GPLER Round 4 successful pre-proposals summary

Title	Countries involved	Contact
Mitigation via the Nitrogen Detour Pathway: exploring an abiotic nitrogen removal mechanism that bypasses N_2O emissions Intensive agriculture contributes excess reactive N that leads to greater nitrate leaching and nitrous oxide (N2O) emission. Transformation of reactive N from soil back to atmospheric N2 is the most effective way of removing excess environmental N. Various N removal processes including denitrification, codenitrification and Annamox are known to achieve this transformation but N2O is typically a by-product. Our team recently reported (manuscript in review) a chemical (and completely abiotic) transformation of reactive N to N2 that is not dependent on anaerobic conditions and does not require production of N2O. This mechanism effectively bypasses or detours N2O production while moving excess reactive N into inert atmospheric N2. This nitrogen detour opens new avenues for removal of excess soil N and N2O mitigation in grazed livestock systems. We will investigate the potential for this abiotic pathway to be used as a mitigation technique to reduce N2O emissions and nitrate leaching.	NZ (Landcare Research, NIWA), USA	**Andrew McMillan** +64 6 353 4931 McMillanA@landcareresearch.co.nz
High Metabolisable Energy (HME) ryegrass: a bioremediation tool for urine nitrogen (N) and for reduction of on-farm N_2O emissions High Metabolisable Energy (HME) is an enhanced photosynthesis technology that confers increased carbon assimilation and growth rates in genetically modified plants. We have developed HME ryegrass and will conduct overseas field and animal nutrition testing in 2018-2020. Biophysical modelling supports the hypothesis that HME ryegrass will provide a GHG mitigation tool for farmers and will reduce farm nitrogen (N) losses. The proposed research will enhance our programme enabling the verification of modelling by measuring N cycling in PC2 containment glasshouses in years 1-2 and in the field in year 3. We will compare HME ryegrass with non-GM ryegrass at different urine N loading rates to determine if HME ryegrass will reduce N loss from a grazing system through an altered N cycling strategy. This knowledge can be added to the plant performance, animal nutrition and methane mitigation from two separate programmes to increase the value proposition for progressing to NZ based trials in 2021.	NZ (AgResearch, Lincoln Uni, Dairy NZ)	**Greg Bryan** +64 29 200 5013 Gregory.bryan@agresearch.co.nz
A decision tool for predicting N_2O emissions and targeting mitigation. Nitrous oxide (N2O) is produced by nitrification and denitrification pathways under aerobic and anaerobic conditions, respectively. Nitrifiers may also denitrify as oxygen becomes limiting. A tool is required to identify N2O emission pathways in order to better target mitigation. The N2O molecule has a variable isotopic composition (site preference 'SP') due to the placement of the 15N atom in the molecule during its assembly by either nitrifiers or	NZ (Lincoln Uni) Germany	**Tim Clough** +64 3 423 0775 tim.clough@lincoln.ac.nz

denitrifiers. Few measures of SP in situ have been performed and no data is available that connects SP, a potential identifier of the N2O emission pathway, with soil environmental and biochemical conditions. We will measure redox, oxygen, and SP in conjunction with soil gas diffusivity, a measure of the soil's ability to supply oxygen, and thus a determinant of a soils N2O productive potential, in order to provide a tool that identifies the soil conditions pertaining to a given N2O emitting pathway.		
Improving antibody binding to antigenic targets in the rumen	NZ (AgResearch), Argentina	**Neil Wedlock** +64 6 351 8698 neil.wedlock@agresearch.co.nz
Development of a high throughput method for microbial sequencing; and application in sheep and cattle to predict methane emissions Rumen microbial community profiles (RMCP) have been shown to be under genetic control and to be highly predictive of rumen outputs including production of methane and volatile fatty acid (VFA) concentrations. This suggests RMCP are a useful tool in ruminant production systems, and in particular, in systems where there is little infrastructure for direct measurement of methane production and feed intake. By harnessing a new wave of genotyping technologies and robotic efficiencies we will develop a procedure that will make it possible to measure many animals for RMCP at lower cost to elucidate both environmental and host genetic differences. We will compare RMCP across diets, species, breed and individuals within breed using both dairy cattle and sheep to determine common signatures associated with rumen fermentation producing low methane. This project will develop a high throughput method to determine signatures of RMCP predictive of methane and VFA concentrations under both pastoral and intensive livestock production systems. This will have utility in developing both improved management systems and in genetic selection of more efficient, low methane producing, animals.	NZ (AgResearch, Dairy NZ), Netherlands, Australia	**Suzanne Rowe** +64 3 489 9181 suzanne.rowe@agresearch.co.nz
Reducing hydrogen and methyl compound availability in the rumen to decrease methane emissions Current methane (CH4) mitigation research focuses on the direct inhibition of methane forming microorganisms and does not target those microorganisms that produce hydrogen (H2) or methyl (CH3)-compounds which serve as substrates for the methanogens. CH4 formation is dependent on H2 and CH3-compound availability and reducing the supply of these substrates will lead to reduced CH4 formation. Our recent GRA-funded projects (Global Rumen Census, Deep sequencing the rumen microbiome, Hungate1000) now allow us to identify the main H2 - and CH3-compound-producing bacteria, and this proposal targets these organisms with the aim of finding ways to reduce their supply of substrates to methanogens via inhibition of their growth or enzymatic activities. The outcome from the work will be identification of a range of different microorganisms and metabolic pathways to	NZ (AgResearch, Donvis, Otago Uni), USA, Japan	**Graeme Attwood** +64 6 351 8162 graeme.attwood@agresearch.co.nz

manipulate, leading to new inhibitory compounds, vaccines and microbiological interventions to achieve CH4 inhibition.		
Discovery of New Nitrification Inhibitors to Mitigate N_2O Emissions in Grazed Pastures – Phase II: Validation in the Soil and Field Testing In grazed pastures, the main source of nitrous oxide (N2O) is from nitrogen (N) returned in animal excreta, particularly in the urine. Previous research has shown that nitrification inhibitor (NI) treatment of grazed pasture soils is a scientifically proven approach to mitigating N2O emissions. The suspension of the current NI, dicyandiamide (DCD), necessitates the search for new NIs which are effective in mitigating N2O emissions while meeting food safety standards. We have successfully developed phenotypic screening assays and discovered potential new NIs by screening thousands of natural and synthetic compounds in our current GPLER research. This application is to seek additional funding to take this research to the next phase to validate the efficacy of the new NIs in the soil and field testing, eventually leading to commercialisation. The outcome is to enable farmers to reduce N2O emissions from grazed pastures by using the new NIs.	NZ (Lincoln Uni, Otago Uni, AgResearch, Auckland Uni, Ravensdown), China, UK	**Hong Di** +64 3 423 0779 hong.di@lincoln.ac.nz
Diet-based, plant and endophyte effects on pasture N2O emissions: mechanisms and new targets for mitigation. To date, research has concentrated on identifying primary sources of N2O emissions from grazed pasture. However, a complete understanding of the processes controlling the production of N2O remains elusive, as shown by a) the difficulty in modelling emissions and b) the difficulty in explaining the variability measured in field experiments. While, previously, the focus has been on soil processes, we have now confirmed that specific plants, and the resultant urine excreted by animals consuming those plants, can have a marked influence on N2O emissions and we are proposing to attain a mechanistic understanding of how this occurs. To our advantage, we have identified plant (and plant/endophyte) material that is associated with high and low emissions and have important preliminary clues to the processes we need to study. The research will assist in targeting mitigation strategies, provide greater confidence in inventory measurements, improve modelling of N2O emissions and determine the mitigation potential of different forages and livestock diets.	NZ (AgResearch, Massey Uni), China, Colombia, USA	**Jiafa Luo** +64 7 838 5125 Jiafa.Luo@agresearch.co.nz
Targeted management of urine patches to reduce direct and indirect N_2O emissions from soils in livestock-grazed pastures "Spikey2®" is a NZ designed machine that detects fresh urine patches in grazed pastures, in order to target application of N inhibitors (NIs) and novel carbon amendments (CAs) to slow down N transformation rates and reduce N2O and NH3 emissions and NO3 - leaching. To ensure close contact between urine and applied NIs or CAs, mapping urine patch area and depth is essential for calculating appropriate application rates and development of cost-effective N2O, NH3 and NO3 – mitigation strategies. We have assembled an international team with specialist	NZ (Landcare Research, AgResearch, Massey Uni, Lincoln Uni, Pastoral Robotics NZ), Ireland, Chile, Australia	Professor Surinder Saggar +64 6 353 4934 saggers@landcareresearch.co.nz

skills in reduction of N2O emissions from grazing livestock systems who will: i) determine and eliminate the factors that constrain the efficacy of NIs and CAs, ii) further improve the Spikey® technology and iii) extend its use in NZ and other GRA countries. The combination of Spikey® and associated novel mitigation technologies could achieve up to 40% reduction in direct and indirect N2O emissions.		
Mitigating N_2O emissions by optimising irrigation management This study will determine how irrigation can be managed to maximise soil gas diffusivity, thus maximising oxygen entry into the soil, and minimise the anaerobic denitrification processes which dominate agricultural N2O emissions from fertiliser and excreta. Gas diffusion is the predominant mechanism for gas transport across the soil atmosphere interface. A measure of the potential for gas diffusion to occur is relative gas diffusivity (Dp/Do), which describes the diffusion of gas through soil, relative to air, and accounts for functional pore space (where gases can diffuse). Previously, water filled pore space (WFPS) has been used has a predictor of the potential for soil to emit N2O but this parameter does not readily predict functional pore space. Pilot data shows relative gas diffusivity is a better predictor of N2O emissions across varying soil bulk density. Models exist for predicting Dp/Do based on easily measured variables: soil water content and bulk density.	NZ (Lincoln Uni), Australia	Tim Clough +64 3 423 0775 tim.clough@lincoln.ac.nz
Benchmarking ecological management strategies for pasture soils to reduce N_2O emissions and increase productivity New Zealand relies on intense pastoral grazing, with the future goal of doubling primary industry exports. However, current pastoral practices result in high N2O emissions driven by microbial transformation of N in urine that presents a roadblock to that goal. Our prior work has resulted in a mechanistic understanding of the microbes involved, their ecology and key regulators controlling them. Further pathways for N2O emissions were also identified. This project seeks to use the acquired knowledge to validate market ready approaches to decrease N2O emissions, while maintaining or improving productivity. Further, we aim to explore new management options by addressing remaining gaps, primarily the metabolic limitations of N2O reducers controlling net emissions. We will achieve this by combining chemical and microbiological techniques with genomics/transcriptomics to elucidate metabolic processes limiting N2O reduction. We will also work with end users (farmers) and providers (fertilizer company) to validate available market ready solutions.	NZ (Otago Uni, Lincoln Uni, Mainland Minerals), Norway, Ireland	Sergio Morales +64 3 479 3140 Sergio.morales@otago.ac.nz
On-farm precision mapping and management technologies to break the productivity ceiling, reduce GHG emissions intensity and conserve soil carbon Precision mapping technologies that visualise pasture yield, irrigation efficiency and soil characteristics have shown large within- and between-paddock variability even for highly productive dairy farms. Combining these mapping technologies with precision management decisions will ensure more precise nutrient, water and grazing	NZ (AgResearch, Landcare Research, Dairy NZ, Ravensdown, Rakaia Dairy), Australia	Dr Cecile de Klein +64 3 489 9047 cecile.deklein@agresearch.co.nz

management. Our hypothesis is that being more precise 'on all fronts' can not only break the (perceived) pasture productivity ceiling but also reduce GHG emissions intensity and conserve soil organic carbon (SOC). To test this hypothesis, we will use precision-mapping and -management technologies on irrigated dairy farms with soils of contrasting fertility and water holding capacity, and determine the effects of optimising nutrient, irrigation and grazing management on pasture productivity and quality, CH_4 and N_2O emissions, and SOC stocks. In collaboration with our industry and international partners, we will combine 'targeted' measurements and modelling to estimate the effects of improved (more precise) management on GHG emissions intensity.		
Accelerated soil carbon (C) sequestration through targeted use of full inversion tillage when renewing permanent pastures and grasslands Accelerating soil C sequestration is considered a promising option for mitigating GHG emissions from agriculture. Pasture renewal provides an opportunity to use full inversion tillage (FIT; 30-40 cm) to bury carbon-rich topsoil (slowing its decomposition) and to enhance C storage from new pasture in the new under-saturated soil surface. Our proposal addresses four important gaps in knowledge that are needed to provide direct proof-of-function and bring the application of FIT-pasture renewal closer to on-farm use. These gaps include: Guidelines to identify the most suitable soils and sites; ^{13}C tracer experiments to quantify net C sequestration; field trials to demonstrate the practical applications of FIT-pasture renewal; and modelling effects over longer timeframes and across a wider range of soils and climates. Conservative estimates suggest that FITpasture renewal could sequester an additional 3 -10 Mt C in NZ high production grassland (HPG) soils over 30 years (0.4 to 1.2 t C/ha/yr).	NZ (Plant & Food Research, Massey Uni, Landcare Research), Germany	Dr Mike Beare +64 3 325 9485 Mike.beare@plantandfood.co.nz