to predation by pest mammals, including rats, stoats and possums. The government's goal is to eradicate these predators by 2050, but we must act quickly to preserve remaining native bird populations in large forests now if we are to have viable bird populations in 2050. NZ has learned to prevent catastrophic bird declines in cold beech forests by coinciding predator control with rodent and stoat plagues following 'beech masts'. But we don't yet know when and how to intervene to save birds at large scales in the remaining 84% of NZ's warmer, more productive native forests, which potentially support our most diverse bird communities. Our research will develop the capability to predict both predator threats and bird responses across all native forests so that we can successfully suppress multiple predators in them and birds can recover, at large scales. This will require new field studies and building on very large, long-term monitoring datasets. Advanced integrated modelling will be used to link forest environments and fluctuating resources ('productivity'), predators, management regimes, and bird outcomes. These are fundamental interim steps towards a predator-free NZ. Our team will develop this new knowledge, and the tools to use it, in partnership with iwi and large organisations who undertake large-scale forest restoration and predator management. They and future innovators will apply it to develop new predator-control strategies, approaches and devices that are better for birds and meet iwi aspirations. Our goal is that NZ will be able to halt forest bird declines and then reverse them. We will have more birds, not just fewer predators.

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Landcare Research New Zealand Ltd, contd	Cost-effective targeting of erosion control to protect soil and water values	5	$9,800,000	Soil erosion resulting in transfer of sediment into water is an important environmental problem in NZ. It significantly reduces long-term land productivity and compromises the water quality, ecological health and values of our rivers, lakes and estuaries. Our research will improve understanding of where erosion occurs, how much and what type of sediment is produced and by which processes, how sediment moves through catchments, and how erosion and sediment transport can be targeted and mitigated cost-effectively. We will develop modelling frameworks for use by regional councils, land managers and iwi to assist with the implementation of government and regional policy to maintain land productivity and reduce sediment and other contaminant loads (e.g. phosphorus) in rivers. Current erosion modelling tools can only model annual average sediment loads over entire catchments. We will improve this accuracy through better measurements to enable prediction of erosion and sediment delivery from a single storm on a single farm, which is much more useful for planning and mitigation. Using new data capture tools, we will be able to assess the performance (or effectiveness) of different options for reducing erosion and catchment sediment load. We will also develop the capability to measure and predict 'sediment quality' – particle size distribution, shape and composition – which controls impacts on water quality. Our new tools will enable regional councils to better prioritise where to apply cost-effective erosion control to best meet national and regional water quality objectives. We will work closely with regional councils and central government, which currently invest significant funds in regional erosion control, to give them confidence and certainty they can identify and use the best erosion management practices to meet national targets.
	Beyond myrtle rust: Next-generation tools to 'engineer' forest ecosystem resilience to plant pathogens	5	$13,000,000	NZ faces growing risk from the impacts of exotic plant diseases. Under a changing climate, more plant pathogens (disease-causing organisms) are expected to establish here naturally, increasing the need for tools to reduce their impact on our environment and economy. Many of NZ's best-known, highly-valued native trees - pōhutukawa, rātā, mānuka - are in the plant group Myrtaceae. They urgently need protection from a recently-arrived exotic fungal disease called myrtle rust (MR), which can cause plant/tree death. Significantly, MR has never been eradicated from any country, despite significant effort to control its spread. It is probable that MR is now part of the story of New Zealand, and we have a narrow window of opportunity to reduce the disease's impact on our forested landscapes. To do so, we must first understand the short- and long-term impacts of this disease in NZ. Then we must understand the nuances of this organism which has made its home in our land. Even though MR biology has been studied in other countries, we don't know how this fungus will behave here. We can then adapt the learnings from other countries to identify the best approaches and tools to minimise the impacts of MR on our forests and natural landscapes, with a focus on natural tools that draw on traditional Māori knowledge and medicinal approaches. Responding to the aspirations of Māori, industry and communities, we aim to develop new, targeted ways to reduce MR damage to vulnerable plants and landscapes, and future-proof them against other plant diseases. In the same way, HIV is managed to reduce the development of AIDs, our research aims to boost the resilience of our landscapes despite the presence of disease.
Lincoln Agritech Limited	Hand-held high resolution medical imaging using microwave metamaterial lenses	5	$5,995,000	This programme will develop a new medical imaging scanner (MIS) for rapidly diagnosing bone fractures, tissue damage and other sub-surface abnormalities at sub-millimetre resolution. Its simplicity, cost-effectiveness, and portability will differentiate it from currently available imaging equipment and will drive uptake in point-of-care applications, including in ambulances, as well as medical facilities. While we will focus on rapid medical diagnosis of sub-surface trauma, there will be applications in many other sectors. Our scanner will be made possible through our understanding of the imaging potential of evanescent waves, which are components of microwaves. The research will build on an existing MBIE programme, LVLX1505, in which we have developed a method for focusing evanescent waves using special lenses with a number of substructures that bestow the unique focusing properties. This programme will generate new knowledge about how we can make lenses that maintain their high image resolution whatever the ambient conditions. We will also develop methods to reconstruct the two dimensional images produced by the scanner into three dimensional representations of the scanned bone or tissue. Our research will drive new manufacturing capability in New Zealand for the MIS scanners and their IP-rich component lenses. GE Healthcare, global leader in medical imaging equipment market, is an advisor to the Programme. GE will not seek rights of any kind in exchange for this input, leaving the choice of international distributors open for the NZ company taking MIS to market and creating substantial economic benefits to New Zealand. In the future, the scanners can be adapted to a wider range of uses, including veterinary scanning and scanning of built structures, which will increase economic impact. *Contact: Ian.platt@lincolnagritech.co.nz*
	Critical Pathways: Unravelling sub-catchment scale nitrogen delivery to waterways	5	$7,775,000	To better manage freshwater pollution we need to understand: the pathways by which nitrogen travels from land to waterways; how fast it travels; and how much nitrogen is naturally removed by microorganisms as it moves from the soil through the groundwater into a waterway. At present, there is little understanding of nitrogen pathways and removal processes at the sub-catchment scale (10's of km^2), i.e. the scale dominated by streams that feed into our rivers. However, it is at this scale that we have the best management and mitigation options available to reduce nitrogen delivery to waterways. This problem has been recognised by farmers, iwi, industry and councils as they try to work out land use, land management, and mitigation options that allow community-mandated water quality goals under the National Policy Statement for Freshwater Management to be achieved, with all councils required to have policy for water quality management in place by 2025. To provide the essential, currently missing sub-catchment scale information, this programme, developed by scientists from seven organisations in collaboration with iwi, councils, and industry, will deliver: • A range of tools and methods, using new geophysical measurements, that describe the subsurface contaminant pathways within a sub-catchment. • Novel models that use this information to reliable predict the quantity of contaminants entering a waterway. • Methods that enable soil and subsoil contaminant delivery characteristics to be estimated over large areas through relating them to geophysical measurements. • Cost/benefit methods that determine the financial advantage these methods provide through enabling; matching of land-use to existing natural removal capacity, and/or mitigations being installed where they have the greatest effect, ensuring "biggest bang for their buck". . *Contact Roland Stenger, Roland.Stenger@lincolnagritech.co.nz*

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Livestock Improvement Corporation Limited	Transforming dairy cattle improvement through next generation genomic selection and strategic mating	5	$7,000,000	New Zealand's dairy cows are renowned as being some of the most efficient producers of milk in the world. However, given diminishing natural resources, and a practical upper limit on the number of cows that can be farmed in NZ, further improvements in productivity will come from breeding better cows. This programme applies the latest genomic technologies to breed healthier, more efficient dairy cattle. The project is split into two major work streams, both of which rely on large-scale genome sequencing and genetic mapping studies of 100s of thousands of animals. The first component of work uses these mapping studies to pinpoint rare recessive gene variants causing illness and disease. Identification of the causes of these syndromes will allow breeding decisions about which bulls are mated to which cows, avoiding the generation of affected animals, and addressing the production efficiency losses and animal welfare concerns associated with disease. The second component focuses on common genetic variation. Using similar large scale genetic mapping approaches, DNA variants associated with major dairy production traits will be identified. In this case, the impacts on phenotypes are less extreme, highlighting many thousands of variants that make it difficult to pinpoint those that directly cause the change in phenotype. To tease apart these effects, the biological function of variants will be tested directly in lab-based cell culture studies, distinguishing between causative variants, and those that are highlighted by statistical correlation alone. Knowledge of these new variants will be used to add flexibility and enhance dairy cattle selection schemes. These discoveries will drive improvements in production efficiency and animal welfare outcomes, and ensure sustainability of NZ's pastoral industries for years to come.
Massey University	Milks Mean More: Unlocking the potential of New Zealand's ruminant milks	5	$11,268,560	Our research is a partnership between AgResearch, the Riddet Institute hosted by Massey University and the University of Auckland and involves international collaborators from University College Cork, INRA and Teagasc. The partnership also includes key representatives from across all NZ's ruminant milk industries. Mammalian milks are a complete base for developing nutrition-focused foods for all life-stages but their contribution to our wellbeing could be greater than predicted by current nutritional paradigms. This team will define how natural and processing-induced structural assembles in milk (e.g. casein micelles, milk fat globule membrane) affect digestive and nutritional outcomes, and consequences for consumer health and wellbeing. We will use that knowledge to tailor milk products to optimise digestive and nutritional outcomes, ensuring they are scalable to industrial processes, and meet regulatory requirements. NZ's ruminant milk industries will use this new knowledge and industry "know-how" to build credibility and gain endorsement for including NZ milks as part of a healthy diet that consumers in established and emergent markets in North America and Asia will value. Outcomes from this project will help future-proof NZ's agri-food export markets through production of added-value foods that increase export revenues. These products will lead and drive future market signals about nutritional outcomes through high levels of knowledge-embedded, proof-of-efficacy, and as such, will provide competitive advantage for NZ's ruminant milk industries. **Our Vision**: NZ's ruminant milk industries grow their competitive advantage as suppliers of premium export and high margin milk-based foods that deliver superior nutrition by generating additional and accumulated export sales of over $500m p.a. by 2033. *Contact: W.McNabb@massey.ac.nz (Programme Leader).*
MetOcean Solutions Limited	Understanding ocean circulation, connectivity and marine heatwaves to support an enduring seafood sector.	5	$11,500,000	The seafood sector brings $4.18B to NZ annually. The resources that the sector depends on are threatened by increasing ocean temperatures. Indeed, thermal stress is one of the greatest threats to aquaculture and above-average ocean temperatures are also impacting deepwater fisheries (e.g. Hoki). NZ has recently experienced its worst marine heatwave on record, yet we know nothing about these events. This project will vastly improve our understanding of coastal ocean circulation, connectivity and marine heatwaves to provide information that will support sustainable growth of the seafood industry (Māori, fisheries and aquaculture). We will apply the internet of things concept to develop a low-cost ocean temperature profiler that will be deployed by the fishing communities 'on all boats, at all times'. NZ's first open-access ocean forecast system will be delivered by developing new ocean circulation models using a combination of advanced numerics, modern genomics and data from our smart ocean sensors. We will investigate the drivers and impacts of marine heatwaves so that we can predict them, and investigate ocean transport pathways and population connectivity of kaimoana species. This project will provide a step-change in the oceanic information available to the seafood sector and the broader community, accessible through the open-access user-friendly datasets and tools developed. This information will help the NZ seafood sector retain its competitive edge in a rapidly changing ocean impacted by marine temperature extremes and shifting currents. We will build bridges to ensure this new knowledge informs regional marine policy and management. This project is anchored in mātauranga Māori through our relationship with Whakatōhea, facilitating exchange of oceanographic knowledge between Te Ao Māori and western science and serve as an exemplar for other coastal iwi.
National Institute of Water and Atmospheric Research Ltd	New technologies to double the effectiveness of on-farm diffuse pollution mitigation	5	$8,000,000	This research aims to provide new, highly effective pollution mitigation options for land managers, enabling them to reduce diffuse nutrient losses to waterways. This will improve the health of streams, rivers, lakes and estuaries and ensure farming can be sustainable and economically viable within the new paradigm of "farming within limits". Limits being set under the government's National Policy Statement for Freshwater Management will help to address degrading water quality. But meeting these limits with current methods will require significant changes to land-use and stocking intensities, challenging the viability of current farming practices and the social fabric of surrounding communities. Source control of nutrient losses through improved on-farm nutrient and grazing management are cost-effective, but are often insufficient to achieve the required reductions in leaching losses. Current edge-of-field mitigation options, such as riparian buffers, constructed wetlands, and emerging options such as woodchip bioreactors and P-adsorption filters, require large land areas due to low removal rates, and struggle to cope with the episodic high flows and the associated peak contaminant loads common in NZ. **We aim to co-develop a range of *Interceptors,* enhanced bioreactors and scrubbers, to remove diffuse pollution from agricultural drainage that will be at least twice as effective as current methods.** Some options will enable recovery of nutrients for reuse on the farm. We will target surface and subsurface drainage discharges, which short-circuit natural attenuation processes during passage through soils and riparian zones, generally making them the dominant conduit for nutrient run-off into waterways. *Interceptors* will be co-developed and applied with and by Māori land-managers, industry and governance partners to provide the required step-changes in efficacy, cost effectiveness and applicability.

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National Institute of Water and Atmospheric Research Ltd, contd	Advancing New Zealand's carbon inventory: forest, grassland, and urban environments	5	$11,455,000	This research aims to provide New Zealand (NZ) with verified, comprehensive estimates of its national carbon emissions that will inform the transition to a low-carbon economy. The 2016 Paris Agreement is the first universal, legally binding global climate deed to limit global warming through emissions reductions. NZ plans to meet its ambitious national target through reducing emissions, increasing the carbon absorbed by land (mainly forests), and if required, buying carbon credits from overseas. But the amount of carbon absorbed by our land is not well understood. Our research will provide direct, independent estimates of both our carbon emissions and uptake. This will inform land management, our national emissions reduction strategy, and future international emission reduction negotiations. We will focus on the forest, grassland, and urban environments, as these represent the largest components of NZ's carbon budget. We will combine measurements of atmospheric carbon dioxide (CO_2) and methane (CH_4) with weather models and isotope analysis to independently estimate the amount of carbon emitted from fuel and agriculture and re-absorbed by NZ's forests, grasslands, and urban ecosystems. As air passes over a region, the amount of carbon in the air increases or decreases due to carbon exchange. The isotopic ratio of greenhouse gases and the amount of other trace gases in the atmosphere can serve as 'fingerprints' for different carbon exchange processes. Therefore, when atmospheric gas measurements from a network of sites around NZ are combined with weather model simulations that tell us the pathway air took before arriving at a site, we can determine the total amount of carbon that has been absorbed or emitted and use isotopes and other gas measurements to identify the type of carbon source or sink.
Scion	Bark Biorefinery: Unlocking new hydrophobic polymers and a mountain of wealth	5	$9,980,000	This programme seeks to develop a conceptual Bark Biorefinery and new value chains linking NZ bark processing to the extraction and supply of novel products, opening new export opportunities for global specialty chemicals and associated products. Besides increased export revenue from a Bark Biorefinery, an opportunity for job creation and renewed economic growth is enabled through the development of the bioeconomy in New Zealand's rural and regional areas. Bark forms the protective layer of a tree and provides an array of unique attributes evolved to prevent attack (chemical, physical, or biological). Globally bark has been recognised as a novel resource throughout human history; from the discovery of bioactives such as quinine as an anti-malarial, to the use of tannins for leathers and adhesives. By using the latest in green chemistry approaches we will realise the untapped potential for pine bark derived compounds in current and new applications. We hypothesise that through a combination of novel technologies and innovative extraction approaches we can extract and fractionate significant quantities of the unique hydrophobic biopolymer suberin, together with high value monomeric compounds, and targeted molecular weight fractions of polyphenolic tannins as by-products. The waterproofing properties of suberins offer new product opportunities in multiple applications ranging from automotive and construction to medical and textiles. Advanced biobased products like these will accelerate the emerging bioeconomy in NZ. In addition, the residual bark left after extraction will be converted to renewable solid fuels, allowing the integrated biorefinery to approach energy neutrality.
University of Auckland	Data informed decision making and automation in orchards and vineyards	5	$16,769,775	Our goal is to reduce the variability of human worker performance in orchards and vineyards, using augmented reality technology to help inexpert workers make expert decisions, and reduce the risk associated with a transient workforce, using robotic automation. We will create new technologies that capture and convert data about plant structure, and the activities of expert humans, into smart decisions and actions in fruit growing e.g which grape vine to prune and how much to remove. We will use Artificial Intelligence to interpret data and then identify and communicate actions to less experienced humans and to automated robots. Horticulture industries suffer from high labour costs and increasing shortages of skilled labour, which reduce productivity and quality of crops. Our new technologies will assist fruit growing operations, and help NZ companies to generate premium horticultural products for the global market. Our research will be co-developed with NZ grower organisations, individual growers, including Māori fruit crop companies, and NZ agricultural machinery manufacturers. We will use apple thinning, grape pruning, and new blueberry variety harvesting as case studies. Our programme will deliver a suite of human-assist and automation technologies demonstrated for specific tasks and adaptable to other fruit growing operations. The use of field data for decision making and integration into operations will transform horticulture into a data-enabled industry - changing the focus from manual labour to transferable expert knowledge and skills.
	Discovery and nonclinical development of an optimized disease-modifying therapy for type-2 diabetes	5	$13,036,530	Diabetes is a leading cause of disability and death. The International Diabetes Federation (IDF) reported that in 2017, ~400 Million people were living with type-2 diabetes (T2D). To date, all medicines for diabetes treat only symptoms: none can prevent/reverse the diabetic organ damage. The Western Pacific (WP) including China, New Zealand, Australia and Pacific Islands encompasses 37.4% of all people living with diabetes. With 1.3 Million deaths among adults, the WP has the highest number of deaths due to diabetes of all IDF regions. Of T2D-related deaths, ~45% occurred in people under the age of 60y. In NZ, the IDF estimated costs of diabetes to the health system (~326,000 diagnosed patients) to have been in 2017, an annual cost of $1.9 Billion. Our team has identified the probable molecular basis of pancreatic damage that causes insulin-deficiency and T2D. Over recent years, in an MBIE-funded programme, we have learned how to target this mechanism therapeutically, using small molecules that markedly slow progression of diabetes in model systems. Our work has caught the interest of Chinese researchers, and their government has committed support to aspects of our China-based collaborative programme. We expect to develop an innovative new medicine that can prevent the onset/progression of diabetes in patients including Māori, leading to a significant lengthening of life and improvement in organ damage. This therapy will have a positive transformative impact on NZ's economic future by providing an effective therapy for T2D in NZ and worldwide, bringing future manufacturing and export potential to NZ, thereby contributing to economic growth through distinctive R&D, of relevance to Vision Mātauranga and its priorities. If we succeed, this will benefit many people.
	Microbial conversion of kelp to high nitrogen plant and animal feeds	5	$6,091,955	The world's increasing demand for food generates a powerful economic imperative for innovation in food production technology. Our novel system was discovered through our previous research in New Zealand, and has the potential to create several new products for the global food supply chain. Our research revealed that (a) symbiotic microbes in the hindgut of NZ seaweed-eating fishes convert seaweed and atmospheric nitrogen into compounds of nutritional value to fish, (b) these hindgut microbes provide an important source of dietary protein to the fish, and (c) these novel organisms can be grown in culture. Culturing these microbial communities to bioconvert abundant and sustainable seaweeds would thus address four global problems: (a) the economic and environmental costs of feeding capture fish to cultured fish, (b) the unsuitability of many terrestrial protein sources for aquaculture feeds due to the lack of critical nutrients and the presence of compounds inhibitory to digestion, (c) current roadblocks to using abundant seaweed biomass to produce aquaculture feeds, and (d) the growing demand for sustainable agricultural fertiliser. This is a completely novel idea on an international level, as we have only just discovered and begun to understand the microbial and physiological processes in NZ fish underpinning it. The present proposal develops and broadens this research into a number of economic opportunities for NZ. These will be accomplished by developing the culture technology and methodology to maximize the production of desired fermentation end products; single cell protein for animal and aquaculture feeds, organic fertilisers that will decrease the need for more harmful forms currently used and as a food source for black soldier fly larvae, which have growing global importance as feed components for aquaculture and poultry.

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SUCCESSFUL 2018 RESEARCH PROGRAMMES

Organisation	Title	Duration *(years)*	Contract Value *(GST excl)*	Applicant's Public Statement
University of Waikato	He Waka Eke Noa: Maori Cultural Frameworks for Violence Prevention and Intervention	4	$2,160,384	'He Waka Eke Noa' investigates the role of Māori cultural approaches to violence prevention and intervention. The research is a Kaupapa Māori research project that focuses on Māori understandings of family and sexual violence. International research indicates that culture can be an effective 'buffer' in the area of family and sexual violence prevention and healing trauma. Our approach provides a broad view of violence that captures the complex factors that contribute to the prevalence of violence within, and upon Māori communities. The research will investigate a range of explanations for violence in Aotearoa, both individual and collective, and ways through which culture can inform the development of successful approaches to violence reduction. This project has been developed collaboratively with Māori healers, social workers and counsellors who have wide-ranging involvement and knowledge in working with whānau who have been impacted by either family or sexual violence. Over the past 20 years there has been strong advocacy for the development of programmes that are based upon cultural knowledge and practices however there is limited research that explores which principles are most effective and the difference that cultural programmes may have in intervening in contexts where violence has been intergenerational and ongoing. This project will work with a range of organisations in the identification of the prevalence of family and sexual violence for Māori and to explore in depth Māori cultural concepts and practices that successfully inform and support intervention and healing processes.
Victoria University of Wellington	Efficient Drug Development from Transition State Theory	5	$7,394,610	This programme will create medicines addressing pressing unmet medical needs for new targeted therapies against cancer and infectious disease. Our team is unique to New Zealand with a technology providing a distinct competitive advantage internationally together with the technical experience required to develop manufacturing processes to obtain APIs for clinical trials. Biotech companies will be created that will attract investment by the private sector to grow high value assets and take new drugs through clinical trials to market. Additionally they will create new revenue streams accruing to pharmaceutical development service providers and generate new pharmaceutical manufacturing opportunities.
	Addressing the need for magnetic memory to enable superconducting computing	5	$5,971,120	The computing demands of the world's information technology appetite are driving that technology toward increasingly advancing the central-processing power, the supporting data volume, and the speed of both. It is certain that the technology will require a hardware paradigm shift in the next decade, a shift to superconductor central processors. There remains an opportunity in the data storage, the memory demands of these faster computers that can be filled by the only known ferromagnetic semiconductors, the rare-earth nitrides. For more than ten years the semiconductor research group at Victoria University has focused on the rare-earth nitrides. The group now holds, by a large margin, the position of the world's leading center for these materials. Within the group there resides both the engineering expertise required to form excellent crystallographic structures required for data storage and an understanding of their outrageously unusual and interlinked magnetic and electronic properties. The engineering success opens the door to the production of layered devices in which our knowledge of the magnetic/electronic behavior can be exploited to develop data-storage, and indeed other magnetic/electronic devices. The opportunities for New Zealand are in the development of a critical technology for the world-wide computing industry, with many medium-volume exceedingly high-value devices that are easily within the scope of New Zealand's economy. More broadly, our research will benefit the entire ICT industry in New Zealand and beyond, as well as the myriad of companies that rely on their services. We aim to make a very basic-level impact on this not merely high, but rather the highest-tech industry.
	Tuneable monolithic magnetoresistive sensors for asset management	4	$4,800,000	When a digger ruptured the pipeline that carries aviation fuel from Marsden Point refinery, there was major disruption until the fault was found and repaired. Corrosion under insulation is an important cause of faults in pipelines but it is hard to detect. Likewise, faulty power lines can cause major disruption to the power network. Unplanned power outages cost power companies and consumers around $90 million each year. That's because our power lines and poles are up to 70 years old, and are coming to the end of their useful life. Power companies and the government are worried about the cost of replacing them. If we could identify just the faulty sections, and replace only those, we could save the country billions of dollars. In this programme, we will use the science of magnetic materials to develop sensors to detect the weak magnetic signals of defects in power lines, power poles, pipelines, and steel reinforced concrete. This will help engineers accurately assess whether a bridge or a building has suffered internal structural damage inside the concrete, without boring holes in walls. It will give us peace of mind after major earthquakes, knowing that a bridge is safe to use or that a building needs to be red-stickered, even though it may look OK. Our clever sensors will be highly sensitive and able to be dynamically tuned so they can pick up the subtle signals of the magnetic field of interest within the noise of competing fields. This requires a deep knowledge of magnetics and magnetic materials, plus engineering and commercial experience to turn cutting-edge science into a technology that can be made by New Zealand companies to sell to the world.
	Fungal factories: Synthetic Biology for the Manufacture of High Value Products	5	$8,861,560	Many organisms, including plants and microbes, utilise unique arsenals of bioactive compounds that are thought to provide protection against predators and enable establishment of new ecological niches. Although bioactive compounds are used widely for industrial and pharmaceutical applications their diversity remains largely untapped. Very recently, we have developed novel tools to mix-and-match metabolic machinery and construct microbial factories for the production of high value bioactive compounds, by harnessing the power of biology for complex chemical manufacture. Our synthetic biology platform technology allows us to elucidate untapped biosynthetic pathways, providing access to important natural products that were previously inaccessible. Our initial target is a potent insecticide for the agricultural sector. Using our platform, we will extend this to other bioactive compounds with proven commercial potential. These products will be made available to domestic and international markets through industrial partnerships and will elevate New Zealand's role as a provider of advanced biotechnology products and services.