NEW ZEALAND
AGRICULTURAL GREENHOUSE GAS
Research Centre

HIGHLIGHTS 2020

OUR ROLE

THE NZAGRC BUILDING IN PALMERSTON NORTH

New Zealand's Government has set an international target to reduce greenhouse gas emissions to 30% below 2005 levels by 2030.

OUR MISSION

'To provide knowledge, technologies and practices which grow agriculture's ability to create wealth for New Zealand in a carbon-constrained world'

OUR VISION

'To be an internationally renowned centre for research and development into agricultural greenhouse gas mitigation solutions'

The NZAGRC is a core component of the New Zealand Government's approach for addressing the reduction of greenhouse gas emissions from agriculture. This includes New Zealand becoming: (a) a major investor in agricultural GHG mitigation research; (b) a world leader in finding solutions to agricultural GHG emissions via its domestic investment programme; and (c) a leader in international initiatives to advance the search for mitigation solutions and help ensure international treaties address agricultural GHG emissions in an appropriate manner. It is 100% Government-funded.

The Centre is a science funder, has additional responsibilities for strategic research coordination, capacity building and leads New Zealand science input into international activities and policy processes in the agricultural GHG area. The NZAGRC is a 'virtual' Centre and the research that it funds is carried out by researchers working in their own organisations and collaborating across organisations.

The NZAGRC is a partnership between the leading New Zealand research providers working in the agricultural GHG area and the PGgRc. About NZ$53 million has been invested by the NZAGRC into research and development activities over 11 years. From July 1 2020 new governance and financing structures apply and there will be an increase in resources for the NZAGRC, with MBIE (Ministry of Business, Innovation and Employment) matching MPI investment to result in a doubling of NZAGRC revenue.

PGgRc WORKING TOGETHER

GLOBAL RESEARCH ALLIANCE ON AGRICULTURAL GREENHOUSE GASES

Ministry for Primary Industries Manatū Ahu Matua

New Zealand Government

A full list of acronyms used in NZAGRC publications can be found on the back page of this publication

OUR GOALS

ADVANCE KNOWLEDGE AND UNDERSTANDING

- 19 papers published plus 15 papers submitted
- 30 conference papers or presentations
- Methane breeding value estimation implemented into the national Sheep Improvement Limited database. New Zealand breeders can now measure their sheep and rank them for breeding based on methane
- Successfully developed an independent method for assessing the ability of a soil to adsorb new carbon
- Database of 170 farms modelled in Farmax to develop baseline emissions for pastoral farms

ENHANCE AWARENESS AMONG STAKEHOLDERS

- Close cooperation with the PGgRc is a key pathway for the Centre's interaction with industry stakeholders, assisting MPI to manage IP and enabling knowledge transfers
- Maintaining direct links with a broad range of other stakeholders, including policy makers, farmers and other end users, the science community and the wider public
- Continued expansion of Ag Matters climate change website for farmers, growers and rural professionals
- 17 seminars attracted just under 300 rural professionals to share understanding of climate change, why agricultural GHGs are important in New Zealand, their sources, and how they can be estimated and managed at the farm level
- Series of webinars entitled *Towards a low-emissions future drew* 1727 registrations and a total of 1024 attended the live sessions

CONTRIBUTE TO POLICY

- Centre's relationship with MPI and other Government departments continues to grow and strengthen
- Ongoing inputs into the GRA and other international initiatives
- Director Harry Clark appointed to the Climate Change Commission
- Director is a Lead Author of the IPCC 6th Assessment Report. Dr Sinead Leahy is a Contributing Author. Dr Andy Reisinger is a Review Editor

DEVELOP SCIENCE CAPABILITY

- Dedicated undergraduate 'pipeline' scholarship continued with Massey, Lincoln and Waikato Universities each receiving funding to encourage high achieving students to continue their study and assist with career development
- Five undergraduate, one Masters and two PhD students currently studying under NZAGRC funding
- Two active NZAGRC-funded post-doctoral researchers under NZAGRC or GRA funding

DEVELOP SCIENCE AND COMMERCIAL PARTNERSHIPS

- Leadership of science input into Global Research Alliance and coordination of Livestock Research Group
- Three exchanges funded by LEARN/GRASS Fellowships and three overseas delegations hosted
- Eight new research collaborations agreed with national and international research organisations, programmes or centres
- Provided advice and support to MPI in making a case for additional funding for the GRA. The Government subsequently confirmed $34 million as part of Budget 2020
- Delivered a highly-productive LRG meeting in August 2019, including facilitating the participation of 13 GRA representatives from developing countries
- Monitored 29 GRA research projects for MPI during 2019/20 and negotiated an additional three

OUR RESEARCH PROGRAMMES

MITIGATING METHANE EMISSIONS *(Joint programme with the PGgRc)*

- Reducing emissions through inhibitors and vaccines and indirectly through feeding and changes in animal phenotypes

PLANTS AND GHGs

- Identifying and prioritising plant traits for low GHG emissions
- Mitigation practices to maintain soil carbon and reduce nitrous oxide emissions at paddock scale
- Defining the achievable soil carbon stabilisation capacity of New Zealand grassland soils

INTEGRATED FARM SYSTEMS

- Identifying profitable, practical and low-GHG emission sheep, beef and dairy farm systems

MĀORI-FOCUSSED RESEARCH *(Aligned with Integrated Farm Systems)*

- Assisting the Māori pastoral sector to increase resource efficiency and farm productivity while lowering GHG emissions

POLICY SUPPORT

- Ensuring policy makers have current and validated science upon which to base their decision-making

CHAIR AND DIRECTOR REPORTS

CHAIR'S REPORT

Dr Peter Millard
Chair of NZAGRC Steering Group

This is my final report as Chair of the Steering Group. It is a pleasure to report that I am handing over the reins to a new Governance Group with the future of the NZAGRC assured and its funding streams not only determined for several years, but with increased resources at its disposal. It will continue to play a major role in New Zealand's efforts to mitigate the effects of global warming and climate change.

Between 2009-2020, responsibility for running the NZAGRC was devolved to an NZAGRC Steering Group, comprising an appointed representative from each of the member organisations, and Government observers. From 2020 onwards AgResearch will continue to be the legal host of the NZAGRC and devolve responsibility for day-to-day operation and decision making. However, a new governance structure will be implemented.

The new Governance Group (GG) will be more independent and skills-based, comprising an Independent Chair (appointed by AgResearch, MPI and MBIE after an open nominations process) an AgResearch representative (Research Director of AgResearch), two Stakeholder Advisory Group representatives, a Science Programme Advisory Group representative, a Māori representative and an independent member with Government experience/industry knowledge (appointed by the Chair, AgResearch, MPI and MBIE). MBIE, MPI and the PGgRc will appoint observers to the GG.

The Governance Group will receive independent advice from a permanently-constituted Stakeholder Advisory Group (STAG) and a periodically constituted Science Review Panel.

A Science Programme Advisory Group (SPAG) will work with the NZAGRC Director to develop the science programme and oversee its implementation and monitoring. This will ensure that the NZAGRC's research investments are outcome-focussed and high quality.

I am delighted that my involvement with the NZAGRC will not come to an end as I will take up a new role as Chair of the SPAG, helping focus the Centre's programme in terms of industry and policy relevance. It is satisfying for me to complete my tenure as chair of the old governance structure and now to be part of the new.

My thanks go to those who have sat on the Steering Group over the years and who have served the Centre so well.

We can now look forward to a new era for the NZAGRC.

DIRECTOR'S REPORT

Dr Harry Clark
NZAGRC Director

It is an exciting time for the NZAGRC; refreshed Strategic, Business and Science Plans for 2019-2025, new governance and advisory structures and increased funding to drive our future work.

We will continue to work cooperatively with the PGgRC and look to forge strong links with 'He Waka Eke Noa', the partnership between the Government, primary sector and Iwi/Māori targeting the steps needed to put the primary sector on a downward emissions trajectory and to prepare it for farm-level emissions pricing in 2025.

Looking ahead, we will benefit from MBIE matching MPI investment to result in a doubling of NZAGRC revenue. We will also benefit from the New Zealand Government's increased commitment to the work of the Global Research Alliance (GRA); it received $34 million for the period 2020-2024. NZAGRC plays a leading role both in coordinating New Zealand's science input to the Alliance and working closely with key GRA partners to deliver collaborative science and capability development programmes.

NZAGRC staff, our contracted scientists and our partners have responded well to the challenges of COVID-19. Restrictions on working arrangements, travel and meetings may have presented hurdles but they have responded in innovative ways and our contracted science programmes have suffered minimal delays.

An example of our different approach is the series of webinars that replaced the joint MPI/NZAGRC climate change conference, which could not proceed in April due to lockdown. Instead, a series of webinars entitled 'Towards a low-emissions future' were held by Zoom. The registrations for the webinar series massively exceeded the attendance we would have achieved at the conference – 1727 registrations across the full series compared to the 300-350 who would have attended the conference in person.

A major success for the year has been the outreach initiative with the launch of Ag Matters, a climate change website for farmers, growers and rural professionals. Ag Matters is work funded by MPI which strengthens our partnership. In addition, a tailored outreach initiative involving 300 rural professionals through 17 seminars reinforced the NZAGRC's role in providing objective science advice to the sector; this outreach is set to develop further in the future.

The Centre is in a strong position to pursue our goals in the years ahead.

METHANE RESEARCH PROGRAMME

PRINCIPAL INVESTIGATORS: DR PETER JANSSEN AND DR GRAEME ATTWOOD

The methane mitigation programme is jointly planned and funded in partnership with the PGgRc and aligns with existing MPI programmes funded through SLMACC and New Zealand funding in support of the Global Research Alliance. It aims to reduce emissions by directly targeting the methane-producing methanogens through the discovery of small molecule inhibitors and vaccines and indirectly through feeding and changes in animal phenotype. Significant progress has been made this year, with the sheep breeding programme making research breeding values for low methane emissions available to selected ram breeders through Beef+Lamb Genetics.

As breeders and producers consider incorporating methane breeding values into their own breeding programmes, the selection lines continue to provide a vital demonstration that this is a safe and practical mitigation strategy. This has again been a successful year. All selection line lambs were measured for methane through portable accumulation chambers (PAC). The average methane yield (kg methane per kg feed eaten) for the lambs born in 2019 differed by approximately 16%. All lambs were measured for growth, production, parasite resistance and methane. Ewes were recorded for reproduction, milk composition and lamb survival. Using standard industry economic indices, the lines differ in favour of the low line and differ significantly in lean yield, parasite resistance and wool traits.

Milk compositions from 120 selection line ewes at four and six weeks after lambing showed compelling differences between the methane selection lines for individual milk and rumen fatty acid profiles. Rumen microbial profiles also differed between the two lines consistent with different fermentation characteristics of the rumens in the two groups. This year we have repeated these measures for 173 selection lines ewes that lambed and commenced lactation successfully in spring/summer 2019.

Ewes were sampled at two, four and six weeks post-lambing. The resulting dataset will be one of the most comprehensive to date and will provide a unique resource to study associations between rumen microbial composition, methane emissions, circulating volatile fatty acids in the blood and detailed fatty acid profiles in milk. Results will be of interest to all ruminant livestock systems for neonatal growth profiles, milk production, dairy processing and dairy product composition.

One of the objectives of the project is to collaborate with others to maximise the value of the selection lines and to explore differences between the lines outside the scope of the annual phenotyping programme. Microbial samples, buccal swabs, hormone profiles, tissue specific methylation profiles and accelerometer (GPS based movement) data have all been collected this year.

A very successful collaboration has been with the GPLER funded programme 'Microbes to Predict Methane'. This project used samples collected early in this programme to develop methods for the prediction of methane. Results show very promising results for the estimation of methane breeding values in ruminant livestock by rumen microbial community analysis.

There has been a huge amount of interest from media and the international scientific community in this research, presenting numerous opportunities to publish abstracts and short papers for presentation at high profile international and local conferences.

In 2019/2020 the methane vaccine programme facilitated by the PGgRc engaged with an international panel in the form of a 'Methane Vaccine Think Tank'. This endorsed the general approach being taken to develop a methane vaccine, and resulted in some additional work proposed for the coming years.

Since 2017 the PGgRc has solely funded the New Zealand methane inhibitor programme, advancing promising lead compounds that have the characteristics to reduce methane by 20-30% and be delivered to grazing livestock. These requirements will need a benign compound that is highly potent and can be delivered to the rumen while the animals are grazing.

In the last 12 months a lead compound has achieved a proof of concept in being delivered to cattle and sheep using slow release rumen capsules. The PGgRc is also advancing discussion with commercial companies that will partner to deliver these to New Zealand and global farmers.

PLANTS AND GHGs RESEARCH PROGRAMME REPORT

PRINCIPAL INVESTIGATORS: DR CECILE DE KLEIN, PROF HONG DI, DR DAVID WHITEHEAD AND PROFESSOR LOUIS SCHIPPER

Based on the recommendations of a review of the NZAGRC nitrous oxide, soil carbon and integrated farm systems programmes in March 2017, the former nitrous oxide and soil carbon work streams were combined at the start of 2017/18. The overall aims of the Plants and GHGs programme focus are:

1. **Identifying and prioritising plant traits for low GHG emissions;**
2. **Mitigation practices to maintain soil carbon and reduce nitrous oxide emissions at paddock scale; and**
3. **Defining the achievable soil carbon stabilisation capacity of New Zealand grassland soils.**

In 2019/2020 The Plants and GHGs programme focussed on:

Completing modelling work to identify and prioritise plant traits for low GHG emissions.

Process-based models were used to identify traits/management practices that could potentially be environmentally beneficial and could then inform future research to find or breed plants with those traits. Of these, the nitrogen concentrations in animal feed provided the most promising results, with low nitrogen concentrations resulting in lower urine nitrogen excretion and consequently reduced nitrous oxide, ammonia, and leaching losses.

Developing field scale measurement approaches for both nitrous oxide and carbon balance and using these to determine benefits of plantain in ryegrass/clover sward in comparison to ryegrass alone.

Field trials were conducted to assess the effect of plantain content in the sward on nitrous oxide emissions from urine patches.

In the Waikato, in summer, plantain did not have a significant effect. In winter, nitrous oxide emissions from urine applied to a sward containing 60% plantain were c. 30% lower than from urine applied to a ryegrass/white clover sward.

The Otago trial showed that nitrous oxide emissions from the 'young' sward reduced with increasing proportions of plantain. The results were opposite for the 'older' sward, but this effect may have been confounded by high clover contents in some (but not all) of the plantain treatments in the 'older' sward.

Determining the effects of irrigation on carbon balance and nitrous oxide using experimental and modelling approaches.

Preliminary results suggest an additional 1.2 kg nitrous oxide-nitrogen ha^{-1} emitted during establishment of plantain in the sward relative to continuous pasture even with a short renewal period (12 days). Upcoming work will identify whether, when, and by how much, plantain decreases nitrous oxide emissions and maintain carbon stocks.

In Canterbury, measurements were taken for an irrigated dairy system through conversion from lucerne to a mixed species sward. Exchange of methane shows the strong influence of periods when cows are grazing within the instrument footprint.

Determining the recovery of carbon balance following conversion of supplemental feed site (maize) back to grazed pasture.

In the Waikato, research showed that importation of supplemental feed (e.g. maize silage) likely resulted in modest gains of carbon balance of a farm with high feed imports (presumed gains in soil carbon). However, we have also demonstrated large losses of carbon during two years of maize production due to times of bare soil both prior to and post-maize production. We have continued measurements after maize was converted back to pasture as part of the regular farm management plan. Unexpectedly, there were ongoing losses of about 1 t C ha^{-1} in two years rather than a gain of carbon. This might have been due to the strong summer drought (2020). The total loss of soil carbon through maize and subsequent two years represents an 8% decrease in soil carbon stocks. We will continue to track when carbon starts to accumulate again to identify safe return periods that allow recovery and production of supplemental feed.

Determining the effects of irrigation on carbon balance and nitrous oxide using experimental and modelling approaches.

Researchers grew C_4 Bermuda grass in mesocosms and measured the components of net ecosystem carbon dioxide exchange after irrigation was applied to return the soil water content to field capacity after one, three or six days for 30 days. The findings suggest that, over short periods in well-drained soil, irrigation frequency could be managed to manipulate soil water deficits in order to reduce net below-ground carbon losses.

INTEGRATED FARM SYSTEMS RESEARCH PROGRAMME REPORT

PRINCIPAL INVESTIGATORS: DR ROBYN DYNES AND DR KATHRYN HUTCHINSON

During 2019/2020 both the sheep and beef and dairy components of the Integrated Farm Systems research programme have continued. The dairy programme has been a collaboration with DairyNZ and Reputation Matters (Liz Read) to develop the framework for a behaviour change programme. The sheep and beef programme has been co-developed with Beef + Lamb New Zealand (B + LNZ).

These collaborations and co-development have assisted with ensuring alignment with industry investment, initiatives and extension programmes and to ensure the workstream priorities align with needs of each agency. A highlight has been the impact each of the programmes has had through Government and industries.

The sheep and beef programme is designed to provide new insights into GHG emissions from the sector by assessing the drivers of GHG emissions for at least 100 real sheep and beef farms, representing all eight B+LNZ farm classes, to explore beyond the single farm analysis completed to date and to identify characteristics of farm systems linked to different GHG outputs. The focus this year has been in further building the database of real farm data and in undertaking analysis of these data.

Analysis and interpretation have been completed in collaboration with B+LNZ. The data provides insights that enable sheep and beef farmers to understand variation in GHG emissions across a range of farm classes. Individual farmers can identify with one or more of the modelled real farms to see how they got from A to B with their GHG emissions and use these strategies to develop their own pathway to a lower emissions future.

The monitoring and analysis of two existing monitor farms – Highlands and Onetai Station: aspirational mitigation options (e.g. GHG at a collective level, carbon-neutral, integrated catchment management) have been investigated following a line of enquiry agreed upon with the farm owners. A farmer field day at Highlands considered GHG emissions in the farm systems context and the opportunities for reductions/offset. The Onetai field day was the final field day for the Environment Farm. The team reflected on changes in GHG footprint over time and the impacts of management changes.

The dairy programme has designed a 'behaviour change' programme. The partnership with Liz Read brought clarity and focus to the programme and positioned the work for rapid uptake and inclusion within the industry. The programme was developed with experts within the context of farmers making decisions with multiple economic, environmental and social drivers. As a consequence, the framework, knowledge and learnings from the programme have already informed a pilot and subsequent inclusion in the Project Step Change initiative.

Building on the Dairy Action for Climate Change (DACC) rural professionals (2017) and farmer (2018) workshops, and the behaviour change programme, a pilot presentation was made to target farmers (Māori) and to farmers/rural professionals (SIDE conference 2019) and a number of other events (NZIPIM conference 2019). These utilised the 'steps to change' outlined in the behaviour change programme which has had significant impact for Government and industry, with Project Step Change targeting the complexity of farm profitability within multiple environmental (water and air quality) economic and social drivers.

In addition to new work programmes with industry, results from previously funded Integrated Farm Systems research has been widely presented and reported in the rural media over the past year.

MĀORI-FOCUSSED RESEARCH PROGRAMME

PROGRAMME LEADERS: PHIL JOURNEAUX AND DR TANIRA KINGI

This programme built on the previous two stages by demonstrating the on-farm changes required for Māori farms to meet Government greenhouse gas (GHG) reduction targets. The modelling parameters in the previous two stages of the programme (starting in 2014) were largely determined by the farm management and governance teams based on their preferences that aligned with their individual business strategies.

This project covered:

1. Expansion of the project Reference Group, which involved representation from: Te Tumu Paeroa, Federation of Māori Authorities, DairyNZ, Fonterra and Beef + Lamb NZ.
2. Based on criteria developed by the Reference Group, four case study farms (two dairy and two sheep and beef) were selected. Following discussion with the farm governance/managers, a range of scenarios were modelled based around farm system changes and/or land use change (mostly forestry, although one farm included a horticultural development).

   The intent of the scenarios was to investigate options for the farms to meet the Zero Carbon Act GHG reductions. Each had spatial (ArcGIS) models developed and the modelling was done via a mix of Farmax (farm management model), OVERSEER® (nutrient budget/GHG model) and Forecaster (forestry economic model).

   The results were presented using maps, graphs and tables and were then discussed with the respective case study farm governors and management teams to assess the viability of the options available to them, and the implications for GHG emissions and farm profitability.

   A summary of the results is:

   - Changes in farm systems could potentially meet the 2030 10% methane reduction, although this result would require medium-term strategies (i.e. most could not be achieved in a short time frame of one-to-three years)
   - Achieving the 2030 nitrous oxide target and any of the 2050 targets, required offsetting via forestry

A copy of the full report is available at: **https://www.agfirst.co.nz/wp-content/uploads/2020/07/Achieving-Zero-Carbon-Act-Reduction-Targets-on-Farm.pdf**

3. An extension framework was developed. This has resulted in:
   - Raising awareness and understanding of climate change/on-farm GHG emissions
   - Significantly improving understanding of farm systems and land use change and the implications of this on GHG emissions
   - Giving options to consider in both mitigating and/or offsetting GHG emissions, and the implications of this for business profitability
   - And ultimately giving some confidence to consider changes in farm systems and/or land use change

The detailed NZAGRC Extension Methodology developed over the past six years has the following ten steps:

1. Determine owner/farmer objectives (short and long term) and access copies of strategic, management and environmental plans where available
2. Interview owner governance i.e. trustees, directors, committees of management to understand their preferences, priorities and level of interest in environmental mitigation options
3. Access on farm data including farm maps where available
4. Interview farm managers and consultants to gain information and data on livestock policies, farm inputs and expenses, needed to develop OVERSEER® and Farmax files along with mitigation options
5. Produce baseline status quo description of the farm system including GHG profile
6. Produce mitigation options including farm systems changes and land use changes
7. Produce status quo aerial map showing current land utilisation and potential land use changes
8. Present report to the governance and management team to discuss results and options
9. Provide background and context information on climate change policy and the science behind the mitigation options
10. Agree on mitigation options and produce final report with systems and land use changes showing the economic and environmental impacts; along with other social impacts of options including diversification to forestry or horticulture

RESEARCH TO SUPPORT POLICY

During 2017/18 an NZAGRC-funded project reviewed the GHG algorithms in the OVERSEER® Nutrient budget model. This model has been recommended as the tool of choice for on-farm reporting of methane and nitrous oxide emissions. However, on-farm GHG reporting is reliant on full confidence in the GHG estimates being produced by the model.

The current algorithms and approaches for estimating on-farm methane and nitrous oxide emissions in OVERSEER® have been evaluated and the existing code has been systematically checked. Recommendations from the project team have been documented and reported to an MPI/OVERSEER®/NZAGRC steering group. Work on implementing changes to the OVERSEER® code commenced in early 2019.

The Director of the Centre was closely involved with the Interim Climate Change Committee into the start of the 2019/20 year. He was then successful in the recruitment and selection process for the Climate Change Commission, which was announced on 17 December 2019. He has been appointed for a two-year term.

The CCC will assist the Government in deciding on future policy, including the possible inclusion of agriculture in the Emissions Trading Scheme, and the setting of targets for emissions reductions in order to adhere to the commitments New Zealand has made as part of the Paris Agreement.

Extension and outreach was a growing area of work for the Centre during 2019/20. Ag Matters – a climate change website for farmers, growers and rural professionals established by the Centre during 2018/19 – was substantially redeveloped and expanded, and relaunched in June 2020. The site provides engaging, science-based content (written and video format) on understanding and managing agricultural greenhouse gas emissions at the farm level. It has been very well received by the sector and will continue to be developed during 2020/21 with additional funding from MPI's Sustainable Land Management and Climate Change Programme (SLMACC).

The Centre also delivered a nationwide series of one-day training seminars for rural professionals on climate change. 17 events were organised in partnership with the New Zealand Institute for Primary Industry Management (NZIPIM) and co-delivered by senior scientists from the Centre alongside Phil Journeaux, a highly experience farm consultant from AgFirst. Over 300 rural professionals attended, and feedback was extremely positive. Six further seminars will take place in 2020/21 with additional SLMACC funding.

These one-day seminars covered the basics of climate change and on-farm emissions. During their delivery the need was identified for a more advanced, hands-on workshop for rural professionals wanting to work directly with farmers to advise them on on-farm greenhouse gas estimation and management. The Centre, working with Phil Journeaux, began preparing to hold two pilot workshops during the latter part of 2019/20. However, the COVID-19 lockdown restrictions meant delivery of these was delayed until August 2020.

The Centre also worked with NZIPIM to develop a competency framework for rural professionals wishing to measure their basic knowledge of climate change and agriculture. This will be available for use in 2020/21.

PROGRESS TOWARDS SOLUTIONS – A SNAPSHOT

Identifying mitigation solutions is a key component of the NZAGRC's Vision and Mission. The complexity of the problem means that it is a long-term goal. Successfully reducing greenhouse gas (GHG) emissions below a historical baseline will require progress in both direct and indirect mitigation options.

Direct mitigations are those solutions that reduce absolute emissions per unit of substrate (e.g. feed, nitrogen). Indirect mitigations are those that arise as a result of general improvements in the efficiency of production (e.g. by improved animal genetics and feeding practices which will reduce emissions per unit of product but may increase absolute emissions per animal). It is important that the new knowledge developed in NZAGRC-funded and NZAGRC/PGgRc co-funded research programmes has a practical impact on the GHG emissions from New Zealand agriculture. The table below highlights some key outputs from 2019/20 and their envisaged impacts.

NZAGRC / PGgRc CO-FUNDED	EXPECTED IMPACT
The current objectives within the PGgRc-NZAGRC methane programme have made significant progress this year, with the sheep breeding programme making research breeding values for low methane emissions available to selected ram breeders through Beef+Lamb Genetics.	As breeders and producers consider incorporating methane breeding values into their own breeding programs, the selection lines continue to provide a vital demonstration that this is a safe and practical mitigation strategy.
Milk samples were obtained from high and low methane emitting ewes at two, four and six weeks post-lambing. The resulting dataset will provide a unique resource to study associations between rumen microbial composition, methane emissions, circulating volatile fatty acids in the blood and detailed fatty acid profiles in milk.	Results will be of interest to all ruminant livestock systems for neonatal growth profiles, milk production, dairy processing and dairy product composition. They will provide valuable information to help the search for rapid and inexpensive 'proxy' estimates of methane production for use in animal selection programmes.
A very successful collaboration has been with the Global Research Alliance's Global Partnerships in Livestock Emissions Research (GPLER) funded programme "Microbes to Predict Methane". This project used samples collected early in this research programme to develop methods for the prediction of methane.	Results show very promising results for the estimation of methane breeding values in ruminant livestock by rumen microbial community analysis. From next year we will report and compare methane predictions from microbial samples as well as from genomic and Portable Accumulation Chamber (PAC) data.
NZAGRC FUNDED	**EXPECTED IMPACT**
Process-based models were used to assess the effect of three plant traits and one management practice on nitrous oxide emissions, nitrogen losses via leaching or ammonia volatilisation, pasture production and Soil Organic Carbon (SOC) changes (as applicable). The aim was to identify traits/management practices that could potentially be environmentally beneficial and could then inform future research to find or breed plants with those traits.	Of these, the nitrogen concentrations in animal feed provided the most promising results, with low nitrogen concentrations in animal feed resulting in lower urine nitrogen excretion and consequently reduced nitrous oxide, ammonia, and leaching losses.
Work continued on developing field scale measurement approaches for both nitrous oxide and carbon balance and using these to determine benefits of plantain in ryegrass/clover sward in comparison to ryegrass alone.	Plantain has generally been shown to reduce nitrous oxide emissions using chamber studies. We have demonstrated that a newly-developed methodology allows us to test the effect of plantain and other mitigation strategies on nitrous oxide and soil carbon at paddock scales within a farming system.
Determining the effects of irrigation on carbon balance and nitrous oxide using experimental and modelling approaches.	Findings suggest that, over short periods in well-drained soil, irrigation frequency could be managed to manipulate soil water deficits in order to reduce net below-ground carbon losses, particularly those from the microbial decomposition of soil organic matter, with no significant effects on biomass production and nitrous oxide emission.
During 2019/2020 both the sheep and beef and dairy components of the Integrated Farm Systems research programme have continued. The dairy programme has been a collaboration with DairyNZ and Reputation Matters (Liz Read) to develop the framework for a behaviour change programme. The sheep and beef programme has been co-developed with Beef + Lamb New Zealand (B + LNZ).	A highlight of the year has been the impact each of the work programmes has already had through both Government and industries. The sheep and beef part of the programme has provided new insights into GHG emissions from the sheep and beef sector by identifying and assessing the drivers of GHG emissions on > 100 real sheep and beef farms.
The Integrated Farm Systems dairy programme designed a 'behaviour change' programme in partnership with Liz Read (Reputation Matters). The programme was developed with experts from across AgR and DairyNZ within the context of farmers making decisions with multiple economic, environmental and social drivers.	This not only bought clarity and focus to the programme framework, but positioned the work for rapid uptake and inclusion into developments within the industry. The framework, knowledge and learnings from the behaviour change programme have already been used to inform a pilot study and been incorporated into the DairyNZ Project Step Change initiative.
The Māori-Focussed Research Programme built on previous work by demonstrating the on-farm changes required for Māori farms to meet GHG reduction targets. Modelling parameters in the previous two stages of the programme (starting in 2014) were largely determined by the farm management and governance teams based on their preferences that aligned with their individual business strategies.	Modelling suggests that changes in farm systems could potentially allow some Māori entities to meet the 2030 10% methane reduction target. The results suggest that, medium-term strategies are needed as most enterprises examined could not achieve the required reductions in the short term i.e. one-to-three years. Achieving the 2030 nitrous oxide target and any of the 2050 targets, required offsetting via forestry.

NZAGRC INTERNATIONAL DIMENSIONS

The New Zealand Government initiated the Global Research Alliance on Agricultural Greenhouse Gases (GRA) in 2009 to increase international cooperation and investment in agricultural research activities that mitigate the effect of greenhouse gas emissions. A decade later, 64 countries and 22 international and regional partners are working together in the pursuit of this goal. It remains a key plank in New Zealand's work on climate change and agriculture, offering significant opportunities to build global research and commercial partnerships and strengthen domestic capability.

NZAGRC has played a critical science leadership role in the GRA for over a decade, including continuing to co-chair the GRA's Livestock Research Group (LRG) and providing strategic advice and support to MPI (which administers the GRA Secretariat and the Government's dedicated multi-million GRA budget). NZAGRC works closely with key GRA partners such as the FAO, World Bank and CCAFS (the CGIAR's Research Program on Climate Change, Agriculture and Food Security) to deliver international and regional projects on behalf of the GRA and to raise awareness of the opportunities associated with low emissions livestock production. NZAGRC advises on the strategic direction of the GRA, helps link its activities internationally and ensures that the New Zealand science community is well engaged. It also promotes the work of the GRA more broadly via a range of communication channels.

NZAGRC led or supported a wide range of GRA activities during 2019/20 as well as continuing to negotiate and manage GRA research contracts on behalf of MPI. During 2019/20, NZAGRC provided advice and support to MPI in making a case for additional funding for the GRA. The Government subsequently confirmed $34 million as part of Budget 2020. This comes on top of $65 million invested over the period 2010-2020. The new funding ends 30 June 2024. Since the announcements, NZAGRC has been working closely with MPI to develop a comprehensive investment strategy for the new funding focussed on expanding New Zealand-supported capability building activities in developing countries, and collaborative mitigation research with international partners.

NZAGRC delivered a highly-productive LRG meeting in August 2019, including facilitating the participation of 13 GRA representatives from developing countries. NZAGRC also represented the LRG at the GRA Council meeting and associated Climate Smart Agriculture conference in Bali, Indonesia in October 2019, and facilitated the participation of 32 GRA grants recipients and 14 GRA representatives from developing countries at both events.

The impact of the global COVID-19 pandemic in 2020 on NZAGRC's GRA efforts has been substantial. Since March, it has seen the Deputy Director trapped in Italy and unable to return to New Zealand because of visa restrictions. The LRG's annual meeting – scheduled for September 2020 in the UK – had to be shifted to a digital platform, and several significant capability building workshops were either cancelled or postponed. 12 GRA contracts managed by the NZAGRC required renegotiation to extend end dates (and budgets in some cases), and three LEARN awards are also on hold.

RESEARCH ACTIVITIES

NZAGRC monitored 29 GRA research projects for MPI during 2019/20 and negotiated an additional three. 12 GRA contracts required renegotiation because of delays caused by COVID-19 restrictions. Seven projects were completed. The following is a selection of research highlights:

- New leads have been identified in an AgResearch-led project focussed on the development of novel methane inhibitors, with six compounds showing promising reductions in in vitro testing
- Proof of concept was demonstrated for a walk-on integrated field monitoring platform for real-time monitoring of beef cattle. The platform is the first of its kind to measure real-time animal productivity in the field. The project is led by Massey University
- Ten compounds have showed promising efficiencies in inhibiting nitrous oxide emissions and are being further developed in a GRA project led by Lincoln University
- A new global database on ammonia and nitrous oxide emissions from manure management has been launched as part of AgResearch's 'Dataman' project
- Results from Plant & Food's Full Inversion Tillage (FIT) research indicated that there may be lower nitrous oxide emissions from FIT pasture renewal compared to no tillage renewal or continuous (undisturbed) pasture

CAPABILITY BUILDING

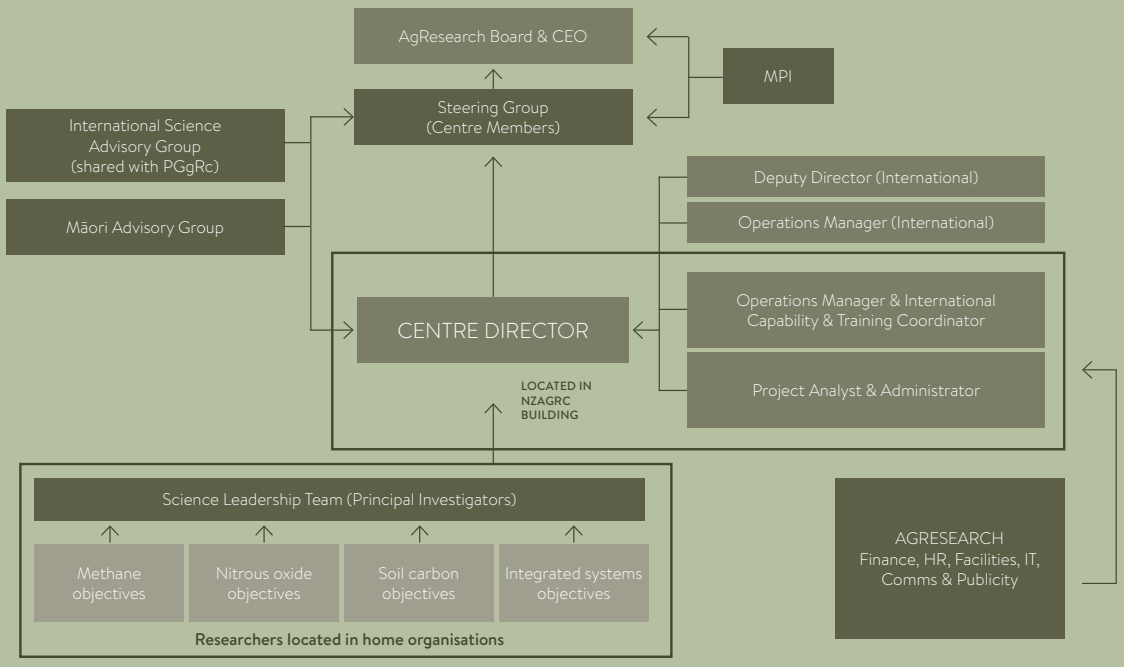
Provision of capability building services to the GRA was another major area of effort for NZAGRC during 2019/20. Key achievements included:

- Continuing to support developing countries progress to more advanced greenhouse gas inventories for livestock sector emissions and co-developing a much-needed set of guidelines to improve activity data input to inventories
- Development of a GRA Action Plan for Africa and work to better understand approaches in the region to measuring, reporting and verifying (MRV) livestock greenhouse gas emissions and to develop associated emission factors
- Continuing to lead the GRA's relationship with the international Climate and Clean Air Coalition (CCAC)
- Maintaining the long-standing relationship with the Intergovernmental Panel on Climate Change, including appointing two Postdoctoral Researchers to the NZAGRC to assist the Director in his Lead Author role for the IPCC's Sixth Assessment Report

NZAGRC GOVERNANCE

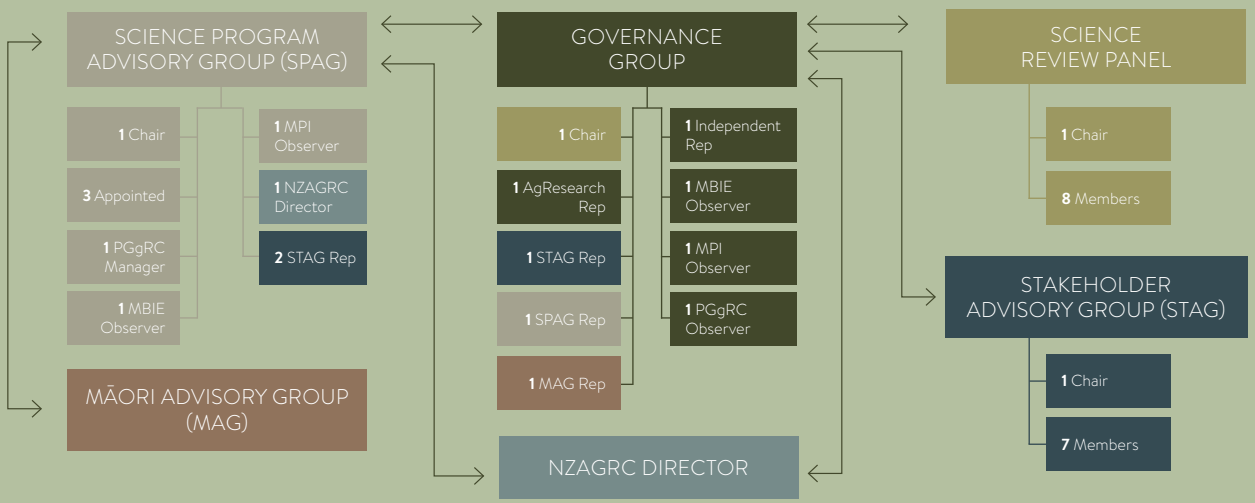
GOVERNANCE TO JUNE 30 2020

The NZAGRC was set up as a unit operating within AgResearch, with the Board and Chief Executive (CEO) of AgResearch having ultimate responsibility for the NZAGRC. A Steering Group comprising a representative of each NZAGRC Member has provided advice and recommendations to the AgResearch CEO and Board on the operation of the NZAGRC, and the NZAGRC Director reported to the AgResearch CEO and Board via the Steering Group. An International Science Advisory Group (ISAG) monitored, advised and reported on the NZAGRC's science quality and direction to the SG and NZAGRC Director as required.



GOVERNANCE FROM JULY 1 2020

AgResearch will remain as the NZAGRC's legal host from 2020. Governance and oversight of decision making will be devolved by the AgResearch Board to a separate NZAGRC Governance Group, supported by Stakeholder and Science Advisory Groups. The Governance Group is a skills-based group that will oversee the NZAGRC's work. It will comprise an Independent Chair (appointed by AgResearch, MPI and MBIE), an AgResearch representative, a Stakeholder Advisory Group representative, a Science Programme Advisory Group representative, a Māori Advisory Group representative, an Independent member with Government experience/industry knowledge (appointed by Chair, AgResearch, MPI and MBIE), and observers from MBIE, MPI, and the PGgRc.



NZAGRC STAFF

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Dr Harry Clark
NZAGRC Director

Dr Jeroen Dijkman
Deputy Director (International)

Jessica Somerton
NZAGRC Operations Manager

Dr Nimlesh Balaine
Operations Manager

Laura Kearney
Operations Manager (International)

Dr Sinead Leahy
International Capability and Training Coordinator

Jillian Sinclair
Project Analyst

Kate Parlane
Project Analyst (from January 2020)

Trina Bishop
NZAGRC Administrator

STEERING GROUP REPRESENTATIVES

Trevor Suthridge

Dr David Burger

Dr Peter Millard (Chair)

Kevin Hurren

Prof. Peter Kemp

Mike Harvey

Mark Aspin

Sarah Bromley

Dr Steve Wakelin

Neil Williams
MPI (Observer)

Liz Clayton
MPI (Observer)

Dr Gerald Rys
MPI (Observer)

Alison Fordyce
MBIE (Observer)

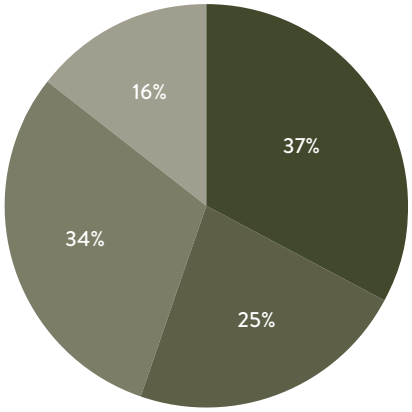
FINANCES AND PERFORMANCE

Total funding for the Centre in 2019/20 was $4.39 million (including carry over from 2018/19). This covers core research programmes, other research funding (including fellowships and short-term projects) and administration.

In addition to the investment in science, funding has also been used to contribute to Governmental policy projects and the implementation of a communications outreach plan.

NZAGRC CORE RESEARCH FUNDING SPLIT 2019/20

- Methane
- Nitrous Oxide
- Soil Carbon
- Integrated Farm Systems and Māori



CAPABILITY DEVELOPMENT
(ACTIVE IN 2019/20)

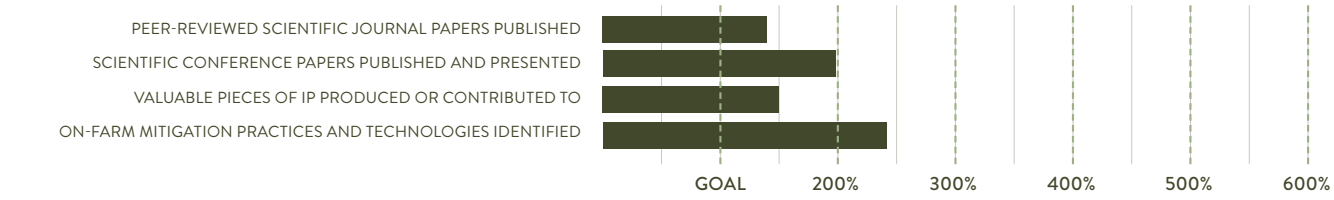
INTERACTIONS AND OUTPUTS 2019/20

- 37 MEETINGS AND PRESENTATIONS (NEW ZEALAND)
- 32 CONFERENCE PRESENTATIONS
- 19 JOURNAL ARTICLES PUBLISHED
- 16 OTHER INTERACTIONS/ PUBLICATIONS
- 15 JOURNAL ARTICLES IN PRESS
- 12 MEETINGS AND PRESENTATIONS (INTERNATIONAL)
- 10 GLOBAL RESEARCH ALLIANCE RELATED INTERACTIONS
- 07 INTERNATIONAL VISITORS AND GROUPS
- 06 MEDIA INTERACTIONS
- UNDERGRADUATES 05
- POST-DOCTORAL FELLOWS 02
- MASTERS 01

The NZAGRC has five Key Performance Indicators (KPIs) relating to its work for 2016-20. Below is the progress towards meeting these and our specific goals as at 30 June 2020.

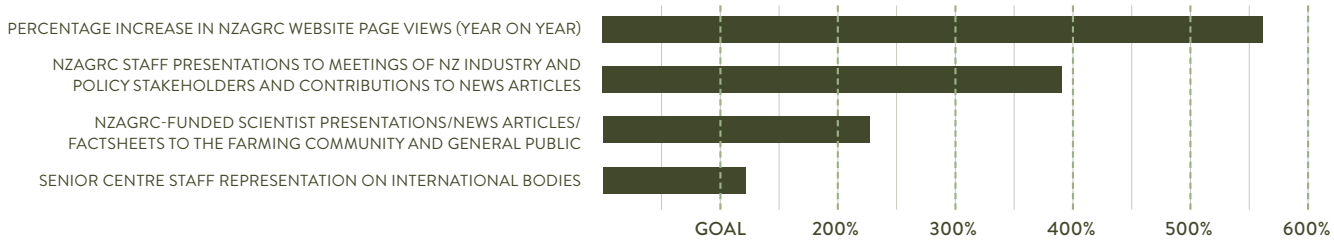
KPI 1: Advance knowledge and understanding

To be the most important and trusted New Zealand source of scientific knowledge in the field of agricultural GHG emissions mitigation



KPI 2: Enhance awareness among stakeholders

To be the most important and trusted source of information for New Zealand agricultural stakeholders on agricultural GHG emission mitigation

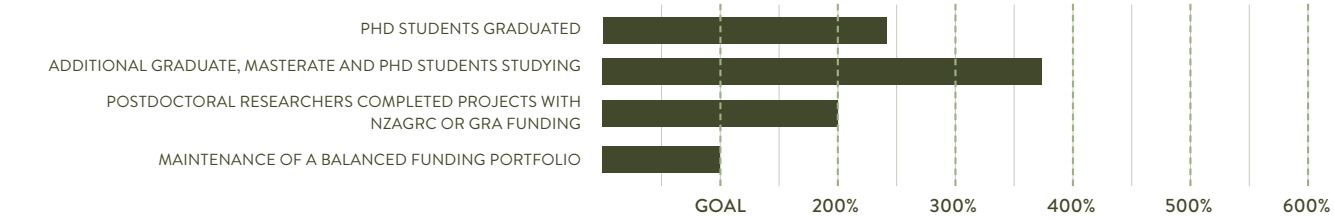


KPI 3: Contribute to policy

To be the authoritative source of information for the New Zealand Government on agricultural GHG emission mitigation

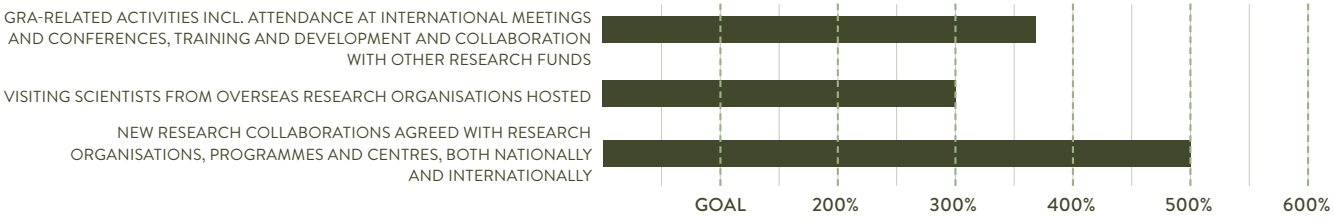
KPI 4: Develop science capability

To be a major source of new capability in the field of agricultural GHG emission mitigation



KPI 5: Develop science and commercial partnerships

To be a key player in many research and commercial partnerships relating to agricultural GHG emission mitigation



ACRONYMS USED IN NZAGRC DOCUMENTS

ACRONYM	DEFINITION
NZAGRC	New Zealand Agricultural Greenhouse Gas Research Centre
PGgRc	Pastoral Greenhouse Gas Research Consortium
GRA	Global Research Alliance on Agricultural Greenhouse Gases
GHG	Greenhouse Gases
LEARN/GRASS	Fellowships – Livestock Emissions Abatement Research Network and Global Research Alliance Senior Scientist awards to build international capability in live stock emissions research
MPI	Ministry for Primary Industries
SLMACC	The Sustainable Land Management and Climate Change Research Programme of MPI
DACC	Diary Action for Climate Change
FAO	The Food and Agriculture Organisation of the United Nations
CGIAR	A global partnership that unites organisations engaged in research for a food-secure future
CCAFS	The CGIAR's Research Programme on Climate Change, Agriculture and Food Security
MBIE	Ministry of Business, Innovation and Employment

LEADING PARTNERS IN SCIENCE

agresearch *āta mātai, mātai whetū*

DairyNZ

Manaaki Whenua Landcare Research

Lincoln University *Te Whare Wānaka o Aoraki* CHRISTCHURCH•NEW ZEALAND New Zealand's specialist land-based university

MASSEY UNIVERSITY

NIWA Taihoro Nukurangi

Plant & Food RESEARCH RANGAHAU AHUMARA KAI

PGgRc PASTORAL GREENHOUSE GAS RESEARCH CONSORTIUM

SCION FORESTS•PRODUCTS•INNOVATION

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