MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

2016 Endeavour Round successful proposals

Smart Ideas

Organisation	Title	Duration (years)	Contract value (excl GST)	Public Statement*
AgResearch Limited	Plugging into electron flow in the rumen: developing a microbial fuel cell to control electron flow and direct rumen fermentation towards better ruminant nutrition	3	$1,000,000	Ruminant animals (cattle, sheep, deer, goats) are important to the NZ economy, providing much of our export income from their milk, meat and fibre products. Digestive processes in the ruminant are carried out by rumen microbes, and drive farm productivity. Rumen microbes cross-feed with each other in coupled reactions, where the fermentation end products of one microbe are used as the food for the next organism. It is assumed that the fermentation intermediates themselves act as the coupling agents between microbes, but recent genetic information from rumen bacteria suggest they use a different system called Direct Interspecies Electron Transfer (DIET), which involves electron transfer between microbes. DIET has not yet been demonstrated in the rumen, but samples of rumen contents inoculated into microbial fuel cells (MFCs, "microbial batteries") generate small electrical currents, indicating some rumen microbes can transfer electrons directly to electrodes. Furthermore, efficient DIET reactions have been shown to minimize methane production in MFC systems. In this project, we will make rumen MFCs that can measure the DIET that occurs between rumen microbes, and which can direct microbial electron flow to control rumen fermentation. Prototype devices will be tested in rumen simulations in the laboratory, and then inserted into sheep, to test their effects and safety in a living animal. We will measure the significance of ruminal DIET by monitoring the MFC current generated, and will apply small external voltages to the devices to examine the effect on the composition and total amount of rumen fermentation products formed. Conditions which favour the re-direction of rumen fermentation towards the nutritionally favourable product, propionate, will be optimized and used to design a device for commercialisation.
	World first proof-of-	3	$869,562	Agricultural pests cost New Zealand over $2-4 billion p.a. and new tools for managing them are urgently

	application of Trojan female pest control			needed to replace flawed pesticide-based approaches, and bolster plant resistance and classical biocontrol, which have important limitations. Trojan female (TF) pest control is an ingenious approach for controlling or even eradicating pests, conceived in NZ, which we propose to implement as a world-first proof-of-application. Recent modelling and laboratory research support its exciting potential for use in the real world. TF pest control involves breeding up females that carry natural mutations in their mitochondrial DNA which reduce male fertility, and releasing them back into wild populations 2. This simple intervention involves no genetic modification (GM). TFs survive and reproduce similarly to normal females, and persist across generations. However, their infertile sons mate with wild females, produce few offspring and reduce pest population fertility. Using TFs to control pests has unparalleled advantages including: controllability, species-specificity, persistence, zero-toxicity, non-GM, affordability, humaneness, social acceptability and efficacy. We propose to develop TF pest control to improve control of, and eventually eradicate, a pasture pest called clover root weevil (CRW), which causes $0.45 billion of economic losses to New Zealand each year. By the end of this project, we aim to be ready to implement TF control for CRW in the field, then afterwards to implement it in partnership with industry. TF pest control is applicable to numerous vertebrate and invertebrate species, and our proposed research will serve as the basis for TF control of many other pests.
Auckland University of Technology	Smart sensor design for high-quality, non-invasive, long term biopotential measurement	3	$999,000	There is a growing interest in sensing electrical activity of the brain and heart for rehabilitation, fitness, consumer electronics and long term healthcare. However, current sensors don't work long-term because they irritate skin, dry out or are very affected by movement. We will deliver sensors that solve these problems for existing products and open the way for new markets. For example: • Sensors embedded in clothing to detecting abnormal heart rhythms, or help with fitness training • Sensors in baseball-type caps to detect epileptic seizures, or provide accurate brainwave control of motorised wheel chairs, or even video games • Sensors that help with more effective rehabilitation from strokes Our sensor system relies on 2 new ideas not found in patent, scientific or product literature. We are a team of engineers, physicists, cardiologists, physiologists and Maori health researchers, who have previously commercialised novel medical technology and have support from potential NZ channel partners.

Institute of Environmental Science and Research Limited	Concurrently tracking multiple sources of water contamination using synthetic DNA tracers	3	$900,000	We will overcome a major barrier to improvement of water quality through developing a new, environmentally safe tool for tracking multiple water contamination source locations and pathways. At present, where water quality is impacted, it is only possible to trace the source location of the contamination one site at a time. For Councils to act rapidly and efficiently to require mitigation of water contamination, they need to be able to simultaneously identify which, of multiple potential sites, are putting contaminants into groundwater, surface water or soil. Our challenge is to develop a new generation of water contamination tracers that are environmentally safe, only required in microscopic quantities and can be used in all waters. These tracers will be detectable at considerable distances downstream from the application and will concurrently track multiple contamination sources. Our novel idea is to use synthetic double-stranded DNA which will remain detectable in surface-water and groundwater and also to encapsulate this DNA in a food-grade gel to ensure protection from degradation in the environment, while permitting detection. Synthetic DNA tracers will have no functionality i.e. have no effect on soil or water or organisms. There are existing, cost-effective methods to detect DNA in water. Once we have developed our new tracers, the team from ESR, University of Canterbury and the University of Calgary will first test them in controlled lab conditions. We will conduct field experiments at existing experimental sites in collaboration with ECan, the CAREX group and Waikato Regional Council. Field testing will be crucial to this programme and demonstrate we have developed a robust system for tracking water contamination. The tracers will have future applications in New Zealand where tracking of materials or ingredients is important. These include food security, protection of high-value goods, forensic, hospital, ecological and environmental investigations.
Institute of Geological & Nuclear Sciences Limited - Trading as GNS Science	Ion sources and silicon-28 islands for quantum bits	2	$1,000,000	Mobile phones, tablets and computers are reaching their limits regarding processing speed and power. Quantum computing is a new technology that promises to be faster by several orders of magnitude and will allow further size reductions. Parallel processing will be possible by exploiting quantum phenomena on a scale smaller than that of an atom. These phenomena are so sensitive that even the tiniest fluctuation in their surrounding can collapse their function. We can use this sensitivity to make communication secure – once encrypted signals are ‘touched’ we know they’re hacked! The unmet challenge is to create a material with literally no background noise in which the basic units of a quantum computer, called qubits, can be

				housed. The research leader Dr Andreas Markwitz, a Principal Scientist at GNS Science, and his team will develop new technologies and processes to create a material suitable for quantum computing. Our objective is to produce the world's first isotopically pure islands in silicon, the material of choice in today's microelectronics. Quantum computing is estimated to have a market value of US$5b by 2020, and our novel technology will create large opportunities for New Zealand business. We will create a new device that will fire 28Si atoms into native silicon to eliminate 29Si atoms that interfere in quantum computing. Our research will enable a new industry in New Zealand to build these devices, as well as manufacture and sell them to meet future demand for quantum computing base materials. We have teamed up with a world leading quantum computing group at the University of Melbourne, the world renowned magnet manufacturer Buckley Systems in Auckland and the New Zealand leading 3D metal printing development agency TiDA in Tauranga. Companies including high-value manufacturers, investors and Maori owned businesses in New Zealand, will benefit from this work by being partners in the supply chain.
Landcare Research New Zealand Ltd	'Biosecure-ID': Machine learning to automate image-based identification of species	3	$1,000,000	New Zealand's wealth and well-being rely on the quality of its natural environment. While primary production and tourism (our two largest economic sectors) depend on effective biosecurity, our productive and natural environments are under growing threat from introduced pest animals, weeds and diseases, due to global trade, travel and climate change. Our unique native species, including species important to Maori, are especially vulnerable to introduced pests. Rapid, accurate identification of pest species is vital for effective biosecurity, to prevent spread and minimise the high costs of pest control. Currently, identification of possible pest species by scientific experts is time-consuming and costly. Automated identification of species, based on images of their physical features, is emerging as a promising application of artificial intelligence, a state-of-the-art computer science technique. We will develop a prototype, image-based system for rapid, automatic identification of potential pest species in New Zealand. It will enable users to upload a photo online, and rapidly receive a species identification and information on whether it is a pest, or not.

				This ambitious project will use the latest advances in machine learning and automated image classification to develop a fully automated prototype system to identify any type of organism (e.g. fungi, plants, insects) and detect new species without complex manual engineering of the system for each different organism. In future, our prototype will be further developed into a rapid, easy-to-use identification tool, enabling more accurate, cost-effective border biosecurity. This tool also allows 'citizen scientists' to photograph and identify unfamiliar species they find, and help protect New Zealand's natural environment by alerting biosecurity agencies to any pest species identified.
	Optimal release strategies to maximise biological control: RHDV in rabbits	3	$750,000	Wild rabbits in NZ compete with livestock for grazing, and reduce vegetation and grass cover leading to soil erosion by wind and rain. High rabbit numbers cost the country tens of millions of dollars each year in control costs and lost production. In 1997 a virus, rabbit haemorrhagic disease virus (RHDV), was illegally imported into NZ to control rabbits and did very well - initially. But over time rabbits have become resistant and their numbers have recovered to damaging levels. From this release we learnt that timing of disease introduction and variation in rabbit population abundance and immunity across the landscape has a large influence on establishment and level of the disease. A new strain of RHDV is being considered for release. We aim to maximise the success of this and future releases to give better and longer-term suppression of rabbits. In both NZ and Australia, RHD regularly appears, causes an epidemic, then dies out in local rabbit populations. But it persists continuously at a larger regional scale (called a metapopulation) through virus-carrying flies transmitting the disease between local populations. We need to find out more about where, when and how far these fly vectors can transmit RHDV in NZ. We will use this information and that from our colleagues in Australia to build a NZ metapopulation model of RHDV. Our model will then be used to determine the best timing and spatial pattern of releases for an optimal release strategy for the new RHDV strain. An optimal strategy will give higher and longer-term rabbit population suppression, thus saving pastoral farmers and the country millions of dollars in lost production and control costs.
	Using genome mining to identify targets for developing species-	3	$1,000,000	Controlling possums is a national priority if we are to reverse the decline in native species and keep livestock TB-free. Landscape-scale control requires poisons, as trapping is too costly. However, current poisons, e.g. 1080 and anticoagulants are controversial due to risks to non-target species, environmental persistence and

	selective toxins			the potential for entry into the food chain. Using novel applications of innovative pharmaceutical technologies we will identify targets in the possum to which we will develop, for the very first time, possum-selective poisons that have little or no effect on non-target species. These toxins can be used in conjunction with current poisons, greatly reducing the amounts needed, and possibly replacing them altogether. As a consequence, the environmental impact of large-scale pest control operations will be markedly reduced, helping Predator Free NZ, Zero Invasive Pests and TBfree NZ to achieve their goals. Adoption of these improved, environmentally friendly poisons will enhance Primary Industry's sustainability credentials, enabling NZ producers to differentiate their products and potentially charge a price premium. These toxins will support tourism by safeguarding NZ's natural environment and biodiversity. In particular, taonga species of importance to Māori will be protected. Once possum poisons are developed, the new technology will be extended to other pests, such as rats and stoats. These safer toxins will be far more suitable than current poisons in sensitive locations such as processing plants, warehouses and schools. The project aligns with the Biological Heritage National Science Challenge, providing an essential research stream that the Challenge will leverage to achieve its goal of developing more effective tools to control predators.
	Wetland Assessment and Monitoring Tool (WAAM): pre-human baselines for assessing, monitoring and restoring New Zealand's wetland ecosystems	3	$1,000,000	Wetlands are valuable ecosystems, delivering ecosystem, biodiversity and cultural services valued at $US40–50,000/ha p.a. Despite their value, over 90% of NZ's wetlands have been destroyed since human settlement, and protecting remaining wetlands is a key conservation priority. However, protection and management of remaining wetlands is hindered by our current inability to accurately assess how modified a wetland is relative to its natural (pre-human) state. In this research programme we will develop a world-first tool for assessing the current state of a wetland relative to its long-term (past 2,000 years) history. We will use ancient DNA preserved in wetlands to elucidate the biota (including microscopic eukaryotes, invertebrates, plants and fish) that formed wetland communities in the past. We will link this information with radiocarbon dating, analyses of charcoal (from past fires) and element concentrations (to inform on factors such as sediment input) to create a historical picture of the range of natural variations in the past state of the wetland. This will be compared to the current state, and will provide a basis for ongoing

				monitoring using environmental DNA. Our 'Wetland Assessment and Monitoring Tool' (WAAM) will be used by local and central government, iwi, NGOs and industry to assess current wetland condition and inform policy and planning for wetland management. Better knowledge of the current state, relative to the historical state, will allow prioritisation of restoration activities in wetlands where relatively little effort is required to return or maintain a state similar to that in the past. We will introduce WAAM to international bodies involved with protection and management of wetlands, raising NZ's profile on the international stage for preserving biological heritage.
Lincoln University	Reducing environmental damage following urea application in pastures by using a bio-inoculant	3	$977,500	Nitrogen is a key nutrient for pasture growth, and is commonly applied as urea fertiliser. However, urea-nitrogen can be quickly lost from the soil system because of the activity of soil microbes which break down the urea, reducing the nitrogen available for pasture growth. Instead this nitrogen ends up as nitrous oxide (a greenhouse gas which contributes to global warming) or nitrate which, when leached from the soil, pollutes waterways, thus increasing environmental pollution by deteriorating water quality. Currently New Zealand farmers have access to a chemical which can delay urea breakdown in the soil but needs to be applied several times per year and is therefore expensive. We are taking a more environmentally friendly approach by suppressing soil microbes which are creating the problem. We have identified beneficial fungi which reduce the activity of the soil microbes, thereby reducing nitrogen losses, reducing environmental damage and increasing pasture production. Our research goal is to develop a cost-effective commercial bio-inoculant product that can protect our environment by reducing nitrogen pollution and sustainably increasing pasture production.
National Institute of Water and Atmospheric Research Ltd	Growth and productivity of fish populations in a changing world	2	$506,000	Fishing activity and climate change are having major impacts on marine fish populations in the world's oceans. However, it is difficult to determine just what impact each of these two factors is having, mainly because long-term observational data on the productivity of marine ecosystems is sparse. Our research aims to determine how growth in selected culturally and commercially important New Zealand fishes (snapper, tarakihi, hoki and ling) has varied over the last 50+ years. We will link this variation to past fluctuations in climate variables (e.g., sea surface temperature) and fishing activity (e.g., fish stock size, intensity of fishing). Determining what caused fish growth to vary in the past will provide insight to help predict fishery productivity under future regimes of climate and fishery exploitation. This predictive

				information can be incorporated in the scientific assessments of fish stocks, which are conducted regularly by the Ministry for Primary Industries, thus improving the quality of scientific advice and enhancing the management of New Zealand's natural marine resources. We will use existing fish otolith (ear bone) collections to determine past growth. Growth histories of individual fish will be constructed by measuring the widths of increments laid down annually in their otoliths, similar to the formation of tree rings. A year when the fish experienced good growth is marked by a relatively broad otolith growth increment. The data from each fish will be combined to determine population-scale growth patterns. These will be analysed alongside population trajectories from stock assessment, and globally available environmental and climate data.
	Using crustacean body chemistry to assess human induced impacts on seafloor environment	3	$861,000	The state and health of New Zealand's marine environment is paramount to our societal and economic wellbeing. Not only does New Zealand have vast marine resources, such as fisheries and economic deposits, but the oceans play an important part in New Zealand's traditions and culture. Of particular concern then, is any change to this environment brought about by human-induced (anthropogenic) activities. These changes can be from local activities, such as mining, trawling or coastal pollution, or from global impacts, such as ocean acidification. An important factor in being able to preserve our unique marine estate is understanding the chemistry of our marine environment and to be able to monitor any change that might occur. As crustaceans, such as crabs, shrimp, crayfish and lobsters, interact chemically with the environment around them the amount of potentially toxic trace elements they accumulate in their bodies reflects the composition of trace elements in their environment. Change the environment's chemistry, change the organism's chemistry. In this way they are direct indicators of the chemistry of the marine environment. For this research we will measure trace element contents in crustaceans throughout New Zealand's waters to provide present-day baseline values of trace elements in their environments. Future analyses of the same species from the same region can then be compared to this baseline to ascertain if any chemical change has occurred. This method also provides a means to test the quality of kaimoana, as any increase in toxic elements above natural values will affect the quality and heath of the food chain ultimately consumed by us.

New Zealand Forest Research Institute Ltd Trading as Scion	A new model for the rapid evaluation of reproductive control in conifers	3	$1,000,000	New Zealand's forest industry faces significant future challenges; the adoption of GE (Genetic Engineering) into the breeding programs of production forests overseas has given them a competitive edge over NZ in terms of productivity. NZ's forest owners are interested in deploying GE trees but require sterile trees to mitigate social and environmental concerns. The ability to control reproduction would both facilitate field-testing and provide assurance of genetic containment for commercial release of GE conifers. Moreover, reallocation of 5-20% of energy used for reproduction is expected to boost productivity. Studying reproduction in radiata pine is especially challenging as it takes 6 to 8 years to reach reproductive maturity. Conventional breeding is thus nearly impossible and obtaining research results would take over a decade. Additionally, there is no current model plant for conifers to test hypotheses on gene function and phenotype, unlike in angiosperm research. Our project aims to develop the first conifer high-throughput model system using the early flowering *Pinus densiflora* to enable rapid testing of biotechnology-based reproductive control strategies. Using biotechnology we will inactivate genes essential for reproduction to create 'knockout phenotypes'. We will use genome and transcriptome data to identify target genes which can prevent male and female reproduction simultaneously. This has never been reported for conifers. Deploying GE trees would be a significant step towards facing the industry's challenges. Using GE to develop trees with shorter rotation times, greater wood volume, and improved quality is predicted to add $6.5B to New Zealand's GDP by 2051, while the limited reproductive ability of the trees would provide unique benefits such as prevention of wildings and pollen dispersal.
	A novel biotech route to new biobased high performance engineering plastics	2	$1,000,000	Imagine that your next electronic device or new car contained plastic material manufactured in New Zealand from renewable materials. How will this be achieved? The *Bioinspired Aromatic Polyesters* proposal aims to develop microorganisms to mass produce aromatic polyesters. Petroleum is a major part of the chemical makeup of the vast majority of plastics. The new aromatic polyesters will not be derived from petroleum but will be produced by feeding microorganisms using a similar fermentation to that used for beer production. The polyester can be taken out from the microorganisms and refined for use in the manufacture of plastic products. Why the focus on advanced plastics?

				High performance, hard wearing plastic products are increasingly a part of everyday life because they allow strong, lightweight and robust objects to be manufactured. High-value electronics, aviation and automotive, industrial, medical and sporting goods all contain advanced plastic materials. Current drawbacks with advanced plastics are their high cost, due to energy intensive and difficult chemical syntheses. By developing a biotechnology route to aromatic polyesters this project aims to overcome high production costs and provides a renewable alternative. Success would lead to new opportunities to produce high performance plastics in New Zealand through biotechnology for domestic use and export, and provides manufacturers with new renewable plastic materials with enhanced properties from which to develop a range of lightweight products.
The New Zealand Institute for Plant and Food Research Limited	Elastomeric, conductive and functionalised electrospun nanofibres for high-performance anti-fouling microfiltration membranes	2	$1,000,000	Microfiltration is an important process in a wide range of liquid filtration applications in numerous industries including food and beverage and water/wastewater treatment. For example in the food and beverage industry, microfiltration is necessary for creating high-value products e.g. wine, beer, milk and its fractions, juices, oils and syrups. In the water/wastewater treatment industry microfiltration is used to pre-treat wastewater, in membrane bio-reactors, and to remove bacteria and algae or protozoans from surface water or contaminated water. However, one of the main problems with the application of this filtration technique is membrane fouling. Fouling is the deposition of retained particles, colloids, macromolecules, microorganisms, salts, etc. at the membrane surface and inside the pores. This severe problem reduces the performance and efficiency of membrane processes and limits their practical application. This can be minimised by periodical washing and cleaning with harsh chemicals, but that can be difficult, damaging, costly, environmentally harmful and sometimes impossible. The Plant & Food Research and The University of Auckland team is proposing an innovative approach for design and fabrication of ***stimuli-responsive microfiltration membrane*** with effective fouling control through dynamic surface features and targeted surface functionalities. These inbuilt attributes will significantly minimise fouling and facilitate membrane cleaning, thus reducing capital and operational costs while improving the regulatory compliance. Our success will contribute significant economic, social, cultural and environmental benefits to New Zealand's food and beverage manufacturers and water/wastewater processors. Beyond these direct

				benefits, the New Zealand economy will benefit through the export of high-value nanofibres and new membrane technologies. For more information please contact Dr Karimi (Samaneh.Karimi@plantandfood.co.nz) or Dr Larsen (Nigel.Larsen@plantandfood.co.nz).
The Research Trust of Victoria University of Wellington	Aptamers for customisable analytical devices: application to methamphetamine detection	3	$999,999	This project will pursue a novel way of creating customisable analytical devices and apply it for rapidly detecting and quantifying methamphetamine. Such technology is essential for improving road and workplace safety and assessing the need to remediate hundreds of contaminated homes. The analytical devices feature DNA aptamers, also known as synthetic antibodies, whose sequences are programmed to specifically recognise target molecules. This project features a novel method for rapid, high-throughput aptamer generation for use in analytical devices. The project will focus on qualitative colourimetric sensors for saliva testing, and a quantitative electrochemical device for detecting and mapping contamination in homes allegedly used as illicit drug laboratories. As well as helping New Zealand communities mitigate the ravages of methamphetamine, this project will also benefit New Zealand by developing high value analytical devices, including for other target molecules, through New Zealand company AuramerBio Ltd.
	Improving New Zealand's tax policy via international tax-transfer model benchmarking	3	$625,366	This project brings together researchers and tax policy officials in New Zealand and Australia to devise new ways of modelling taxpayers' behavioural responses when taxes and welfare benefits change, benchmark the models against each other and demonstrate how the resulting insights can be incorporated formally into tax/social policy advice. These behavioural responses have potentially large impacts on some key economic indicators (GDP, income inequality, tax avoidance, wellbeing). Better knowledge of their size and scope will substantively improve the reliability of predicted policy outcomes. Two behavioural modelling approaches will be developed for NZ. The first uses computer microsimulation techniques applied to the personal income tax and welfare benefit system to identify how labour supply will be affected when taxes and benefits change (e.g. as people move in/out of unemployment; work more/fewer hours). The models developed will include new outcome measures (e.g. impacts on overall social welfare) and new types of policy, such as government-funded childcare provision. The second approach measures *overall* taxable income responses (including tax avoidance), using econometric techniques applied to individual taxpayer records. It estimates taxable income responses: that

				is, how much taxpayers' declared taxable income changes in response to reforms to income tax rates, brackets etc. Both approaches will be formally benchmarked against similar Australian, and other countries', examples, with the objective of designing best-practice, robust methods. A third component of the project will demonstrate how tax and social welfare policy advice can be improved via application of the new models. This will include simulating how well (new) model-projected outcomes of past policy changes align with observed outcomes, and how these can best be integrated into future policy advice processes.
	Wave-guiding piezoceramics for high resolution medical imaging and non-destructive testing	3	$1,000,000	The multi-billion dollar ultrasonic imaging industry: medical ultrasound, ultrasonic testing, sonar, is based on piezoelectric ceramics. These piezoceramic transducers convert electrical pulses into acoustic waves and vice-versa, acting as both source and detector of high frequency acoustic pulses. For 3D imaging piezoceramics are processed to form 2D arrays of pillars using "dice and fill" machining: fine criss-cross saw-cuts in the ceramic wafer backfilled with epoxy. This machining limits imaging resolution and increases transducer costs roughly 100-fold, imposing a major barrier to wider application. Our research will develop a novel manufacturing process for piezoceramic wafers with an oriented-pore microstructure: a dense array of aligned micropores, running completely through the 1 to 2 mm thickness of the wafer. We aim to produce material with sub-micron pore size and pore spacing of around 10 microns, about 1/10th the thickness of an average human hair. Because the array of pores acts like a wave-guide for ultrasonic pulses, 2D array transducers can be fabricated simply by plating with an electrically conducting electrode pattern with no need for machining. This simpler manufacturing process is a potential game changer. A finer scale of the array of pores means higher frequency acoustic pulses can be generated and detected, producing higher resolution images than is possible with "dice and fill". Our oriented pore piezoceramic process has been conceived with scalability to industrial manufacture "designed-in". Benefit to NZ will come from manufacture of oriented-pore piezoceramic wafers for export to a global market and their early adoption by the New Zealand high-technology ultrasonics manufacturing sector.

University of Auckland	Fundamental redesign of percutaneous drains for effective drainage and reduced infection	2	$999,870	Abscesses, which are collections of infected fluids in the body, are becoming more common with the rise of diabetes and antibiotic resistance. Traditional treatment is by open surgical drainage to allow the pus to drain out, and involves a wide incision which can make patients sicker, the risk of collateral damage and leaves an open wound. There is a move to less invasive approaches that pass a catheter drain through the body wall for external drainage, but these drains were not designed for purpose and commonly fail. Our critical review of these catheter drains has identified several fundamental design issues that could dramatically improve their efficacy and scope of use. This innovative research programme will be conducted by an expert multidisciplinary team to develop a new drainage catheter product range that will address deficiencies, provide new solutions for a global market, improved health outcomes, and economic benefits by commercialisation, employment and manufacture in New Zealand.
University of Canterbury	Autonomous forest pruning and data collection of tree metrics	2	$1,000,000	This programme will develop a NZ-manufactured and exported UAV capable of autonomously pruning forests. As early adopters and benefactors of the technology, the New Zealand forestry industry will gain increased productivity and product quality, resulting in increased timber export revenue of more than $144m p.a. Export of the UAV pruner technology is estimated to generate $38m p.a. in foreign exchange within ten years of market entry.
	A Neuromorphic computer chip: Computational hardware that works like the brain.	3	$1,000,000	The human brain is incredibly efficient in performing certain extremely complex tasks, such as image recognition, that are extremely difficult to implement with standard computers. It has recently been demonstrated that computers that emulate the way the brain works can perform complex image recognition tasks in real time, but this great success requires dedicated supercomputer facilities costing ~$100M. While the architecture in such a machine is new, it is still based on traditional CMOS circuitry, requiring a large number of transistors to emulate each synapse, and is a long way from the ultimate goal of building architecture similar to the human brain, in which neurons and synapses are self-assembled to allow brain-like functionality. If such neuromorphic behaviour can be achieved within a single chip it could revolutionise certain kinds of computing, and provide a step change in image recognition technologies, because such hardware implementations are intrinsically much faster and more efficient. While applications in other market

				segments are also potentially very important, we focus here on the potential for enhanced image detection and related pattern recognition tasks because of its importance to many New Zealand stakeholders. Our vision is to create a new company, NeuromorphNZ Ltd (NNZ), which will become the world leader in the fabrication of neuromorphic computer chips. NNZ's core business will be to build the neuromorphic component deposited on CMOS chips. By designing the input/output layers of the chip in standard CMOS technology, and outsourcing production overseas, NNZ maximises the leverage of its core intellectual property and minimises the need to develop expensive technologies that are the core business of large international semiconductor companies. NNZ will work with NZ companies in the image/pattern recognition space to develop prototypes and provide opportunities for those companies to compete internationally. The company will also leverage a strong intellectual property portfolio to license the technology to overseas manufacturers in other applications.
	A new route to high-purity Titanium: Ultra-high-temperature electrolytic production of titanium from waste slag	2	$1,000,000	Titanium metal is used in a broad range of applications and in New Zealand high purity powdered titanium is used for 3D printing (additive manufacturing) components such as medical implants. New Zealand does not currently have the capability to manufacture titanium metal, which means that companies such as Tauranga-based Rapid Advanced Manufacturing and Auckland-based Zenith Tecnica must import their precursor titanium powders. Our research proposal is to tap into the vast quantities of titanium rich waste material that are produced as a by-product of NZ Steel's steelmaking process. Specifically, the game changing opportunity is to use the waste material directly from the process in its molten state at approximately 1750 K, and electrolytically separate the titanium metal, in a similar way to the production of aluminium at New Zealand's Aluminium Smelters at Tiwai Point. Initially the project will focus on producing small quantities of high-value, high-purity titanium for powder production to supply New Zealand's burgeoning additive manufacturing market, while the ultimate goal is to capture a share of the massive and rapidly growing international demand for high-purity titanium. A technology such as this has the potential to create jobs, to reduce our dependence on imported titanium by supplying all of our domestic needs as well as to establish a healthy export revenue stream. Furthermore, titanium extraction from ironsand slag will inevitably add value to ironsands developments by extracting

				greater value from a natural resource which will provide opportunities for the people of Ngati Hikairo, Ngati Mahuta and Tainui waka.
	Development of a solar redox flow battery for direct solar energy capture and storage	3	$1,000,000	Energy supply and demand is a global problem. Addressing this problem in parallel with the issues associated with climate change is an enormous challenge. We propose an entirely new approach to solving this problem: The development of a battery which directly captures and stores solar energy. The key to this new battery is that we will use the sunlight's energy to transfer electrons between metals dissolved in a solution and the low-cost electrodes which we will develop. The benefit of this approach is that we no longer will require separate solar cells and batteries to store up solar power for later use. In effect, our technology "removes the wire" between solar cells and battery systems. These batteries will be primarily developed to store solar energy for residential-scale applications. A secondary useful feature of the technology is that hot-water can be simultaneously generated by the battery system, thereby increasing the overall energy efficiency of the battery.
	Maximising genetic diversity in endangered species: a conservation genomic approach	3	$1,000,000	Conservation managers strive to prevent the extinction of endangered species and to restore the species' roles as functional parts of natural ecosystems. A critical goal of recovery programmes is to ensure endangered species retain sufficient genetic diversity to adapt to environmental change. Where recovery programmes use captive management to recover wild populations, selection of appropriate breeding pairs is vital, as unique genetic diversity may be held in only a few, easily lost, individuals. Current selection methods rely on robust pedigrees that are almost never available, or genetic-based measures of relatedness that are inadequate. Globally, there are 400+ captive breeding for release programmes including over 20 in New Zealand. Our project will provide conservation managers with a forward-thinking, cost-effective and rapid conservation genomic approach that will enable them to pair unrelated captive individuals with confidence. Applicable to a wide range of endangered species, our Proof of Concept will demonstrate the most efficient approach for making effective captive pairing decisions is to combine low coverage high-throughput sequencing with an innovative reference-guided approach to generate genomic-based measures of relatedness. The establishment of a multi-stakeholder end-user working group consisting of leaders in the national and international conservation community, including relevant iwi and iwi trusts, will ensure the project is

				responsive to diverse end-user needs. A commitment to retain the whakapapa of Aotearoa's taonga species is at its core. This highly skilled group will enable the adoption of our conservation genomic approach as best practice by the Department of Conservation and promote its rapid uptake by equivalent agencies overseas. By fundamentally changing the way we manage our natural capital, New Zealand's reputation as a world leader in evidence-based conservation management will be enhanced.
University of Otago	enGAGing the brain; sugar-coated clusters as potent drugs to restore brain-function	3	$1,000,000	Stroke is the leading cause of lasting impairment and can affect anyone at any time. Until recently the brain was thought not to recover following a stroke. However, we have previously shown that if the right treatment is given at the right time following a stroke, significant improvements in motor and cognitive function can be achieved. This three year Smart Idea project, under the leadership of a stroke biologist at the University of Otago (Dunedin), brings together leading experts in chemistry from the Ferrier Research Institute (Victoria University of Wellington) and KODE Biotech (Auckland University of Technology), and biomaterials experts at the University of Otago (Christchurch). Their common goal is to develop novel treatments to improve function following brain injury. This research builds on our team's ability to greatly simplify the synthesis of novel compounds capable of targeting any part of the brain extracellular matrix; the glue that holds all brain cells in place, vital to brain health. The team will use an iterative, smart design approach to develop and test a range of potential drugs to help patients recover from stroke. Such novel compounds have wide-ranging potential as they have the ability to modulate many biological and physiological processes in the brain. So beyond holding great promise for treatment of stroke, in the future they may aid in improving outcomes for numerous other neurological conditions. For more information: andrew.clarkson@otago.ac.nz
	Intelligently deformable skin penetrating nanoparticles for drug delivery through skin	3	$933,037	This project will revolutionise the treatment of strawberry birthmarks, and other related disfiguring conditions, such as keloid scars, by developing an effective topical treatment based on novel drug-delivery technology. The new technology involves deformable skin penetrating nanoparticles loaded to transport bioactive agents through skin directly to the affected site. We believe this new technology, which we affectionately call "Squish", will stimulate a high-profit, technology-based pharmaceutical product enterprise that will occupy niche markets in the global pharmaceuticals industry.

	"Silverbone" - Otago's nano-silver technology plus NZ-manufactured bonegraft produces unique antibacterial biomaterial	3	$999,804	Bone grafting is often required when replacing damaged hip- and knee joints or replacing teeth that have been lost. Subsequent inflammatory disease around artificial joints or titanium dental implants or teeth may require additional bone grafting. Bone grafts may come from the patient themselves, which requires an additional surgical site and carries the risk of further complications. Alternatively, the surgeon may use use artificial bone grafting substitutes. Bone graft substitutes are commonly sourced from animal bone, particularly treated beef bone, which is known as bovine bone xenograft, or BBX. Infection of the bone-grafted site is a frequent complication, and there are increasing problems with bacteria resistant to the antibiotics used to prevent or treat these infections. Metallic silver is an alternative approach to killing bacteria that avoids the problem of antibiotic resistance. Otago University has developed a nanoparticle medical technology that uses tiny particles of silver to prevent bacterial infection. Our new product SilverBone combines nano-silver with BBX grafts produced by a New Zealand firm from New Zealand beef bone, resulting in new bone grafting materials that are resistant to bacterial infection. These will encourage bone growth and repair when used in patients undergoing orthopaedic or oral surgical treatment.
University of Waikato	Tipping-point responses of coastal primary productivity to projected ocean acidification scenarios	3	$999,960	Globally, the effects of elevated atmospheric CO2 (driving ocean acidification) on coral communities, and increasingly, shellfish aquaculture, are of prominent concern. However, very little is known about the response of microbial communities to ocean acidification, despite their critical function in regenerating the nutrients that sustain food webs. Substantive changes to coastal microbial functionality as a result of ocean acidification have the potential to significantly affect primary productivity and communities that rely on this productivity—including wild fisheries, aquaculture, as well as people and tangata whenua that value kaimoana. This research will provide some of the first insights into future coastal ocean responses to elevated CO2. Using a combination manipulative laboratory experiments, targeted sampling in the field, and sensitive DNA-based analyses, we will determine how the microbial communities will respond, the effects on sediment nutrient generation, and the resilience of the microbial community to ocean acidification. The results will be provided in a form that will add to urgently needed input estimates to marine productivity models that are critical to sustainable coastal resource management. This project will be the first to identify and test bioindicators that can assess change and resilience in coastal ecosystems.

MINISTRY OF BUSINESS, INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI

Research Programmes

Organisation	Title	Duration (years)	Contract value (excl GST)	Public Statement*
AgResearch Limited	Capturing the true value of NZ meat: Objective measurement of meat quality in beef, lamb and venison	5	$4,250,000	NZ meat has an excellent reputation in the international marketplace, with our animals being largely raised on grass-based pastures in extensive production systems. Other related extrinsic factors such as our clean, green image form an important part of our meat value proposition. However, NZ's ability to leverage our unique position is dependent on the ability to measure, improve and market the positive intrinsic quality benefits of NZ meat products. Given that no suitable sensor-based system for routine meat quality measurement exists, this is currently impossible. We therefore propose to transform the industry through development of a platform of sensor technologies that can measure the nutritional composition and structural properties of meat products at processing. This system will enable the meat value chain to target consumer demand by leveraging both extrinsic and intrinsic meat quality information to aid consumer purchase decisions. We will therefore lift the quality and value of NZ meat and enhance its reputation. There is evidence in many of our key export markets that consumers are willing to pay a premium for high-quality meat products. Successful outcomes from this research are estimated to capture significant additional export revenue, around 80% of which will be captured by NZ farmers and meat processors. This collaboration brings together key capabilities and resources required to achieve a transformational change in the way meat is evaluated, marketed and produced. Together we will undertake the essential research and development required to shift NZ meat products from commodities to meal components to re-define NZ's position in the production of high quality meat products.
	Evaluating the potential of forages with elevated photosynthesis and metabolisable energy	5	$10,000,000	This programme will develop a transformational technology for NZ's pasture based livestock feed supply. High metabolisable energy (HME) is a novel trait that enhances photosynthesis in plants with C3 photosynthetic systems including our most economically important species, perennial ryegrass. Genetically modified (GM) ryegrass plants expressing the HME trait have 10% more metabolisable energy via the accumulation of foliar lipids, a 40% increase in growth rates and increased water use efficiency. The

				increased plant lipids provide significant animal nutrition benefits, improving the energy balance in the diet. Modelling and supplemental feeding experiments indicate this would increase animal productivity, improve fecundity and decrease environmental impacts. Animals fed this diet would produce less urinary nitrogen reducing runoff into waterways, a 20% decrease in nitrous oxide and 30% decrease methane emissions providing farmers with a valuable greenhouse gas mitigation tool. HME ryegrass has enhanced root systems, improved water use efficiency (WUE) and drought tolerance, therefore farmers on non-irrigated land will have access to a more reliable feed supply reducing reliance on brought in feed. The value to NZ's economy is estimated to be $2B-$4B p.a. This research programme has industry support and co-funding to investigate biological aspects of HME ryegrass including increased photosynthesis, altered nitrogen metabolism and WUE using controlled environment experiments. This will guide separately funded US-based field and animal nutrition trials and enable NZ to have an informed discussion on the costs and benefits of conducting similar trials locally.
Cawthron Institute	Improving Chinook salmon feed efficiency for industry growth	5	$12,854,857	A successful fish must be able to feed, swim and survive. Farmers are concerned with fish growth rates, how efficiently they convert feed into weight gain (feed conversion efficiency (FCE)), and how much waste they produce. These factors make a big difference to the economic bottom line and to environmental sustainability. Feed is the largest cost of production, so knowledge about FCE and the underlying biological processes that determine it are extremely important. We will develop new tools to fully understand and improve the FCE of Chinook salmon for social, economic, cultural and environmental benefit. The will enable significant industry growth. Chinook salmon is a high-value, premium quality product that generates significant regional employment and export revenue for NZ. Chinook salmon have been farmed in NZ for decades without fully understanding what influences the wide range in FCE of farmed individuals or capitalising on the individuals best at converting food into weight. Genetics plays a role, but does not explain all the differences in FCE, which are influenced by multiple factors, such as behaviour, nutrient retention, or gut bacteria that affect digestion and health. This study will identify the biological mechanisms influencing FCE using an innovative and customised Chinook salmon FCE toolkit. The FCE toolkit will ultimately allow industry to understand what influences FCE on the farm and breed for improved FCE. This knowledge will improve husbandry, health and fish quality, while reducing

				environmental impacts. The FCE toolkit will revolutionise the farming of Chinook salmon and will be widely adopted within NZ, with potential for uptake by the international aquaculture sector.
	Novel farming systems enabling multiple shellfish species culture in open ocean sites	5	$5,303,458	New Zealand has over 10 000ha of water-space consented for aquaculture, between 8 - 12km from the coastline, offering the potential to dramatically increase NZ's aquaculture production. However, aquaculture is challenging in the harsh environment of the open ocean. The high energy environment is very demanding on equipment and can significantly reduce production and increase costs. If the maintenance costs of open water farming were minimised, and production efficiency increased, NZ could effectively double its shellfish production resulting in ~$300M of exports and thousands of direct and indirect jobs. This programme will design revolutionary new flotation and mooring systems to facilitate shellfish aquaculture in the open ocean and enhance productivity in this environment. An experienced international multi-disciplinary team has been assembled, led by the Cawthron Institute in Nelson, and will work together with the NZ aquaculture industry. Concepts will be developed and tested as scale models in wave and flume tanks in Germany using unique equipment not available in NZ. Initial testing will ensure prototypes are fit for purpose before open water testing. Prototype systems will be built, loaded with shellfish and deployed with weather and hydrology monitoring buoys at selected offshore sites for testing under real-world conditions. Structural performance will be monitored alongside biological productivity, adapting the structure to the shellfish and the shellfish to the environment. Success with the prototypes will result in industry confidence, subsequent investment and expansion of the industry to deliver aquaculture products NZ can be proud of.
Institute of Geological & Nuclear Sciences Limited - Trading as GNS Science	Diagnosing peril posed by the Hikurangi subduction zone: New Zealand's largest plate boundary fault	5	$6,497,375	Faults that accommodate "subduction" of one tectonic plate beneath another plate produce the largest earthquakes and tsunami on Earth, as tragically demonstrated by the 2011 Magnitude 9 earthquake and tsunami in northern Japan. Offshore of the east coast of the North Island, the Pacific Plate subducts beneath the North Island along the Hikurangi subduction zone. This feature is New Zealand's largest and fastest-moving plate boundary, and poses a significant hazard to New Zealand. Knowledge of the subduction zone's potential to produce damaging earthquakes and tsunami is needed to improve plans to mitigate the hazard it poses. This project uses offshore and coastal geological and geophysical data to reveal the history of past

				earthquakes on the Hikurangi subduction zone, and the modern-day fault slip behaviour of the offshore portion of the plate boundary where tsunami are typically generated. Matauranga Maori will help to discern the human impacts from past Hikurangi earthquakes. Critically, this project leverages a suite of major, internationally funded experiments (totalling 25-30 Million NZD) planned at the offshore Hikurangi subduction zone to reveal the physical mechanisms that control subduction earthquake occurrence. We will provide a scientific base for assessments of hazard, risk and potential losses due to great earthquakes on the Hikurangi subduction zone. This will lead to better informed decision making by asset and insurance managers, and help guide engineering practices to mitigate risks and reduce the costs of economic recovery following a major earthquake. Research results will inform improved tsunami evacuation procedures. New seafloor monitoring capabilities will give New Zealand the tools needed to eventually progress to an earthquake and tsunami early warning system, similar to those being developed in Japan and the United States.
Landcare Research New Zealand Ltd	Building resilience and provenance into an authentic Māori honey industry	5	$4,500,000	Manuka honey is a high-value export product, with high potential for further market growth. Other New Zealand honeys, such as rewarewa, also offer promise to lift the economic value of Māori-owned land. We will partner with Māori agribusiness to develop a comprehensive model (‘The Honey Landscape’), to increase production of native honeys and improve their value, as well as more sustainably manage the honey resource. The model will be at a scale relevant to Maori landowners, incorporating both novel science and tikanga Māori to ensure uptake. The model will optimise hive placement across the landscape, resulting in a drop in the number of hives that fail to produce enough honey to be economically viable. In addition, we aim to grow the range of high-value native honeys by exploring the chemistry of other native species, where preliminary research has shown good potential to develop value-added natural products from native honeys. Linking whakapapa (interconnectedness) with the genetic provenance of the plants used to produce honey will create unique value in export markets, differentiating NZ native honeys from Māori land and securing premium value from natural, rather than plantation, manuka honey. This is a partnership driven programme, jointly designed with our Maori agribusiness partners to ensure it is fit for purpose. A key indicator of success will be the Maori agribusiness partners being able to tell their own story of economic and cultural benefit, strengthened with well-focused and relevant science. The rapid economic benefits we expect to

				deliver to our partners through this work will support this.
	Innovative ways to reduce farm nitrogen losses by manipulating carbon inputs	5	$7,301,000	Water storage schemes to provide irrigation have the potential to transform dry, eastern areas into highly productive farming regions with many associated economic and social benefits. However, as these soils are typically shallow and stony, irrigation and nitrogen inputs need to be managed carefully to avoid increases in greenhouse gas emissions and decreases in groundwater quality below certain standards. This is to ensure healthy rivers and lakes and to meet cultural expectations of Maori to sustain their relationships with te taiao (natural environment). Innovative on-farm solutions are needed urgently to enable conversion of dryland areas to be farmed intensively and profitably while managing potential adverse environmental effects. In a novel research programme, for the first time in stony soils, we will investigate the biological processes that modify both soil carbon and nitrogen cycling, leading to nitrogen leaching and gaseous losses. To do this, we will experimentally manipulate carbon inputs to soils, measure the impacts on nitrogen losses, and use molecular techniques to reveal the biological drivers. We will use this new knowledge to inform farm nutrient budgets and demonstrate improved management practices that farmers can apply to reduce nitrogen losses. As a result, the farming sector will have improved ability to operate profitably within the limits set by regional councils for nitrogen leaching. Our research will contribute to the government's 'export double' and water quality goals while reducing environmental risk by improving water quality, increasing soil biodiversity, and reducing greenhouse gas emissions.
	Integrated research and tools for wilding conifer management and ecosystem restoration	5	$14,000,000	Introduced conifers are the backbone of commercial forestry in New Zealand, worth ~$5B a year. However, invasion by wilding conifers is arguably New Zealand's most serious and intractable weed problem. Wildings are thought to occupy ~1.8 million ha and may invade 20% of our total land area within 35 years. Wildings have profound impacts on our national biological heritage, ecosystem services, economy and cultural values. As a result, land managers, government agencies and community trusts collectively spend over $11M each year managing wildings. Despite these efforts, the area invaded is increasing by ~6% per year. We are now at a critical juncture: more management may not accomplish long-term or large-scale gains in control of wildings or maintenance of our biological heritage. A smarter, more cost-effective approach to wilding

				management is now urgently needed. This research aims to resolve where and when management can minimise the spread and negative impacts of wilding conifers, while minimising costs. We will combine research on invasion dynamics and management interventions to ensure future management efforts can slow or reverse wilding conifer invasion by 1) increasing the effectiveness of wilding control through early detection, 2) maximising gains in biological heritage and ecosystem services from wilding management, and 3) forecasting the optimal combination of current and future interventions to achieve desirable long-term outcomes while minimising costs and negative impacts of both invaders and their management. We will work closely with on-the-ground operations and across government to stop the accelerating impacts of wildings across New Zealand.
	Science to underpin next-generation S-map and smarter land management decisions	5	$9,250,000	Soils are one of NZ's most valuable and strategic resources, but they are highly complex and variable. Better soil mapping is required to enable more informed decisions to be made on efficient irrigation, how to optimise use of marginal land, and what nutrient leaching mitigation options are relevant to this soil. The *S-map Online* website already provides access to NZ soil information, being widely used by farmers/growers, advisors, industry bodies, and councils. However, the majority of NZ is not yet mapped. There is an urgent demand from industry for cost-effective extension of mapping coverage, as well as more accurate, fit-for-purpose, multi-scale soil information on soil hydrological properties and their dynamic response to land management. To meet this need we will undertake the research required to create next-generation *S-map*. Interactive and dynamic tools will be incorporated into *S-map*, allowing a greater range of soil information to be provided, and enriching *S-map* with site-specific data. This research will substantially reduce uncertainty in soils information and guide decision-making to enable farming within environmental limits. The benefits of this include increased regional economic growth and Maori land productivity; informed irrigation development; better nutrient management, and avoided environmental costs.
	Security for iconic species: kiwi rescue	4	$3,600,000	Despite decades of management and research by agencies and communities, kiwi populations are still at risk from predation by stoats, ferrets and dogs, and the tools available for controlling pests and counting kiwi are inadequate. As a result, kiwi are still declining nationally, although the rate of decline is uncertain, and it is

				not clear exactly how many species there are. Some of these issues are shared by other iconic mainland birds, like takahe, weka, and penguins. We will work together with DOC, Kiwis for Kiwi, Maori and community groups to make new, cost-effective tools that help everyone to help kiwi. We will work with tangata whenua to identify kiwi on their land, to help their land management and restoration decisions. We will ask whether current science, modelling and monitoring techniques meet their information needs, and if not, derive new tools that do. Working with DOC and Kiwis for Kiwi, we will clarify how many kiwi species there are, develop new DNA-based techniques to estimate kiwi population size from feathers and scats and identify predatory dogs, stoats and ferrets at the individual (not just species) level. We will assess impacts of cats on the little-understood Rakiura tokoeka kiwi at Stewart Island, and help achieve approval of new, experimental meat baits that target stoats. To weave these strands together, we will model cost, social and regulatory factors that determine the feasibility of current and new management options. Together, these diverse advances and new tools will help DOC, Kiwis for Kiwi, Māori and other involved communities recover kiwi populations faster, more cheaply, and across more of Aotearoa/New Zealand.
	Soil ecosystem health and resilience – a pathway to prosperity and wellbeing	5	$7,500,000	Healthy soils are essential to sustain primary sector production and unlock the potential of Maori land, but pressure on NZ soils is increasing under agricultural intensification and land use change. In response, the Crown has set a national goal of healthy, resilient soils by 2020. To achieve this, a unified national framework to monitor and enhance *long-term* soil health and resilience is urgently needed. NZ currently lacks agreed ways to assess long-term soil health and resilience that can be easily used by primary industry, landowners, iwi/hapu, and central and local government. Current soil health measures focus on short-term soil characteristics, and do not include resilience or Maori values. Using innovative methods, we will test long-term land use sequences on different soils to determine if land use intensification affects soil characteristics thought to be stable over human lifespans. Understanding whether soils are subject to thresholds from land use intensification, beyond which they change abruptly, is key to assessing long-term soil health at local, regional, and national scales and achieving a step change in managing soils to maximise resilience. We will define long-term soil health from a Maori perspective and integrate cultural value systems with

				western science to deliver a nationally consistent universal soil health framework for use by primary industry, landowners, iwi/hapu, and central and local government to enhance long-term soil health and resilience. This research will ensure landowners can increase the productive capacity of soils while operating within environmental limits and meeting community and market expectations.
Lincoln Agritech Limited	A sensor and model-based analyser for blockscale grape yield prediction	5	$5,986,600	New Zealand's wine industry is a star performer, growing export revenues year on year. One of the risks to the industry is oversupply, which pushes prices down as bulk wine is released to the market. Management of wine supply remains challenging for the industry, as current models of grape yield deliver poor predictions (+/- 33%). Improvements in yield prediction for vineyards during grape growth can also accrue through improving crop management (e.g. accurate scheduling and scale of defoliation or grape bunch removal). This research programme will provide the tool needed for grape yield forecasting and thus wine supply and grape crop management during the growing season. It will build on the existing expertise of the team from Lincoln Agritech, Lincoln University, Plant and Food Research, University of Canterbury and CSIRO (Australia), as well as undertaking challenging research in predictive modeling. The team will develop a Grape Yield Analyser, which comprises sensors to identify quantities and volumes of flowers, grapes and onset of grape ripening, working with Sauvignon blanc and Pinot noir varieties. This data will be compiled in a novel analytical framework that generates yield predictions and can continuously improve the accuracy of its forecasts, reducing the error rate to +/-10%, as new location-specific data continues to be added during each season. Through the new grape yield technology, this programme will assist an already successful wine industry to increase its productivity by growing more and better quality grapes through advanced canopy management. Site specific yield prediction will improve efficiency by reducing labour costs, increase export returns and will also assist growth in New Zealand's high value manufacturing sector through export sales of the Grape Yield Analyser product.
National Institute of Water and Atmospheric Research Ltd	Are we there yet? Sustainable co-management and restoration of	4	$4,554,920	Cultural Keystone (Taonga) Species are fundamental in the customary practices and identities of communities. Their distribution and abundance are declining, altering the socioecological systems they support. Indigenous communities must be actively involved in the management of Cultural Keystone Species to balance competing values, needs and opportunities. This approach will open cross-cultural lines of

	Cultural Keystone Species			communication, increase the capacity and capability of resource managers, which in turn will optimise the recovery of Cultural Keystone Species. This programme will use multidisciplinary approaches to consider how processes acting across multiple spatiotemporal scales jointly influence the dynamics of tuna (freshwater eels), koura (freshwater crayfish), and kakahi (freshwater mussels) populations, focusing on critical knowledge gaps related to juvenile life stages. New, more holistic, statistical techniques will be developed with the ability to bring multiple knowledge systems together to inform Cultural Keystone Species state and temporal trend analyses and meaningful State of the Environment reporting. The development of cross-cultural approaches that engage our communities, and recognise and empower both matauranga Maori and science-based knowledge systems is critical for improved freshwater decision-making in New Zealand. This programme will develop frameworks that facilitate dialog and exchange of information between knowledge systems to support the diagnosis of complex problems and the development of context-specific interventions for the effective co-management and restoration of Cultural Keystone Species.
	Maximising the economic benefits of irrigation through dynamic, high-resolution weather forecasting	5	$4,750,000	Expansion of irrigation merely through increasing water abstraction is coming to an end. The future is about making better use of available water. This is a result of abstraction limits, high capital and operating costs of new supplies and the effects and costs of inefficient water application, including degraded downstream water bodies and contaminated groundwater. Our approach is to support farmer decision making by providing carefully customised information on current demand and future supplies (e.g., forecast rainfall) via an online farm-scale system. We aspire to help farmers apply irrigation 'justifiably'. JI will address the question of maintaining farm productivity, as influenced by irrigation practices, based on advanced, high resolution weather forecasts. We envisage a future where farmers actively manage irrigation, applying precisely the water needed—when, where and how much. As a consequence, farmers will increase yields, reduce costs (fertilizer, energy) while environmental flow, water quality and nutrient leaching targets are met. Motivation for uptake of JI is through both the need to reduce direct costs and to comply with increasingly stringent planning rules. Our continued liaison with leading industry partners (DNZ, Fonterra, INZ) and

				programmes such as the SMART Irrigation led by INZ will be key to future uptake. Our programme will use a collaborative (co-innovation) approach that brings together multiple stakeholders with diverse perspectives on water management including Maori owned farming enterprises. JI will enable farmers to optimise economic (profit) and environmental (farm footprint) outcomes and provide evidence of efficient water use to domestic and overseas markets.
	Moving from limiting fisheries juvenile habitat bottlenecks to open high production pipelines	5	$6,500,000	New Zealand's coastal finfish fisheries are now largely fully exploited, and under increasing pressure as human populations expand; both directly (harvest) and indirectly (e.g., fishing seafloor impacts, sedimentation). For species with specific juvenile habitat associations (e.g., snapper, blue cod, tarakihi), evidence is accumulating that biogenic (living) 'habitat bottlenecks' occur, and limit juvenile fish numbers. These habitats include subtidal seagrass, horse mussel beds, and sponge gardens. All have been adversely affected by marine and land-based activities. We will identify and promote actions and programmes to reduce/remove these bottlenecks, fundamentally increasing the number of small fish growing into the adult population and associated fisheries. We will use surveys and experiments to learn how these bottlenecks work (effects on juvenile survival and growth), how fish behaviours respond (e.g., snapper and tarakihi social hierarchies, blue cod territoriality—who gets the best real estate?), where they occur, their links to adult populations, and what threats and stressors affect them. We will also assess whether areas currently closed to protect fisheries habitats (e.g., Separation Point) are functioning as intended. We will use a predictive life history 'simulation model' to run 'what-if' scenarios of different management strategies to identify the best ones. Two Technical Advisory Groups of Maori, resource managers and other end-users will guide this process and agree on real-world strategies to implement. These when implemented will over time significantly increase fishery yields, as well as fundamentally increasing ecosystem productivity and biodiversity.
	Overcoming dispersal and recruitment constraints on native freshwater biodiversity	5	$7,275,000	Enabling ecologically sustainable water resource use is a key challenge for New Zealand. Land use change and human infrastructure in and around waterways can disrupt the movement of organisms between environments used by different life stages, and degrade critical habitats, preventing successful completion of life cycles. These disruptions to connectivity and habitat reduce the resilience of freshwater communities to other environmental disturbances, such as floods, pollution events or climate change. In combination, these

				pressures greatly contribute to declines in macroinvertebrate biodiversity and the abundance of iconic fish, such as whitebait species, which are regarded as taonga by Maori and indicators of healthy waterways. Understanding how species respond to human impacts is fundamental to resolving the challenge of maintaining resilient aquatic ecosystems. This project will improve the biological integrity of threatened ecosystems and species in modified landscapes. This will be achieved by identifying habitat and connectivity bottlenecks that limit dispersal and recruitment in fish and macroinvertebrate populations, and by providing guidelines on practicable solutions to overcome these constraints. The guidelines will incorporate improved understanding of the abilities of exemplar species to move between critical habitats, and how to mitigate human alterations to river habitats that impact on reproduction and colonisation success. These tools will inform effective and efficient restoration, protection and maintenance of ecosystems in modified landscapes. This help will sustain our aquatic fauna and the ecosystem services they provide to people.
	Resilience of deep-sea benthic fauna to sedimentation from human activities	5	$3,748,110	The aim of the proposed research is to assist the development of a new and valuable deep-sea minerals industry in New Zealand. Uncertainty about the potential environmental effects of deep-sea mining is currently impeding this development, this research is to determine the effects of sedimentation on deep-sea faunal communities caused by human activities such as seabed mining. It will, for the first time in New Zealand, combine *in situ* observations on the effects of sediment deposition with laboratory-based experiments. Areas of the seabed will be subjected to disturbance and effects on seabed animals at these sites will be determined by a range of vessel-based surveys. Sampling will be repeated over time to determine which seafloor communities are more affected than others, and whether species and communities can recover over time. The suspended sediment flow from the disturbance will be monitored to refine sediment plume models, which are used to predict the likely extent of impacts from sedimentation, and are a key component of environmental impact assessments. Laboratory experiments will use live deep-sea coral and sponge species to determine their resilience to levels of sedimentation typically generated by mining operations. The study will help establish levels of suspended and settled sediment where impacts on seafloor communities become ecologically significant, provide information to mitigate impacts on the community of organisms which live on, in, or near the seabed, and the potential for recovery following seabed disturbance.

New Zealand Forest Research Institute Ltd Trading as Scion	Preparing New Zealand for extreme fire	5	$8,750,500	Extreme fire is here, now. With 2015 globally the warmest year on record, NZ is not immune to the extreme fire behaviour normally associated with Australia or North America. Images of Hanmer burning are a very graphic warning. Extreme fire can occur in any fire, at any time and is highly dangerous. Current management strategies cannot suppress these fires and NZ urgently needs new methods, decision support and models to better protect our natural environment, primary producers, vulnerable communities and taonga species. The annual average direct impact of rural fire on NZ's economy is ~$67M, with indirect 'costs' estimated to be at least 2-3 times direct cost, plus intangible indirect impacts as much as 30-60 times direct costs. A world-class international team from Scion, US Forest Service Missoula Fire Science Laboratory, University of New South Wales, San Jose State University, US Forest Service Pacific Northwest Laboratory, University of Canterbury and Lincoln University, will challenge existing understanding of fire behaviour based on convection and develop targeted protection against extreme fire. If validated, under the real-world field conditions NZ offers, the hypothesis will globally change wildland fire science and drive innovation in fire-fighting decision support, training, mitigation tactics and community readiness. We address the Government's investment priorities for the environment by enabling NZ to identify, mitigate and adapt to the threat of extreme fires. We will work with the Resilience to Nature's Challenges National Science Challenge to help communities prepare for the threat. All rural fire stakeholders will benefit from this programme, including Rural Fire Authorities (RFAs), Department of Conservaton (DoC), rural land owners, and in particular Maori with their large presence in rural NZ, and their role as kaitiaki of our indigenous forests.
The New Zealand Institute for Plant and Food Research Limited	Enhancing production of New Zealand's seafood sector using accelerated breeding techniques	5	$5,413,145	PFR and its industry partners have shown strong commitment to maximise the value of NZ's seafood sector. Together, we have focused on making the best of our wild fisheries using profitable, sustainable and ethical fishing practices (*Wildfish2020* and PSH) and by transforming the wild fish production sector through new production and management technologies (*Wildfish2030*). In this programme, we will address the challenge of developing new marine finfish species for our aquaculture sector. Our research aims to enhance production of NZ's aquaculture sector by developing accelerated breeding approaches for two new marine finfish species. The programme will lay the groundwork for a general breeding approach for additional indigenous species in the future. Our approach will be based on novel

				tools, many which have been developed by team members, to reduce the breeding time and lead to aquaculture-ready species in less time and for less money. Our research will develop best practices for finfish breeding, including methods to increase production and productivity through enhanced growth, disease resistance and temperature tolerance. We will work with iwi, Maori industry and stakeholders involved in aquaculture enterprises, to maximise the contribution aquaculture makes to the national economy and its potential for growth. Aquaculture is a vital part of New Zealand's future. Our research will significantly advance NZ's seafood sector's move to be an internationally competitive and sustainable industry and its economic transformation to become a NZ$1B industry. In five years, the programme will: • Deliver novel genotyping and phenotyping tools for finfish species to fast-start new breeding programmes. • Implement selective breeding in two new native finfish species. • Significantly shorten the time to harvest in the two exemplar species. **Contact details:** Mark Jarvis, Mark.Jarvis@plantandfood.co.nz, mobile: +6421403288
	New breeding technologies for New Zealand's high value plant industries	5	$8,500,000	Many of New Zealand's highest value crops suffer from a "handbrake feature", a characteristic which limits their economic potential. Examples include very short storage after harvest, e.g. apricot, cherry and kiwi berry. A combination of long breeding cycles and limited genetic resources means improvements to these fruit crops are very limited. This programme will develop rapid next generation breeding tools for NZ's tree crops, for high-value novel cultivars, seven times faster than currently possible. Novel traits, such as long storage and shelf-life, will be delivered through pinpoint alterations in the plant's genome, without introducing foreign DNA. We will demonstrate the advantages of new technologies in an exemplar crop, kiwi berry. Co-innovation with Maori growers in the horticultural and forestry sectors will enable us to align Maori development with state-of-the-art molecular genetics and to identify new ways of improving perennial crop breeding and plant-based industries in a way that is relevant to and appropriate for New Zealand society. For more information contact: Andrew.allan@plantandfood.co.nz

	Perfecting storage life prediction for delivery of high quality fruit	5	$14,000,000	New Zealand fresh fruit exporters depend on delivering high quality products through a complex supply chain. Plant & Food Research, Massey University and University of Waikato researchers will deliver innovations in predictive models, sensors and data-driven best practice systems to support NZ's horticulture's export supply chain that will provide our exporters with a significantly strengthened position to deliver consistent, high quality fruit to consumers. The research focus will address the requirement for improved determination of maturity. We will identify new measures that provide strong prediction of maturity and storage performance in major fruit crops. We will develop technology for fruit assessment from which maturity and storability of fruit and readiness-to-eat can be predicted. This concept is novel in fruit supply chains and will deliver substantial benefits to the fruit export industry. Value will accrue from improved supply chain management based on strong predictive models. Fruit lines with good storage potential will be channelled into longer term storage and lines with less storage potential will be marketed earlier. Supply into high value niche markets, such as the rapidly growing e-commerce market, will be supported by these new technologies. Implementation will be through close collaboration with technology companies and major fruit exporters, ensuring rapid uptake of research outputs. For further information contact Brian.Ward@plantandfood.co.nz.
The Research Trust of Victoria University of Wellington	Enhanced geothermal energy recovery through nanotechnology: An innovative enduring solution to the worldwide silica deposition problem	4	$3,190,000	Geothermal energy is an important renewable source of energy, available any time on demand. New Zealand is at the forefront of geothermal energy development due to an abundance of easily accessible resources, some of which are owned by Iwi, in the Taupo, Rotorua, Bay of Plenty and Northland areas. New Zealand companies export geothermal knowhow and technology worldwide. The development of geothermal energy is compromised by the presence of silica in geothermal brines, which forms problematic silica scale in pipelines, heat exchangers, valves and in reinjection wells. The removal of silica scale is costly, which is why the industry has developed workarounds. These involve dosing geothermal brine with acids or using higher operating temperatures and scrubbing the steam with cold water. Acid treatment only delays silica formation, which means that reinjection wells still clog up and also silica

				scale damage equipment and pipes persists. Higher operating temperatures and scrubbing steam with cold water lowers the amount of energy that can be extracted from geothermal brine. We have developed innovative disruptive technology that uses up the silica from the brine transforming it into a competing calcium silicate species, so that no silica scale can be formed and itself forms no intractable deposits. Calcium silicate particles do not adhere to metal surfaces and can be reinjected or recovered as saleable industrial products. By using this technology, the problems with acid dosing and higher operating temperature methods can be avoided, which means less corrosion to equipment, higher energy generation (15% plus) and less downtime for the plants. The project involves scaling up and proving the technology and demonstrating it at a pilot scale operation which is integrated with binary cycle electricity production.
	Manufacture of self-adjuvanting peptide vaccines for cancer and infectious disease	5	$9,677,865	With the clinical success of drugs that harness the immune system to fight cancer, such as Keytruda, we are at a time of rapid change for cancer therapies. Despite their success these drugs and related therapies are controversial due to their high cost, limited response rates and toxicity concerns. This research seeks to develop complementary immunotherapies through vaccination approaches that leverages long term government research investments. These vaccine immunotherapies will be produced and tested in patients locally and due to clever chemical approaches the manufacture of these vaccine products will be incredibly simple ensuring low production costs. Successful preclinical data will lead to well-paid job opportunities in the biomedical sector and its service industry and investable opportunities offering high rates of return.
University of Auckland	Building damage-avoidance seismic technology using a novel resilient slip friction joint	4	$3,438,500	Damage in recent major earthquakes has stimulated development of techniques which not only provide life-safety, but also aim to minimise damage so that buildings can be re-occupied with minimal business interruption and repair costs. We have recently invented a novel structural connection system branded Resilient Slip Friction Joint (RSFJ). The RSFJ technology not only allows a structure to withstand seismic activity by providing friction damping but also includes an inherent self-centring function; a characteristic which greatly improves building resilience and reduces post event repairs. This connection system provides a cost-effective seismic solution for damage avoidance design of buildings either in concrete, timber, steel, or any hybrid with a wide range of scalability (from low- to high-rise) and different applicability (residential, commercial, or industrial). It can

				be used in new buildings or for retrofit of existing buildings, with particular relevance to upgrading earthquake prone buildings. The RSFJ technology is also very well suited to retrofit of Marae buildings to resist earthquakes. Its application outside of the actual building enclosure preserves Marae integrity. For all building types, the joint system will provide the required earthquake resistance and ensure that structures return to their initial configuration following a seismic event. The proposed research programme will investigate how the systems will improve structural performance against earthquakes. Numerical modelling and full-scale structures tests will be undertaken to determine the effectiveness of the system. This cutting-edge technology will have a considerable impact in the rapidly expanding New Zealand building industry, and other high seismic-risk countries, as it provides cost -effective damage avoidance construction techniques.
University of Otago	Development of next-generation sanitisers for the control of bovine mastitis in the dairy industry	3	$1,681,443	Mastitis is a bacterial infection of the udder and is the foremost production limiting disease for dairying worldwide, costing the New Zealand dairy industry over $280M pa in treatment and discarded milk. Mastitis is controlled through the use of teat sprays containing bioactive ingredients such as chlorhexidine. Chlorhexidine is also widely used for infection control in hospitals all over the world in hand and pre-surgical skin sanitisers. Mounting concerns around antimicrobial resistance mean that new, non-medical sanitisers are urgently required to manage mastitis and protect both New Zealand's dairy industry and healthcare system from rising antimicrobial resistance. Our research aims to deliver new sanitisers by identifying, developing and testing naturally derived compounds that inhibit mastitis-causing bacteria using the micronutrient zinc. Zinc is important in the human immune response and is known to have potent anti-infective qualities. We will develop compounds that efficiently move zinc into bacterial cells, where it will exert its antimicrobial action, whilst remaining harmless to mammalian cells. These novel, non-medical compounds will pave the way for new teat-spray formulations, protecting New Zealand dairy herds from mastitis. For more information relating to the research programme contact: greg.cook@otago.ac.nz or adam.heikal@otago.ac.nz.

	Ending homelessness in New Zealand: Housing First	5	$2,537,514	Over 6000 people are without any accommodation every night in New Zealand and over 40,000 lack safe secure accommodation. The consequences of homelessness exact a high cost to this country both in economic and human terms. Based on robust international evidence, the Housing First Research Team and The People's Project together with the Universities of Otago and Waikato are developing a new model for ending homelessness through a 'Housing First' approach. This has been shown to provide the best environment for addressing the often complex needs of hard to reach groups. In this innovative programme, housing is unconditional. It is not 'earned' by compliance, rather it is a 'right'; treatments are made available, but uptake is voluntary. This approach shifts service engagement from a forced chore, to a self-rewarding pathway. It is a paradigm shift that maximises the benefits from modern engagement services. Security of tenure provides the stability that enables participants to contribute positively to their community, society and the economy, with rising incomes and higher quality of life a common outcome across Housing First studies. The success of the Housing First approach has displaced long held assumptions about people who have complex needs, reaffirmed the importance of housing, and helped to consolidate the link between evidence and practice.
	Targeting drug delivery within the brain - Building a system for human application	4	$4,859,256	This Programme will stimulate a high-profit, technology-based medical device and consumables industry in New Zealand for the treatment of brain disorders. The technology will incorporate a delivery system for brain chemicals together with a controller that will manage timing and dose. Drug delivery will mimic natural release of neurochemicals in the brain, reducing side effects and improving treatment efficacy. The new technology will enable smart, non-invasive drug delivery that will revolutionise the treatment of disorders with underlying neurochemical imbalances. We wish to expand our device concept into a drug delivery platform that will first be applied to better treat Parkinson's disease (PD), preventing, and in theory reversing, current treatment-induced side effects in humans. Our technology could also target chemotherapy to brain cancers and arrest epileptic seizures at the site of origin.
University of Waikato	People, Cities and Nature: Restoring	4	$2,862,684	Two key facts are behind the "Cities, People and Nature" research programme. First, many of the native plants and animals that are special to New Zealand (our native biodiversity) are threatened or in decline and

	indigenous nature in urban environments			rarely seen in our cities and towns. Second, most people in New Zealand live in urban areas where councils are spending large amounts of money on projects to restore native biodiversity, often relying on community support and volunteers. Those facts mean that there is huge public interest in urban biodiversity. Unfortunately, there is not enough specialised information on how to make urban restoration projects most successful and cost effective. Nor is there NZ-specific information on how urban residents or people from different cultures relate to nature and what encourages them to help protect it. Our team of leading researchers will address those questions through a series of studies in towns and cities around New Zealand. We want to find out what works best in different locations and then make all that information readily available to everyone. Ultimately, we believe our research will help create flourishing natural environments to improve the quality of life, health, and economic wellbeing in our cities and towns. Our native plants and animals will have a better chance of thriving and urban restoration projects will be more cost effective. If you would like to know more about this project, please contact Bruce Clarkson, clarkson@waikato.ac.nz

**** Please note: All public statements provided in this document were supplied by applicants.***