-A Pastoral Greenhouse Gas Research Strategy

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Executive Summary

The purpose of this paper is to present a strategy for research on abatement of pastoral agriculture's greenhouse gas emissions. The research is funded through a partnership between Government and the agricultural industry and is managed by the Pastoral Greenhouse Gas Research Consortium (PGGRC). The dairy, sheep, beef cattle, deer sectors, and fertiliser manufacturers are industry partners in the PGGRC and contribute funds to its current and future research programmes and, independently, through their own programmes. The Government contribution is direct to PGGRC via the Foundation of Research, Science and Technology (FRST) and through the Ministry of Agriculture's (MAF) own research programmes, which will continue to fully fund New Zealand's official inventory measurements.

This strategy combines the recommendations of the report prepared by O'Hara, Freney and Ulyatt for Government and the Primary Industries Council (O'Hara report) the strategy developed by the PGGRC at its launch in 2002 (in keeping with the requirements of the Foundation for Research Science and Technology for establishment of Research Consortia), and work already being funded individually by the agriculture industry. All of the areas of research recommended by the O'Hara Report are represented in the columns headed "Areas of Investigation" in the tables and specific proposals below.

STRATEGY GOALS

The goals of this strategy are:
- to identify, establish and develop on-farm technologies to improve production efficiency for ruminants;
- to identify, establish and develop on-farm technologies for sheep, dairy and beef cattle, and deer, which lower methane emissions from New Zealand ruminants and nitrous oxide from grazing animal systems; and
- to exploit commercial opportunities arising from the science and technologies in a global market.

The target is to have **safe, cost-effective** greenhouse gas abatement technologies, which will lower total New Zealand ruminant methane and nitrous oxide emissions by at least 20 percent as compared with the 'business as usual' emissions level, by the end of the first commitment period (2012). Individually, none of the options outlined below provides a simple, universally applicable mitigation technology. However, taken collectively, and if widely adopted, they should at the very least defer any rise in New Zealand's agricultural emissions over the next 10 years.

An overall reduction in methane production per individual animal is the ideal goal. Realistically, given the nature of agricultural production systems, the immediate goal will be to reduce methane per unit of production. Thus, as productivity per animal increases, the goal is to reduce the amount of methane produced for each unit of output (e.g. kg of milk, meat).

RESEARCH STRATEGY AND PLANS

The O'Hara report identified short to medium term research opportunities, which may improve the efficiency with which plant energy and protein are utilised by grazing animals and reduce the methane and nitrous oxide emissions per kg of dry matter. However, these technologies would

only reduce total emissions if animal numbers and/or production was capped. Nonetheless, improving efficiency is an important objective that may create mitigation options that do not currently exist.

The O'Hara Report also noted that a better understanding of fundamental biological processes was needed before technologies that might alter the processes by which methane and nitrous oxide are formed could progress. This area, therefore, requires research of a longer term nature.

This strategy proposes a balanced portfolio that explores both the shorter-term efficiency gains and the longer-term fundamental 'discovery' research. Research funds will be allocated to three **science result areas**:

- "discovery": fundamental studies to understand processes;
- "proof of function/concept": research that demonstrates feasibility and establishes the parameters of the technology;
- "product development/on-farm testing": development of the technology to a usable form.

The pursuit of the dual outcomes of improved productivity and abatement of greenhouse gas emissions have been emphasised in the development of this research strategy. Farmers wish to invest primarily in research that has a productivity benefit and that in some research programmes, the measurement of methane and nitrous oxide emissions may not be necessary to measure productivity gains. The substantial government research investment through the Foundation for RS&T acknowledges the national benefits that are derived from making these measurements in those circumstances.

The proposed research is summarised in the following tables.

A SUMMARY OF METHANE RESEARCH

Result Area	Areas of investigation	Funded programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
Discovery	Methanogen genomics	Genome sequences Identification of methanogen inhibitors.		
	Rumen microbes	Strategies to modify hydrogen and methane production by microbes Novel methanogens in other species.	Explanation of apparently low emissions in deer. Methane oxidising bacteria.	2004-05 - follow-up research investigating deer emissions planned under Inventory work in 2003-04. If lower emissions do prove repeatable, develop research objective to look at why deer appear unique and opportunities offered for other species.
	Animal factors	Investigate whether between-animal differences are genetically determined or due to other factors.		

Result Area	Areas of investigation	Funded programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
	Methane inhibitors-Forage	Isolation of condensed tannins/plant inhibitors with anti-methanogenic properties. Desk-top study of literature on inhibitors.		Review will occur in first half of 2004.
	On-farm testing protocols	Desk study protocol for evaluation of potential rumen function modifiers before trialling. Malate / fumarate review completed.		
Proof of concept/ function	Vaccination	Test CSIRO vaccine in sheep.		Review will occur in second half of 2003.
	Condensed tannins	Feeding trials with Lotus corniculatus, kikuyu and sulla.		
	Diet Manipulation	Evaluation of mitigation options using grains, oils, fats.		
	Forage mixes	Design of rations to economically improve efficiency by reducing methane output per kg DDMI and through diluting the animal's maintenance requirements.		Research is currently underway with known products e.g. sulla. Additional work would be needed on completion of Discovery work around Forage Methane Inhibitors.
	Monensin	Monensin (Rumensin™) may reduce methane by 20 percent - some acceptability concerns with feeding an antibiotic. Evaluation is needed in NZ farming conditions.		
Develop-mental / on-farm testing	Farm scale modelling / resource accounting		See Modelling	
	Inhibitor screening bioassay	Anaerobic culture methods used to test methanogen survival following addition of plant extracts with suspect anti-methanogen properties.		
	Increased Legume Content	On-farm evaluation to increase CTs feeds available (clover establishment). Development of management guidelines to assist farmers growing/feeding birdsfoot trefoil and sulla.		
Technolgy Transfer	Increased Legume Content	Extension of results of practices to improve legume establishment and survival.		

A SUMMARY OF NITROUS OXIDE RESEARCH

Result Area	Areas of investigation	Funded Programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
Discovery	Nitrification inhibitors		Identify novel nitrification inhibitors	The novel inhibitors work would follow if DCD work in Proof of Concept proves unsuccessful.
	Fundamentals of N2O production, transformation and transfer.	Identify factors which affect Pasture plant uptake of N. Processes and drivers of N loss from soils and emission of N2O.		Desktop study in first half of 2004 to provide base for development of Science Programme.
	Research into effect of timing of fertiliser applications that produce the required agronomic result on N2O[1] emissions	Set guidelines on N fertiliser use and timing of application in relation to rainfall and soil wetness to minimise N2O emissions from soils.		Commence 2004
	Input response functions for excreta[2]	Definition of the relationships between quantities of N in urine and N2O output together with outputs from dung affected soil. (Increase N retention and increase the dung-N to urine-N ratio).		Commence 2004
	Diet manipulation (N levels that more closely match animal needs) Manipulate dietary C/N ratio to increase N retention	Trial will look at, effect of use of stand off pads and maize silage inputs.	Selection of forage species that reduce N intake in excess of animal requirements Or offer an energy/N balance that favours N retention.	Post Desktop study, Yr 1 - 2004/05
	Research into product gas ratio (N2O vs. N2)[1]	Investigate product gas ratios (trap nitrate and favour the emission of N2 rather than N2O in riparian and other wet areas), including determination of CH4 emissions from these areas.		Commence 2004
Proof of concept/function	Delivery of nitrification inhibitors to target sites	Ongoing development of cost effective ways to use DCD Developing early DCD results in the field.		Commence 2004

Result Area	Areas of investigation	Funded Programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
Developmental/ on-farm testing	Farm scale modelling / resource accounting		See Modelling	
	On-farm testing protocols	Desk study protocol for evaluation of potential inhibitors of N2O production before trialling.		
	On-farm testing of mitigation options through managing critical source areas of N2O	Management practices for improving soil aeration and drainage, reducing soil compaction, and/or application of effluent and sewage.		
Technology Transfer	Development of soil management guidelines	Wet soils best management practices. Best management practices for irrigated soils.		

A SUMMARY OF METHANE, NITROUS OXIDE MEASUREMENT, INVENTORY AND MODELING RESEARCH

Result area	Areas of investigation	Funded Programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
Methods and Tools	Improved measurement of ruminant methane emissions Selection and development of models	Dairy whole farm model including GHG estimates. Reduce cost of SF6 measurements. Measurement of the environmental performance of the dairy industry (includes GHG measurement).	A critical evaluation of existing models with a view to selecting and developing the most promising ones depending on their purpose e.g. • research • inventory • whole farm resource allocation • regional resource use • decision support	In the first half of 2004 conduct desktop study of Models and develop Strategic direction for greenhouse gas modelling.
Inventory	Refine emission factors (NZ Tier 2 status)	More data on N2O emissions from range of pastoral land Verify methane emission estimates for deer. Get IPCC acceptance of input/output model estimates of CH4 and N2O emissions.		

Result area	Areas of investigation	Funded Programme objectives	Objectives to be investigated, developed and funded	Timing of Objectives
	Verification tools	Methods and models that enable verification of adopted abatement measures.		
	Uncertainty	Define practical limits of uncertainty reduction in inventory estimates (MAF).		

RESEARCH BUDGET

The available funding is summarised in the following table. The funding in the column headed 'Primary' refers to joint industry- Foundation for RST funded programmes directly controlled by PGGRC. The column headed 'Secondary" refers programmes funded by industry or government agencies that is not under the direct control of the PGGRC. The term of the joint industry-FRST funding is to 2006/07. The terms of the other programmes varies between 1 and 5 years. Details are provided in the tables in the body of this report.

		Primary $000(GST exclusive)	Secondary $000 (GST exclusive)
Methane	Discovery	1197	400
	Proof of concept/Development	871	1,806
Nitrous oxide	All research	676	545
Measurement Modelling	All research	243	498
	Total	**2,987**	**3,249**