A Stocktake of Agricultural Greenhouse Gas Research in New Zealand

Edition 1
June 2021

About this stocktake

This document has been put together to provide a source of information, based on information available as of June 2021, for entities and/or individuals interested in obtaining:

An overview of agricultural greenhouse gas research funding in New Zealand – what funds exist and what is the current investment in mitigation options that seek to directly reduce agricultural emissions.

The document has been divided into three sections:

1. *Overview of the funds and funders of agricultural greenhouse gas research in New Zealand*
2. *Mitigation options and their current investment and progress status in New Zealand*
3. *Case studies of how the funds have worked together to accelerate research progress*

Please cite this report as:

Leahy S, Aspin M, de Klein C, Rys G, Clark P. 2021. A Stocktake of Agricultural Greenhouse Gas Research in New Zealand. Edition 1. A report coordinated by the New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC), the Pastoral Greenhouse Gas Research Consortium (PGgRc), AgReserach Limited and the Minisitry for Primary Industries (MPI).

Funding

How is agricultural greenhouse gas funded in New Zealand?

Agricultural greenhouse gas (GHG) mitigation research funding comes from multiple sources. The growing appreciation of the need to tackle climate change, and the diversity of the challenges that agricultural GHGs present, means there are a range of different funding entry points from fundamental science through to applied research and commercial development and production. Different funders have different interests and are looking for specific solutions to issues facing their farm, organisation, industry or government ministry.

Given the variety of interests and approaches, there are several different funding streams that seek to service those different needs. As a result, the organisation and funding of agricultural GHG mitigation research in New Zealand can appear complex. This is a guide to the system and the way the funds work in partnership to grow New Zealand's understanding and global contribution to real solutions to tackle climate change.

The following are an overview of some of the main research funds in operation in New Zealand, their aims and their partnerships with other funds (Table 1).

Pastoral Greenhouse Gas Research Consortium (PGgRc)

Funded by industry and MBIE
Governed by a Board of Directors
https://www.pggrc.co.nz/

The PGgRc is a consortium of agricultural industry organisations that invest their funds and levies to develop mitigation solutions through research, in partnership with the New Zealand Government. Currently the PGgRc invests ~$5 million annually via a 50/50 funding partnership with the Ministry of Business, Innovation and Employment (MBIE). The current tranche of 2-year MBIE funding will be completed in August 2021. MBIE's current contribution comes from the Strategic Science Investment Fund (SSIF).

The $85 million research funded through the PGgRc since 2003 has been largely dedicated to technologies that reduce ruminant methane production through enteric fermentation but has also invested in nitrous oxide research. The PGgRc aims to deliver knowledge and economically viable mitigation practices or products that will help New Zealand farmers manage GHG emissions, while increasing productivity. The PGgRc leads the commercialisation of the methane vaccine and inhibitor mitigations through an agreement with the New Zealand Government via MPI assigning them intellectual property and requiring them to act in both parties' interests. The PGgRc is funded in partnership with MBIE by Fonterra, Dairy NZ, Beef+Lamb NZ, DEER Industry NZ, AgResearch and has the following non-contributing participants: Fertiliser Association, PGG Wrightson Seeds and Landcorp Farming.

New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC)

Funded by MPI and MBIE

Administered through MPI and NZAGRC Governance and Advisory Groups

https://www.nzagrc.org.nz/

The NZAGRC is funded by the Ministry for Primary Industries (MPI) and the Ministry of Business, Innovation and Employment (MBIE) and is a partnership (non-financial) of nine New Zealand research organisations: AgResearch, DairyNZ, Landcare Research, Lincoln University, Massey University, NIWA, PGgRc, Plant & Food Research, Scion. The NZAGRC was launched in 2009.

The NZAGRC investment is close to $10M per year and its goal is to discover, develop and make available to New Zealand farmers and growers, products, tools and knowledge that enable the practical and cost-effective reduction of agricultural greenhouse gas emissions, encompassing methane from both enteric fermentation and manure management, nitrous oxide from agricultural soils, and the management of soil carbon. It also works to co-ordinate New Zealand's research into agricultural GHG emissions mitigation and be a key authoritative source of technical advice and support on agricultural GHG emissions and soil carbon sinks. Apart from focusing on developing new solutions, the NZAGRC also devotes effort to developing young scientists at postgraduate (Honours, Masters and PhD) and postdoctoral levels to ensure the on-going capability and capacity of the New Zealand research community to deliver against these challenges. The NZAGRC is also a key source providing the greenhouse gas evidence base for policy. The Centre also supports a programme to understand the greenhouse gas profiles of Maori Agribusiness. The NZAGRC leads New Zealand's science input into the Global Research Alliance on Agricultural Greenhouse Gases, which is New Zealand's main way of fostering international science for collaboration and helping build capacity in other countries to tackle their own GHG emissions.

Global Research Alliance On Agricultural Greenhouse Gases (GRA)

Funded by MPI and MFAT (New Zealand funding)
Administrated by MPI and NZAGRC
https://globalresearchalliance.org/country/new-zealand/

The Global Research Alliance on Agricultural Greenhouse Gases (GRA) was launched in December 2009 and now has 65 member countries from all regions of the world. The New Zealand Government initiated this global initiative to increase collaboration between countries to find ways of reducing GHG emissions from agriculture without jeopardising global food security. The GRA provides a framework to bring together research and investment into mitigation practices and technologies from around the world. It covers paddy rice, cropping and livestock industries, and across these industries looks at integrated systems including soil carbon, nitrogen cycling, and GHG inventory and measurement. New Zealand's support for the GRA is for accelerating globally relevant GHG mitigation research and building international capability and capacity.

The GRA has a dedicated research group for livestock focused on reducing the emissions intensity of livestock production systems and increasing the quantity of carbon stored in soils supporting those systems. The New Zealand Government has committed funds to support the Livestock Research Group to accelerate global research in mitigating GHG emissions from pastoral livestock. All work funded via the GRA support fund has a strong New Zealand relevance but will aid and draw on international work on understanding GHGs and provide science and policy links around the world. Additionally, New Zealand holds the secretariat position for the GRA and provides key inputs into scientific and capability building activities. Financially, since 2009, New Zealand has allocated $122 million to the GRA, and other alliance member countries provide additional, significant cash or in-kind funding to shared activities. Wherever possible, the GRA seeks to align with other international funders and institutions.

Sustainable Land Management and Climate Change (SLMACC)

Funded by MPI

Administrated by MPI (Agriculture and Investment Services (AIS) Programmes)

Website: https://www.mpi.govt.nz/funding-rural-support/farming-funds-and-programmes/slmacc/The SLMACC Research

Programme commenced in 2007 as one of ten programmes forming the SLMACC Plan of Action, after the announcement of the New Zealand Emissions Trading Scheme to help the agriculture and forestry sectors understand and resolve the challenges arising from climate change. The SLMACC Research Programme is a policy needs- driven fund, investing in targeted basic, applied and policy research. Up to 2018 this included the impacts of adaptation to climate change, mitigation of agricultural and forestry GHG emissions, cross- cutting issues, including economic analysis, life-cycle analysis, farm, catchment and systems analysis and social impacts, and policy research to address targeted policy questions. It currently focusses more specifically on impact and adaptation research. Apart from addressing direct policy-relevant questions, this fund was often used to test the feasibility of new areas of mitigation research that show potential. Promising results are then funded and progressed by other means, such as through the NZAGRC/ PGgRc or Global Research Alliance.

New Zealand GHG Inventory (NZGI)

Funded by MPI, administrated by MPI in consultation with MfE

https://www.mpi.govt.nz/funding-rural-support/environment-and-natural-resources/greenhouse-gas-inventory-research-fund/

New Zealand is required to maintain an inventory of its GHG emissions as part of its obligations under the United Nations Framework Convention on Climate Change (UNFCCC). The GHG inventory is an annual report of all human-induced emissions and removals of GHGs in NZ. The first formal inventory was submitted in 1994 as part of New Zealand's first national communication to the UNFCCC, and annual reporting started in 1998. The inventory is coordinated by the Ministry for the Environment (MfE), while MPI produce estimates of agricultural GHG emissions and supports forestry sink estimates particularly from planted forests. While a national inventory uses some assumptions and generalisations to estimate emissions from different sources, it is also designed to reflect as much as possible the eventual emissions reductions in agriculture that could arise from current mitigation actions on farm. There is funding to support research on agricultural greenhouse gas emissions reporting, and projections of future emissions from land use. Direct investment in inventory projects comes from MPI and all projects have a domestic focus to ensure New Zealand can continue to comply with UNFCCC rules including continuous improvement of the national GHG inventory.

Substainable Food And Fibre Futures (SFFF)

Funded by MPI

Administrated by MPI

http://www.sff-futures.mpi.govt.nz

The Sustainable Food and Fibres Futures Fund (SFFF) replaced the previous Primary Growth Partnership (PGP) and the Sustainable Farming Fund (SFF) from October 2018.

Sustainable Food and Fibre Futures (SFF Futures) supports problem-solving and innovation in New Zealand's food and fibre sector by co-investing in initiatives that make a positive and lasting difference. SFF Futures funds a range of projects, from less than $100,000 to multi-million-dollar, multi-year programmes. The funding is aimed at helping partners to innovate and achieve their goals faster. Projects can be national in scale or related to just one community. This can include projects focused on finding new ways of tackling environmental issues, such as mitigating GHG emissions and the impacts of climate change. In December 2020, SFF Futures opened a call for proposals to investigate regenerative farming practices. SFF Futures is a co-investment fund, so partners will need to contribute some of the costs. MPI prefers cash co-investment but, on a case-by-case basis, will consider a proportion of the contribution to be in-kind. Applications are open year-round.

Other Ministry of Business, Innovation and Employment (MBIE) Funds

Strategic Science Investment Fund
Endeavour Fund
Catalyst Fund
Te Pūnaha Hihiko: Vision Mātauranga Capability Fund

Beyond the NZAGRC and PGgRc already covered in this document, MBIE invested around $17.4 million in 2020/21, in agricultural greenhouse gas mitigation research, or aligned fields. Due to the nature of large contestable funds with broad investment areas, this investment varies from year to year. The Endeavour Fund (Research Programmes and Smart Ideas) and related contestable funds (for example a precursor to Endeavour - the 'Contestable Research Fund') are the largest direct MBIE investments in agricultural greenhouse gas reduction research. Additional research in this area, or aligned areas is by the Strategic Science Investment Fund (SSIF) through Crown Research Institute research platform projects (e.g., AgResearch's Understanding the Rumen Microbiome, or Manaaki Whenua's Soil Carbon Storage project). Currently no specific projects under the National Science Challenges (NSCs) address agricultural greenhouse gas reduction directly, as all NSC projects in this area have been completed. Some NSC projects will align broadly to the goals of agricultural greenhouse gas mitigation, but not as their primary goal. Endeavour and other contestable funds are evaluated and recommended for investment by independent assessors or a panel – in the case of the Endeavour Fund, the MBIE Science Board makes final investment decisions, following assessments by the Assessor College, and signals from the Endeavour Investment Plan and public Gazette Notice.

The Strategic Science Investment Fund (SSIF) funds strategic investment in research programmes and scientific infrastructure that have long-term beneficial impact on New Zealand's health, economy, environment and society. SSIF Programmes are structured around science platforms and support for example:

- Crown Research Institute (CRI) platforms (16 platforms across 7 CRIs)
- Antarctic Science platform
- Advanced Energy Technology platform

For SSIF platforms, MBIE is the final decision maker. Once funded, most SSIF platforms are managed as devolved funds, administered by a host or 'virtual centre', overseen by a governance group. For CRI SSIF funds, CRI Boards make decisions about individual programmes. Funding decisions are aligned with the SSIF Investment Plan, while the strategic purpose of a SSIF platform is agreed on by Cabinet.

The NSCs, like SSIF platforms are devolved, each Challenge has established a governance entity that is responsible for managing the delivery of the research and funding to address the Challenge research goals. This entity is accountable for the fulfilment of contractual and performance requirements as agreed with the MBIE Science Board. Priorities for each Challenge were set by gazette notices approved by Cabinet, with funding decisions made by the MBIE Science Board.

Other MBIE funds in this area include the Vision Mātauranga Capability Fund, Partnerships (discontinued, however some contracts are still running their course) and Catalyst Strategic Fund, which supports activities that initiate, develop and foster collaborations which take advantage of international science and innovation for New Zealand's benefit.

Industry and Private Companies

A variety of livestock industry and private organisations are engaged in the New Zealand GHG emissions mitigation research effort. Industry provides significant funding in partnership with government via the PGgRc (see PGgRc above) to further enteric methane mitigation research, but as well as this, there are other programmes involving globally based organisations that are also working with industry to develop mitigation solutions for New Zealand farming systems. In addition, many of the meat and milk processing companies are involved in activities with their suppliers to enhance the understanding of on-farm emissions for supply requirements, and also through their involvement with He Waka Eke Noa - the primary sector climate action partnership. (www.hewakaekenoa.nz). A far greater proportion of industry research funding is provided to increase the productivity and efficiency of the New Zealand farming industry. The emissions reductions brought about by these efficiency gains are a co-benefit of these research programmes. The requirement for increased productivity and efficiency is mainly driven by the need for non-subsidised New Zealand farmers to remain economically viable in a global market, but domestic and international expectations around improved environmental practices, in particular water quality form part of the decisions. Given the mix of private and commercial investment in productivity and efficiency it is difficult to estimate the total investment.

Other Funds and Initiatives

Various other private and government funds and initiatives have added or may add to our knowledge of GHG emissions and mitigation options. For example, New Zealand Green Investment Finance (https://nzgif.co.nz/), Agmardt (https://agmardt.org.nz/) and Callaghan Innovation (https://www.callaghaninnovation.govt.nz/)

Table 1. Organisations and funds to address GHG mitigation research for agriculture in New Zealand

Organisation/programme	Funder	How funds are distributed	Funding scope
Pastoral Greenhouse gas Research Consortium (PGgRc)	Industry / MBIE (SSIF) Industry good facing	Negotiated	CH4, N2O
NZ Agricultural Greenhouse gas Research Centre (NZAGRC)	MPI (SFFF fund) and MBIE (SSIF) Domestic public good facing	Negotiated and competitive	CH4, N2O, soil carbon, farm systems, and Māori agribusiness
Global Research Alliance (GRA)	MPI, MFAT (NZ GRA fund) International good facing	Negotiated and competitive	CH4, N2O, soil carbon and farm systems
Sustainable Land Management and Climate Change Research (SLMACC)	MPI Domestic public good facing	Competitive	Three separate programmes of research: 1 Adaptation in agriculture 2 Climate change extension 3 Fresh water mitigation
GHG Inventory Research Fund (GHGIF)	MPI International and public good facing	Competitive	Agriculture and forestry including CO2, CH4, N2O
Sustainable Food and Fiber Futures (SFFF)	MPI Industry/Govt partnership facing	Negotiated co-funding	Mitigation, adaptation and productivity improvement
Industry	Various (including government partnerships) Industry/private good facing	Negotiated and competitive	Productivity, N leaching, N efficiency, GHG mitigation, CH4 & N2O
Strategic Science Investment Fund (SSIF)	MBIE	Negotiated	Aligning to government strategy and SSIF Investment Plan
Endeavour Contestable Fund	MBIE	Contestable	Proposed strategy, aligning to government strategy and investment signals.
National Science Challenges (NSC)	MBIE	Contestable and negotiated	Each Challenge's scope and investment signals was set by Cabinet through gazette notices.

Table 1 (cont). Organisations and funds to address GHG mitigation research for agriculture in New Zealand

Organisation/programme	How funding decisions are made	How priorities are set
Pastoral Greenhouse gas Research Consortium (PGgRc)	PGgRc Board decision guided by General Manager's recommendation	Developed and signaled in 7-year plan, which is reviewed throughout by independent science and commercial advisory panels
NZ Agricultural Greenhouse gas Research Centre (NZAGRC)	Director recommends to NZAGRC Stakeholder, Science Advisory Groups; Governance Groups who approve final list	Signaled in 5-year strategy and science plans, advised by independent science panel, assessed by science and governance panelsder, Science Advisory Groups; Governance Groups who approve final list
Global Research Alliance (GRA)	External Technical Advisory Panel and officials recommend to MPI DG	Alignment with other multi-lateral funds & competitive funding mechanisms: targeted investment based on advice from NZAGRC and GRA Research Groups of GRA.
Sustainable Land Management and Climate Change Research (SLMACC)	External /internal advisory panel recommends to MPI DGMPI/MfE officials recommend to MPI DG	Annually by officials advised by experts and MPI staff
GHG Inventory Research Fund (GHGIF)	MPI/MfE officials recommend to MPI DG	Annually by MPI and MfE officials advised by external Panels (NZoNet and Methanet and Inventory Expert Advisory panel)
Sustainable Food and Fiber Futures (SFFF)	MPI subject experts, fund managers and Independent Advisory Panel advise DDG, Minister of Ag approves applications greater than $1 million.	Non identified unless there is a specific call for targeted research areas e.g., Regenerative Agriculture, strong wool, etc
Industry	Varied	Dependent on research interests. Efficiency and production are key concerns, with GHG reductions as co-benefit of efficiency/ productivity gains
Strategic Science Investment Fund (SSIF)	For new SSIF platforms, MBIE is the decision maker. Once funded, most SSIF platforms are managed as devolved funds, administered by host or virtual Centre, overseen by governance groups. For CRI SSIF funds CRI Boards make decisions about individual programmes. Exceptions are the Data Science and Advanced Energy where individual programmes have been funded and contracted by MBIE.	SSIF investments must first align with the SSIF Investment Plan. Priorities within scope of the SSIF contract are set by SSIF platform governance structures. All SSIF investments are expected to align with government science strategies.
Endeavour Contestable Fund	Proposed programme competes for funding. Final decision rests with the Science Board.	Balancing of investments across areas, and within government priorities and strategies, are signaled in the Endeavour Gazette Notice, and Investment Plan. The Science Board also balances investments in programmes, to ensure a range of investments and priorities are covered.
National Science Challenges (NSC)	A contestable process was held to identify NSC host. The overall programme scope was approved by the Science Board. The Challenges are devolved funds administered by host. A NSC governance group make decisions about specific projects to be supported by the NSC.	NSC investments must first align with the relevant gazette notice. Priorities within scope of the NSC contract are set by NSC governance groups.

Table 1 (cont). Organisations and funds to address GHG mitigation research for agriculture in New Zealand

Organisation/programme	Funding 2020-2025 ($m approx.)	Key linkages between the funding streams*
Pastoral Greenhouse gas Research Consortium (PGgRc)	Approx. $5.0m/year (funded 50/50 by industry/ government) Current tranche of 5 year MBIE funding completed August 2021	PGgRc and NZAGRC co-invest in CH4 programme; NZAGRC Director observer on PGgRc Board; PGgRc Board Chair observer on NZAGRC Governance Group. PGgRc Manager sits on NZAGRC Science Advisory Group & on SLMACC advisory group. PGgRC leads commercialistion of work on behalf of PGgRC and some MPI investment.
NZ Agricultural Greenhouse gas Research Centre (NZAGRC)	Approx. $10.0m/year from MPI and MBIE (50%/50% each). Additional funding from MPI and MBIE may be forthcoming based on budget 2021/22 where Government invested an additional $24m over 4 years.	As signaled under PGgRc + NZAGRC Director and Deputy Director provide advice for SLMACC, Inventory and GRA.
Global Research Alliance (GRA)	Approx. $11.0m year is direct research funding and provision of co-funding for other international funding mechanisms, approximately $3.0m per year from MFAT.	NZAGRC input into technical advisory panel & priority setting. NZAGRC leads NZ input into all GRA Research Groups. NZAGRC contracts most and reports on all research activities.
Sustainable Land Management and Climate Change Research (SLMACC)	Varies. Currently $6.86m/year for adaptation, extension and fresh water over the next 3 years.	Aligns with MPI/MfE National Adaptation Plan requirements and OVERSEER
GHG Inventory Research Fund (GHGIF)	Varies Currently $1.9m/ year	NZAGRC and PGgRc input into advisory panels.
Sustainable Food and Fiber Futures (SFFF)	Dependent on projects that have climate change objectives	SFFF works collaboratively with other groups e.g., SLMACC and projects may be referred to one another. Co- funding important and facilitates collaboration.
Industry	Funding from industry and government in support of industry objectives significantly exceeds $50m per year	Industry input into PGgRc – co-funder, advisors to various other funds.
Strategic Science Investment Fund (SSIF)	Dependent on projects that relate directly to climate change.	A number of SSIF programmes align with other SSIF programmes, or National Science Challenges, as well as other funds and government departments. This depends on the project in question, and cannot be answered in a wide view, due to the very broad scope of SSIF investments. PGgRC and NZAGRC are both tightly aligned with MPI and are thus both captured in the MPI climate change research stocktake. NZAGRC receives matched funding from MBIE and MPI. PGgRC receives matched funding with Industry partners. The MethaneSAT is a partnership between New Zealand space industry, government, and the American Environmental Defense Fund.
Endeavour Contestable Fund	Dependent on projects that relate directly to climate change.	A number of NSC programmes align with other NSC programmes, or SSIF programmes, as well as other funds and government departments. This depends on the project in question, and cannot be answered in a wide view, due to the very broad scope of SSIF investments.
National Science Challenges (NSC)	Dependent on projects that relate directly to climate change.	A number of NSC programmes align with other NSC programmes, or SSIF programmes, as well as other funds and government departments. This depends on the project in question, and cannot be answered in a wide view, due to the very broad scope of SSIF investments.

*Note: MPI provides cohesion across NZ Government funded initiatives

Mitigation options

Current investment and progress status

A brief description of the mitigation options and an overview of the current investment (as at June 2021) is listed here. While there will be research funding from other sources that are indirectly helpful and supportive of the mitigation options described, ***only funding that directly seeks to reduce agricultural emissions is listed and where information was publicly available at the time.***

Methane Vaccine

Vaccination against methane forming microbes (methanogens) in the rumen of ruminant animals is expected to have broad applicability globally and could be practical and cost-effective even in extensive systems. Research into a methane vaccine remains in the development phase and methane reduction has not yet been demonstrated in live animals. However, all major components of a vaccine chain have been demonstrated: genome sequencing of methanogens has identified targets that stimulate antibody production, antibodies can be created by host animals and detected in saliva and the rumen, and those antibodies have been shown to suppress pure methanogen cultures in vitro. The in vivo efficacy of a vaccine is necessarily speculative but a reduction of 30% is considered plausible given the efficacy of methane inhibitors. Commercial availability of a vaccine is estimated to take seven to ten years after demonstration of an effective prototype in animals.

Funders	Time Period	Amount $NZD	Project
PGgRc - NZAGRC	July 2020–August 2021	3,400,000	Methane Vaccine

Methane Inhibitors

A methane inhibitor is a chemical compound that suppresses the activity of methanogens in the rumen. Inhibitors could be delivered as a feed additive or as a intra ruminal device (a small capsule containing the active compound, inserted into the rumen). 3-Nitrooxypropanol (3-NOP) is an example of an inhibitor compound which has been shown to consistently reduce methane emissions by around 30% when feed continuously in Total Mixed Ration (TMR) farm systems without compromising animal productivity and is expected to be commercially available in some countries within the next two years. 3-NOP has limited applicability in grazing systems as one-off administration decays within a few hours in the rumen, but its applicability could be extended to most dairy systems via slow-release formulations. Research is also progressing in the use of 3-NOP in young ruminants to stimulate lifetime reductions, and on other methane inhibitors with longer rumen lifetimes and low dosage rates to allow bolus or other forms of delivery. These developments could increase the utility of methane inhibitors beyond TMR systems into grazing systems. While 3-NOP has reached the pilot stage, there are other inhibitor compounds being actively researched, from synthetic bromoform to the discovery of alternative inhibitor compounds that target alternative microbial processes to 3-NOP.

Funders	Time Period	Amount $NZD	Project
PGgRc	July 2020-August 2021	3,000,000	Discovery & development of methane inhibitors
NZAGRC	July 2021-June 2023	1,604,320	Novel delivery of methanogen specific inhibitors
NZAGRC	July 2021-June2023	500,000	Molecular tools for methane inhibitor mitigation
NZAGRC	April 2021-June 2023	495,000	Inhibiting ruminal methane using bromoform
NZAGRC-DairyNZ	July 2021-June 2023	450,000	On-farm delivery of methane inhibitors
NZAGRC-AgResearch	July 2021-June 2023	600,000	Targeting methanol formation for methane
NZAGRC-DairyNZ	July 2021-June 2023	1,600,000	On-farm solutions: life-long methane reduction
NZAGRC-Ruminant Biotech Corporation Limited	July 2021-June 2023	1,924,796	Safety of bromoform in livestock
GRA	July 2017-June 2021	1,700,000	Reducing hydrogen and methyl-compound production to mitigate rumen methane
GRA	June 2020-July 2021	85,400	Review on rumen microbiology to accelerate methane mitigation research
SFFF-DSM NZ Limited	May 2021-May 2024	1,354,235	Early Life Application of Methane Inhibitor BOVAER 10 in Dairy Calves

Methane feed additives

Feed additives have been defined as the addition of an additive totalling 5% or less of the animal's diet. There are several different types of feed additives currently being proposed as potential methane mitigation options in New Zealand. They range from plant extracts, oil blends, direct fed microbials, compounds such as prebiotics, nitrate, biochar, humates and feed types such as seaweed. While there is some evidence to suggest there are additives that reduce emissions when fed to livestock, the effect is generally small, variable, ingredients are often prohibitively expensive; and efficacy is unknown under New Zealand farm systems. However, seaweed has recently gained attention due to its high efficacy in reducing methane emissions when fed to animals in international animal trials.

Seaweed Algae of the genus Asparagopsis have been shown to reduce ruminant methane emissions by 20-98%, although the persistence of this effect over multiple seasons remains unclear. The role of bromoform and bromochloromethane as active ingredients in Asparagopsis raises challenges from a regulatory and market acceptability perspective. Animal trials have detected residues in urine and milk but no detrimental effects on meat quality. Increased levels of iodine in milk have also been observed. There are open questions regarding palatability to livestock, animal health and the ability to produce and supply seaweed at large scale especially to extensively grazed livestock.

Funders	Time Period	Amount $NZD	Project
GRA	May 2020-June2021	550,000	New Zealand Collaborative Seaweed Programme for methane emission reduction in ruminants
PGgRc	July 2020-August 2021	1,414,000	Proving of KowBucha - natural methane inhibitor
Provincial Growth Fund	Not Determined	500,000	Seaweed climate change solution

Methane: Breeding low emissions sheep

Sheep vary naturally in the amount of methane they produce per kg of dry matter consumed. This trait has been shown to be heritable and thus enables the breeding of lower methane emitting sheep. Emissions differ by approximately 10-20% between low emitting and high emitting flocks after three generations of selection without adverse effects on major production traits and some indications of positive correlations. Following industry pilot trials, the low methane trait is expected to be available to sheep farmers in New Zealand within the next one to two years.

Funders	Time Period	Amount $NZD	Project
PGgRc	July 2020-June 2021	135,000	Sheep genetic selection roll out
NZAGRC	July 2020-June2023	600,000	Maintenance of the low and high methane sheep lines
GRA	October 2019-June 2021	200,000	Grass to Gas: Strategies to mitigate GHG emissions from pasture-based sheep systems

Methane: Breeding low emissions cattle

Cattle show similar potential for breeding strategies to reduce methane, but proof of concept is less advanced due to the higher cost of measuring and identifying low-emitting animals. Research is underway to measure young bulls who will sire a significant portion of the future New Zealand dairy herd and to develop proxy indicators (e.g., in milk, rumen microbial profiles) to enable cheap and rapid identification of lower-emitting animals.

Funders	Time Period	Amount $NZD	Project
NZAGRC	Sept 2020-Apr 2022	840,887	Low methane emitting cattle full trial
NZAGRC	2020/2023	3,000,000	Low methane emitting cattle measurement equipment
GRA	May 2021-June 2022	80,000	Review of low emissions animal research – proxy measures
GRA	April 2018-June 2021	530,863	Enteric Fermentation Flagship Project: Rumen microbiomes to predict methane
Inventory#	FY20/21	460,000	Understanding cattle methane yields
Inventory#	FY20/21	850,972	Review and revision of the methane conversion factor for dairy cattle
Inventory#	FY20/21	91,155	Dairy cattle monthly population model

#Focuses on improvement of dry matter intake (DMI) and methane production data for inventory purposes

Methane: Breeding low emissions deer/goats

Limited research has been undertaken to understand the potential for breeding strategies in deer and goats in New Zealand.

Funders	Time Period	Amount $NZD	Project
PGgRc	July 2020-June 2021	90,000	Measurement of deer methane emissions

Low emission feeds

In New Zealand, livestock diets are predominantly self-selected grass/legume pasture meaning that the opportunities to reduce emissions by dietary manipulation are limited. However, farmers in the dairy sector have been increasing their use of supplementary feeds to improve performance and the chemical makeup of these supplementary feeds can influence emissions.

Feeds with higher energy levels (fodder beet, grains) can improve animal performance such that less total feed is needed to reach a given level of milk yield or liveweight gain; if less total feed is consumed as a result, absolute emissions may reduce. Additionally, research has focussed on identifying feeds that reduce emissions per unit of feed intake. For example, some feeds ferment differently in the rumen and reduce CH_4 per unit of feed intake, while others have a lower N concentration such that less N is excreted onto pastures and N_2O emissions are reduced.

Low-emissions feeds are not currently included in the national GHG inventory. For feeds that would reduce N_2O emissions, this is largely because of the absence of robust information on quantities being fed and, in some cases, the variability of results under different management and feeding practices. For feeds that might reduce methane emissions, the evidence is also not robust yet about how emissions reductions scale if low-emission feeds constitute only a (variable) part of the overall animal diet.

Supplementary feeds relevant to New Zealand that might reduce the amount of CH_4 produced per unit of feed eaten include forage rape and fodder beet. Some widely used supplementary feeds such as maize and fodder beet have N concentrations that are lower than the standard grass/clover diet. Increasing the proportion of these feeds in the diet further lowers total dietary N concentration and N excretion and thereby reduces N_2O emissions.

In addition, some plants appear to also modify the soil microbial activity and alter the amount of N in the soil that is lost in the form of N_2O, thereby reducing N_2O emissions further e.g., plantain. However, results to date on the impacts of different plants on N_2O emissions and on the potential underlying mechanisms for reductions have not always been conclusive.

Genetically modified ryegrass Researchers have developed a genetically modified ryegrass which has a higher lipid content. In vitro testing and modelling suggest that a genetically modified ryegrass with higher lipid content could potentially lead to a reduction in greenhouse gas emissions. Work is on-going to confirm efficacy and any future genetically modified material will need to meet regulatory approval.

Funders	Time Period	Amount $NZD	Project
PGgRc	July 2020-June 2021	25,000	Plantain and methane
NZAGRC	August 2020-June2021	200,000	Methane yield of cattle fed plantain
NZAGRC	July 2021-June 2023	1,200,000	Low GHG plants and feeds
GRA	Oct 2017-June 2021	463,450	CEDERS: Capturing Effects of Diet on Emissions from Ruminant Systems
GRA	Jan 2019-June 2021	446,000	Enteric Fermentation Flagship Project: The effect of feed and nutrition on methane emissions from cattle
Endeavour Fund*	July 2016-Dec 2021	10,000,000	Evaluating the Potential of Forages with Elevated Photosynthesis and Metabolizable Energy

*Note: Only a portion of the research is focussed on direct mitigation of GHGs. The main focus of the funded programme is broader in scope.

Nitrous oxide inhibitors

Nitrification inhibitors are chemical compounds that inhibit the formation of nitrate in the soil, and thus the potential for nitrous oxide production. Researchers in New Zealand are seeking new nitrification inhibitors that have wide availability, are low cost, and have a low risk of residues in food products. A suite of promising compounds has been identified and testing has begun to deliver proof of concept in the field. Researchers are also investigating ways in which these inhibitors can be practically delivered.

Urease inhibitors inhibit the hydrolysis of ammonia from either urine or urea fertiliser, reducing the potential for indirect N2O emissions from ammonia deposition. A quarter of urea fertiliser sold in New Zealand is already coated with a urease inhibitor, but this achieves only a small overall emissions reduction. The main benefit from a GHG emissions perspective is that in principle, less urease-coated fertiliser is needed to achieve the same pasture growth, but data are lacking whether farmers are using less fertiliser or are instead aiming to boost pasture growth even further. Urease inhibitors are the second agricultural mitigation technology recognised under the New Zealand's national GHG inventory.

Funders	Time Period	Amount $NZD	Project
NZAGRC	April 2021-June2023	480,000	Development of a novel N2O inhibitor
NZAGRC	July 2021-June 2023	795,000	Targeted on farm urine management
GRA	Apr 2021-July 2021	80,000	Review of biological nitrification inhibition technologies
SFFF*	Oct 2020-Sept 2025	5,405,500	Future Ready Farms (Spikey)

*Note: Only a portion of the research is focussed on direct mitigation of GHGs. The main focus of the funded programme is broader in scope.

Low nitrous oxide emitting animals

Low nitrogen (N) sires are available through the breeding industry. Bulls with negative breeding values for milk urea nitrogen (MUN) are expected to reduce MUN in their daughters thereby reducing the amount of nitrogen excreted in cow urine. With less nitrogen expected in urine patches this is theorized to reduce the production of nitrous oxide emissions. However, there is currently no empirical evidence to demonstrate a reduction in nitrous oxide emissions from low N sires.

Funders	Time Period	Amount $NZD	Project
Endeavour Fund*	2019-April 2025	8,400,000	Livestock Genetics and Management to Reduce Farm Environmental Impacts

*Note: Only a portion of the research is focussed on direct mitigation of GHGs. The main focus of the funded programme is broader in scope.

Case Study -DCD and the National GHG emission inventory

DCD is one of two dedicated agricultural mitigation technologies recognised under New Zealand's national GHG inventory. Incorporation of the nitrification inhibitor DCD into New Zealand's Inventory was the result of a comprehensive field evaluation process. At the time of incorporation, a total of 28 peer reviewed papers were published demonstrating the mitigating effect of DCD on either direct or indirect N2O emissions and/or nitrate leaching in New Zealand. This included a three-year, four site evaluation measuring nitrous oxide and nitrate leaching co-funded by industry and government. DCD was voluntarily withdrawn from the market due to trace levels found in milk powder and the lack of any CODEX minimum residue level. The GHG mitigating effect of DCD at the national level was small due to its limited use, owing to its high cost. For the 2007-year, DCD was applied to 3.5% of the effective dairying area, resulting in a 0.73% decrease in N2O emissions. The main driver for its use was the management of nitrate leaching. The increased pasture growth was promoted but insufficient to justify its cost. The implicit carbon price, if DCD was used solely to mitigate GHG emissions, have been in excess of $200/tCO2-eq.

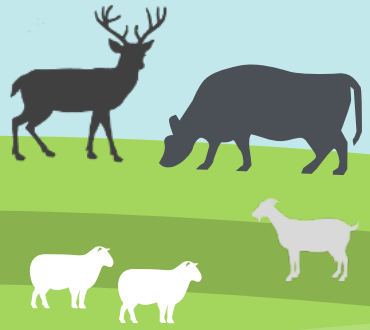
Capture and destruction or use of agricultural methane

Manure collection and storage provides farms, particularly dairy farms, with an important capacity to recycle valuable nutrients to the land for future plant uptake, and to manage risks to freshwater quality. Manure is often stored in a liquid storage facility (earthen manure storage pond or a manure storage structure) or as a solid stack for many months. Properly sized storage can facilitate spreading manure on dates closer to when plants can take up nutrients, reducing the potential for pollution of surface and groundwater and reducing the need to purchase fertilizer. Emissions related to the management of livestock manure (collected in milking sheds, stand-off and feeding pads) arise in the form of methane from anaerobic storage of manure, and nitrous oxide from volatilisation of nitrogen contained in manure.

Options to reduce manure emissions exist through the capture of methane produced in anaerobic ponds via bio-digestors, capture and destruction of methane via flaring or methanotroph (methane-digesting) bacteria, aeration of and use of compounds in the pond which reduces methane production by creating more aerobic conditions, and by managing the storage and strategic spreading of manure to minimise nitrous oxide emissions. Where methane is captured as biogas, this can provide additional benefit by displacing fossil fuel use and emissions.

Additionally, industry is developing wearable devices for livestock that reduce methane production at an individual animal level. Devices are intended to be fitted over the animal's snout, capturing exhaled methane and using a special catalytic converter to turn it into a combination of carbon dioxide and water vapour. Work is currently focused on pilot trials to demonstrate proof of concept and practicality for New Zealand pastoral grazing systems.

Figure 1. Simple illustration of the mitigation options currently being funded in New Zealand (as of June 2021) and their placement on a mitigation developmental pipeline.



Discovery

Proof of Concept

Pilot studies

Adoptable

Methane inhibitors

Feed addditive
(defined as <5% diet)

Methane vaccine

Low methane animals

Low methane feeds

Methane capture/use/ destruction

Nitrous oxide inhibitors

Low nitrous animals

Low nitrous oxide feeds

Bacterial inhibitors

Synthetic bromoform

NZ native seaweed

Direct-fed microbial

PGgRc inhibitors

3-NOP grazing

Deer

Vaccine

Cattle

Tannin rich (GM) clover

HME (GM) ryegrass

Animal wearables

Plantain

Low N sires

Plantain (inhibitor)

GM plants

Lincoln inhibitors

NZAGRC inhibitor

Plantain

Maize silage

Sheep

Efficacy

Farm system fit

Economics

Time

Animal Productivity

Animal health and welfare

Food safety

Environment

Markets

Delivery

Accounting

Regulatory

Social & Cultural

Capacity & Capability

Hurdles to implementation

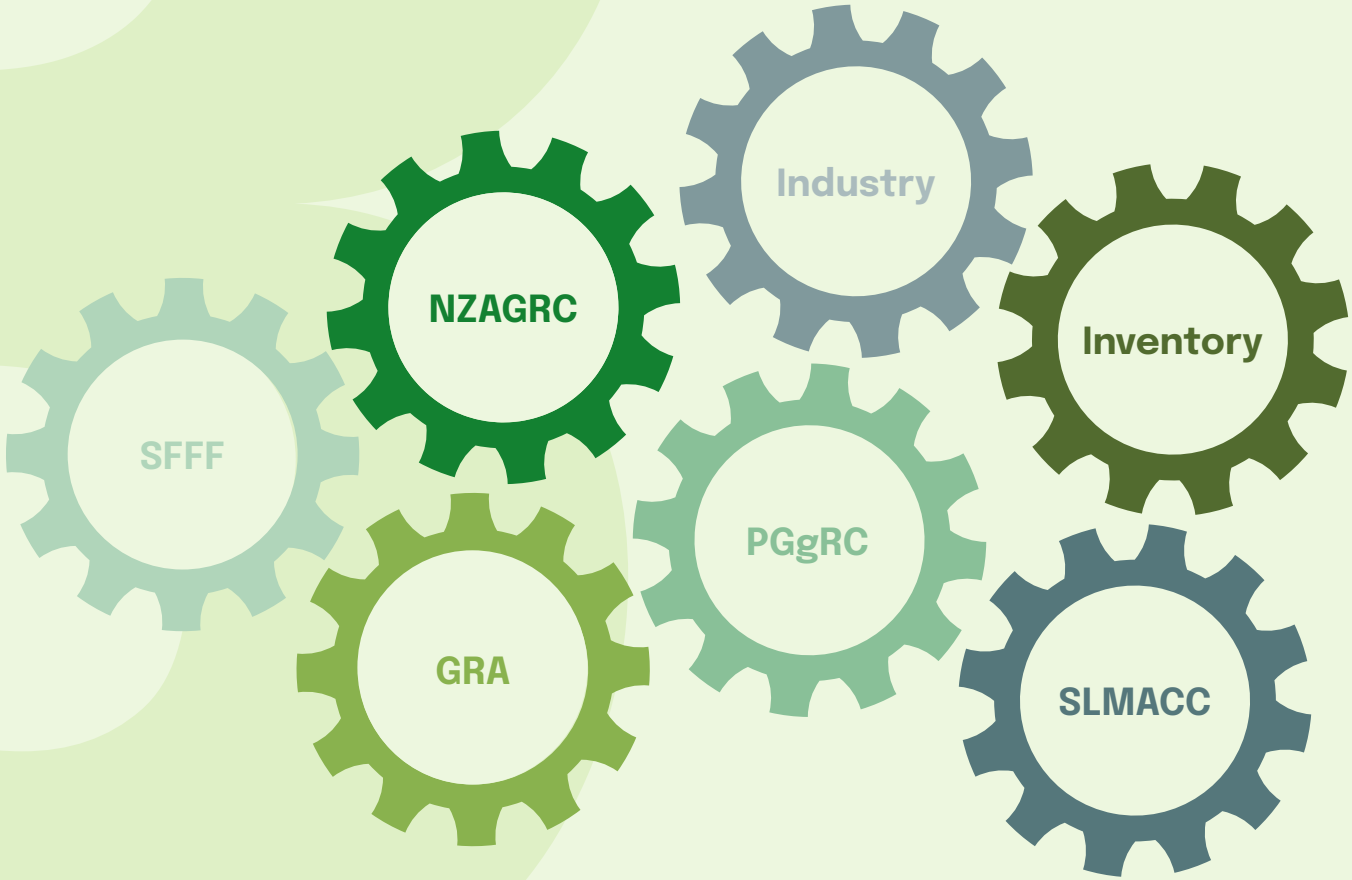
Important criteria that should not be overlooked when considering a mitigation approach for New Zealand farm systems

June 2021

Research currently funded in New Zealand and its progress status

Case studies

How the funds work together



Case studies How the funds work together

New Zealand's agricultural GHG emissions mitigation research funding works together like a set of cogs, rather than individual funds working in isolation. The NZAGRC and PGgRc are a central cog moving together to provide an overall push forward for targeted GHG mitigation research in New Zealand. These two research funds work with all sectors – government, science and industry – while other funds contribute individual, focussed research outcomes to improve New Zealand's overall knowledge of how we can introduce new mitigation strategies on farm. It's also important that all this links closely to improving New Zealand's GHG inventory accounting methods both on farm and nationally, as well as drawing as much as possible on international expertise and collaborations and contributing to expanding and accelerating the global search for GHG mitigation solutions. There are many advantages in this approach to funding. New Zealand is able to support targeted work to address both international and national priorities. This approach enables flexibility of resource input to cover a broad range of solution options - from very basic to very applied - while still maintaining the ability to direct focus to the most promising solution areas.

Four case studies are discussed in this document to highlight how funders have worked and are working together to advance key mitigation approaches for New Zealand farm systems.

Case Study 1: Methane Vaccine

Research funded by the PGgRc, NZAGRC and GRA laid the groundwork for what is now a comprehensive advancement in our understanding of rumen microbiology. A key part of this was the PGgRc sequencing of the first rumen methanogen in 2010. This was followed by sequencing of additional methanogen genomes by the combined funding of the PGgRc and NZAGRC and large international GRA projects (Global Rumen Census and Hungate1000). All of which combined to allow New Zealand researchers to use a genomic approach to selectively target methanogens without affecting the wide variety of other microbes. This underpinning research has been instrumental both domestically and internationally in advancing the development of mitigation approaches such as vaccines and inhibitors (see Case Study 2: methane inhibitors). Additional GRA projects were also helpful in developing experimental tools that are used by the NZ research team to advance the current vaccine research programme. Currently the development of a methane vaccine is supported by funding through the PGgRc and NZAGRC.

Case Study 2: Methane Inhibitors

The search for a methane inhibitor compound that will be suitable for a pastoral grazing system starts with the underpinning research funded by the PGgRc, NZAGRC and GRA. In the early stages of research, genomic and computational approaches funded by the PGgRc and NZAGRC were used to identify promising compounds. Once proof of concept was demonstrated for a selection of compounds, the PGgRc have continued to support the evaluation of those compounds in ruminant animals. The GRA have been funders of research that has delivered an experimental tool that allows for large-scale testing of inhibitor compounds against methanogens. This tool has helped accelerate the testing of compounds, which previously had been time consuming and laborious. The NZAGRC is supporting research into identification of alternative inhibitors, new tools to help inhibitor research and developing practical delivery mechanisms for inhibitor compounds.

Case Study 3: Breeding animals for reduced methane emissions

In the early 2000s, researchers first became interested in the question of whether there is any natural variation between individual animals in the amount of methane they produce. Initially, PGgRc funded a major programme with the dairy industry initiative BoviQuest to measure emissions from 700 individual dairy cows. This trial showed large differences in emissions between animals. Subsequent work in sheep, funded by SLMACC and PGgRc, established that some animals naturally produce up to 10% less methane than others. Using New Zealand's strength in breeding sheep, the PGgRc then funded a larger research project that established that methane production is heritable meaning that the difference between low and high emitting animals can be passed through the generations. Having demonstrated feasibility, the PGgRc and NZAGRC funded programmes have worked together to identify genetic markers, evaluate production outcomes and develop rapid measurement techniques that allow these differences to be exploited as part of standard industry breeding. PGgRc is working with its industry partner, Beef + Lamb New Zealand (BLNZ) Genetics to launch a "methane research breeding value" as part of New Zealand's recognised sheep breeding traits. The NZAGRC are supporting the establishment of a cattle-breeding programme, maintaining the high/low methane selection flocks and investing in methane measurement equipment. Additional investment through the Government's GRA fund has further allowed New Zealand researchers to establish measurement and reporting protocols to increase global genetic information and allow intercomparisons on low-emissions traits. This has also advanced our understanding of the microbes of the high/low sheep and has provided data promising proxy measures. The New Zealand Inventory fund focuses on developing comprehensive emission factors for cattle and sheep and a robust methodology to capture these emissions reductions in NZ's international reporting.

Case Study 4: Nitrification inhibitors

Nitrification inhibitors are widely available overseas and, until 2011, an inhibitor called dicyandiamide (DCD) was used on some New Zealand farms. Research on DCD commenced in the early 2000s led by Lincoln University with initial funding for proof of concept provided by the fertiliser company Ravensdown. As the research progressed and the interest in DCD as a mitigation technology increased, an extensive programme of evaluation of DCD was carried out by Lincoln University, MAF, SLMACC, PGgRc and Ravensdown Fertiliser, who began commercially selling DCD because of its reduction of nitrous oxide, nitrate leaching and increased pasture production. DCD is registered in the National Agricultural GHG Inventory. The Nitrous-Oxide-Mitigation-Research (NOMR) initiative, which was supported by Fonterra, DairyNZ, Ravensdown, Ballance -Agrinutrients, MPI and PGgRc resulted in a coordinated national series of trials over three years in four key dairying areas in New Zealand and provided the proof of function for DCD as a N2O mitigation technology. This collective investment in DCD research resulted in many peer-reviewed publications and supported the evidence required for the incorporation of DCD in the national GHG inventory. However, the discovery of trace residues in milk led to the withdrawal of DCD from the New Zealand market, meaning that New Zealand dairy farmers have limited scope to reduce nitrous oxide emissions from urine patches using nitrification inhibitors at present. Work funded by the NZAGRC in recent years has identified a potential novel inhibitor in both field and laboratory trials that has demonstrated similar efficacy to DCD, but without the same risks. The advantage of this inhibitory product is that it is already widely used for other purposes, is approved for use in both humans and animals and has internationally agreed residue limits in food. Research is now addressing short-term data needs associated with the product, including modes of action, further evidence of efficacy in the field, and the impact on N leaching. Longer-term data needs include effectiveness and longevity of the compound in a range of New Zealand soil and environmental farming conditions. Other alternatives to DCD are also being explored in work funded by New Zealand's contribution to the Global Research Alliance and are expected to be available in the future.

Grasslands Research Centre, Tennent Drive
Private Bag 11008
Palmerston North 4442
New Zealand

Telephone +64 6 351 8334

Email enquiry@nzagrc.org.nz

Twitter https://twitter.com/nzagrc

Facebook https://www.facebook.com/nzagrc

LinkedIn https://www.linkedin.com/company/new-zealand-agricultural-greenhouse-gas-research-centre/