Issue 10 June 2002

From the Editor

This *RM Update* issue is focused on the topical issue of climate change. The Government has recently announced its preferred policy package for reducing greenhouse gas emissions in response to climate change and the Kyoto Protocol. Instead of focussing on the policy debate this *RM Update* issue examines some of the technical issues involved with agriculture and greenhouse gases and aims to provide information on greenhouse gas emissions from agriculture, regional impacts and adaptation strategies, the effects of climate change on water supply, mitigation options, and the possibility of using bio-ethanol for transport fuels.

Duane Redward, Editor

Greenhouse Gas Emissions From New Zealand Agriculture

Agriculture has received considerable attention regarding its contribution to New Zealand's greenhouse gas emissions. The following article by Gerald Rys presents information on the agricultural contribution to greenhouse gas emissions in New Zealand.

Introduction

The world is warming and the climate is changing. This is the conclusion of the Intergovernmental Panel on Climate Change (IPCC) in its latest *Third Assessment Report* (2001).

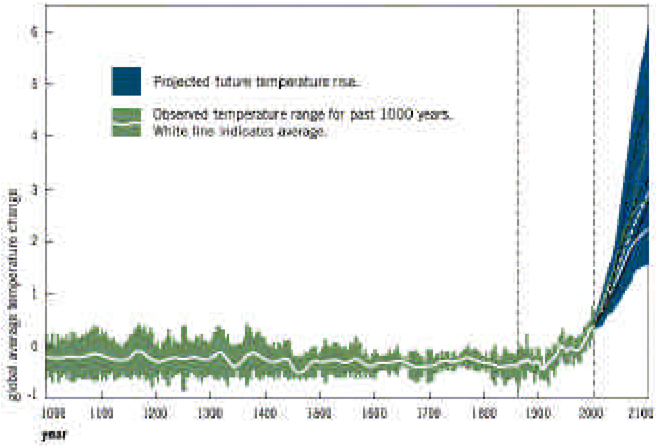
Climate change is considered one of the most serious threats to the sustainability of the world's environment, human health and well-being, and the global economy. Mainstream scientists agree that the Earth's climate is being affected by the build-up of greenhouse gases (GHGs), such as carbon dioxide, caused by human activities. A majority of scientists believe that precautionary and prompt action is necessary.

The effects of climate change are already measurable and include:

- the world's 10 warmest years have all been since 1983 – seven of them since 1990;
- the global mean temperature went up about 0.6°C between 1861 and 2000;
- sea levels rose between 10 to 20 cm between 1900 and 2000;
- glaciers are retreating;
- Arctic sea ice is thinning and reducing;
- 1998 was the world's – and New Zealand's – hottest year since records began.

The graphs below clearly illustrate the increasing global temperature pattern.

Figure 1: Variations in surface temperature for the last 1000 years and projected temperature rise under the range of IPCC future scenarios



Source: IPCC Third Assessment Report One; Climate Change: The Scientific Basis, 2001

New Zealand's Emissions Profile

New Zealand is required to submit an annual inventory to the United Nations Framework Convention on Climate Change. The inventory presented for 2001 gave the following GHG emission and sink levels in carbon dioxide equivalents (Table 1).

Table 1: Emissions and removals of greenhouse gases in New Zealand in 1990 and 1999 as reported in New Zealand's *National Inventory Report* 2001. All data is in thousands of tonnes of CO2 equivalents.

	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	HFCs	PFCs	SF6	Total Emissions
1990	25,399	-22,307	35,211	11,849	Negligible	603	2.87	73,065
1999	30,523	-23,245	33,594	12,397	210	74	33.2	76,831

Note the significant increases in carbon dioxide emissions over the nine-year period are due largely to increases in transport and energy emission increases. Recent reviews of the methodology used for establishing emissions from agriculture suggest that there is an increase (rather than decrease) in methane emissions (above 1990 levels) and that current nitrous oxide emissions (above 1990 levels) are greater than currently identified. These changes have yet to be peer reviewed and incorporated into the national inventory. The reasons for these differences are discussed later. Table 2 presents the distribution of GHGs between different sectors in 1990 and 1999. The dominance of the agriculture sector is clearly evident. The agricultural sector emissions are made up largely of methane and nitrous oxide and have significant uncertainties associated with them. This means New Zealand has one of the highest uncertainties in its national inventory compared with other developed countries party to the Kyoto Protocol. These high uncertainties mean New Zealand needs to ensure that we carry out research and establish best practice methods for deriving our agricultural inventory.

Table 2: Gross relative radiative forcing (% in CO_2 equivalents)– relative sectoral shares in 1990 and 1999 (National Communication, Ministry for the Environment, 2001)

Sector	1990	1999
Energy	33	38
Processes	4	4
Agriculture	59	54
Waste	4	4

Future Developments in the National Inventory

Establishing the current quantity of emissions from agriculture at a national level is not a trivial exercise. While standard values can be adopted through the IPCC Good Practice Guidelines, these values do not reflect the unique circumstances of New Zealand agriculture. New Zealand is seeking to adopt a more comprehensive national approach to assessing our GHG emissions from agriculture. The government approved additional funds this year to improve the national agricultural inventory. This has enabled a detailed re-valuation of the basis for calculating national emissions. The research results have identified some interesting factors that will change the basis of past, present and future calculations. These factors include incorporating assessment of changing animal performance, New Zealand-specific methane emission and nitrogen input factors. One key question that the animal science community can address is the extent to which changes in animal performance, over time, are the result of more efficient feed conversion or better and/or more forage intake, and the relationship of these to methane output. The table below shows MAF figures on changes in some livestock performance attributes over the last 10 years. These changes are clearly due to past research and its adoption by farmers, and are a tribute to the success of past agricultural research in New Zealand.

Table 3: Livestock performance in New Zealand (1990 to 2000). Figures for 2000 are provisional. Sources: Statistics New Zealand, 2000; Ministry of Agriculture and Forestry, 2000

Product	Season Ended	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Wool/Sheep (kg Greasy)	30 June	5.1	5.3	5.4	4.9	5.7	5.8	5.5	5.8	5.7	5.5	5.6
Lambing %	30 June	96.6	100.4	105.7	95.4	102.5	107.3	104.3	111.9	117.3	113.6	114.9
Graded Lamb (kg/carcass)	30 Sept.	13.8	14.1	14.3	15.1	15.2	14.6	15.2	15.9	15.4	15.7	16.7
Graded Beef (kg carcass)	30 Sept.	237	240	233	248	250	244	242	254	241	240	245
Milksolids/Cow (kg)	31 May	232	233	254	252	275	255	259	283	280	262	300

Conclusions

Deriving a New Zealand Agricultural GHG National Inventory is a difficult and complex task. There are uncertainties in many of the parameters used to derive the inventory. This also means that any means of reducing GHG emissions in agriculture will have a significant impact on the national inventory. A programme of research has been instigated to ensure New Zealand will be using "best-practice" methods in deriving our national agricultural emissions in the future. This is important to ensure New Zealand meets international review panel requirements of our obligations under the Kyoto Protocol. Current research suggests that New Zealand agriculture will be significantly over the 1990 baseline GHG emissions by 2010; the middle of the first commitment period to the Kyoto Protocol. This is largely due to increasing animal performance since 1990 and the change in the balance of the numbers of different animal species e.g. decreased sheep and increased dairy animal numbers.

Gerald Rys
Senior Policy Analyst, Sustainable Resource Use Group, MAF Policy
Gerald has a background in agricultural science and science policy. He gained his agricultural science degree from Massey and his PhD for the University College of Wales. He was a scientist with MAF for 15 years carrying out largely agronomic research in Taranaki, Palmerston North and Hawkes Bay before moving to the Ministry of Research, Science and Technology. He recently moved back to MAF to take up a position in the sustainable resource use group looking at climate change and water issues.

Climate Change and Land Management in Hawkes Bay

The following article by Gavin Kenny reports on a pilot study commissioned by the Hawkes Bay Regional Council and the Ministry for the Environment on climate change and land management in Hawkes Bay.

The purpose of this study was to gain a better understanding of what is known about climate change in the region, what the issues are relating to possible impacts, and what the needs are relating to adaptation. Its particular focus was to bridge current scientific understanding with local expertise and knowledge of current issues and problems. This was achieved through a consultation process involving selected farmers, growers, industry people, scientists and Maori. The study also aimed at developing an understanding that adaptation to climate change can be best addressed through developing a long-term perspective in addressing current problems. Through this process it was possible to gauge the degree to which there was a need for a proactive approach to adaptation and what measures, if any, need to be taken to implement such an approach in Hawkes Bay.

There is a good awareness of climate change in the region, although understanding of the science is clouded to some degree by confused messages through the media. A good example is the seasonal and longer-term climate projections. At various times the media provide information on the El Nino Southern Oscillation (ENSO), the Interdecadal Pacific Oscillation (IPO), and climate change. A recent report on the IPO suggests the potential for moister conditions on average in Hawkes Bay over the next 20-30 years. At the same time the media have reported that climate change could lead to warmer, drier conditions on average in Hawkes Bay. The response of the rural sector to such information is "what do I plan for?". There is no simple answer, with the key lying in the need to gather better information on what the risks are in the region and identifying and implementing climate proofing strategies with a long-term sustainability picture in mind.

With an underlying trend from climate change towards warmer and drier conditions on average over the next 70-100 years, key issues identified were:

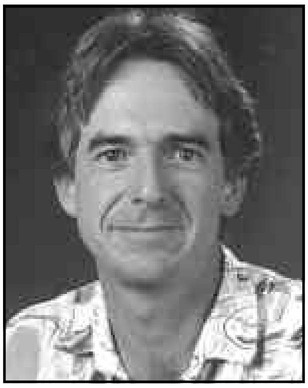
- Water – security of water supply is an issue now throughout Hawkes Bay and will become a bigger issue in future.
- Biosecurity – undesirable sub-tropical grasses and insect pests are already present with the potential to spread rapidly and become much greater threats to the region. A good example is Tasmanian grass grub, the spread of which was triggered during the warmer, drier, conditions experienced in the 1990s.
- Species survival – some summer dry hill country areas are already marginal and would be worst affected by warmer, drier, conditions as existing pasture species may not survive.

There is a strong belief among farmers and growers in Hawkes Bay that they have the capacity to cope with climate change and its effects, but at the same time they recognise that there are issues (such as those identified above) that are likely to require proactive measures. The study identified measures that could be evaluated and implemented over time, both to address gaps in knowledge and understanding and to provide the framework for a long-term adaptation strategy, including:

- more clearly identifying the risks, and areas in the region at risk, in the context of the most robust climate change scenarios. This would also need to take account of the 20-30 year cycles that appear to result from the IPO, and also the effects arising from ENSO and other fluctuations in climate;
- developing monitoring activities, which identify and quantify climate and biological changes that are taking place over time, and focus on identified risks and areas at risk;
- developing a greater capacity for resilient farming systems for the present and future that are both economically viable and ecologically sustainable;
- developing and implementing a region-wide education and information dissemination programme.

Ideally such measures need to be implemented through an integrated approach to land and water resource management in Hawkes Bay, which links climate change to other issues such as biodiversity, biosecurity and land degradation. Such an approach would ensure both short- and long-term benefits to the region, even in the absence of the worst effects of climate change. If adopted, this approach would provide a lead for other regions in New Zealand at a time when such leadership is vital, given the likely challenges of an uncertain future in which climate change will play an increasingly important, but not isolated, part.

Dr Gavin Kenny
Director, Earthwise Consulting Ltd, Hastings



Gavin has degrees in horticultural science and a PhD in agricultural meteorology. He has over 10 years of research experience in the field of climate change, which have included project work in Europe, Bangladesh, Zimbabwe, the Pacific Islands and New Zealand. Through his overseas experience he also became increasingly involved in professional training and development assistance work, the latter involving a project with an agricultural university in northern Vietnam. Since the beginning of 2001 Gavin has been working as an independent consultant, based in Hawkes Bay. Aside from his ongoing climate change work he is also involved with the organic sector, and is currently managing a Sustainable Farming Fund project on behalf of the Soil and Health and Bio Dynamic Associations.

The Possibility of Increasing Soil Carbon to Offset Methane and Nitrous Oxide Emissions from Agriculture

Concerns are being raised, especially by the agricultural sector, about the possible economic impacts of ratifying the Kyoto Protocol. Two potent greenhouse gases, methane and nitrous oxide, represent about 55 percent of New Zealand's emissions profile, and mainly come from agriculture. The sensitivity of the agricultural sector to potential negative impacts of ratifying has caused misunderstanding about how the emissions of these gases might be reduced or even offset altogether. Dr Surinder Saggar of Landcare Research reports on the chances of increasing soil carbon stocks through changes in land use and land management. This report is extended from his recent article in AgScience[1].

Some farmers believe that by increasing pasture production, the humus content of soils (and hence the soil carbon content) will increase to outweigh methane or nitrous oxide emissions completely. If true, even small increases in soil carbon over time could strongly impact on our national carbon budget, because nearly half (13.61 million hectares) of our land is used for livestock farming. Research by Landcare Research in Palmerston North, however, shows that soil carbon levels in New Zealand's grazing lands are at, or near, steady state. This research has involved a review of published data from long-term sites, the comparison of soil carbon in archived and recent samples from the same sites, and the comparison of soil carbon in samples from trial sites under differing management[2]. The review supported the hypothesis that soil carbon levels in New Zealand's grazing lands are at or near steady state.

To understand this conclusion, it is useful to consider how carbon cycles in soil, and what influences the cycling processes.

Carbon enters the biosphere through photosynthesis, and leaves through respiration, principally from the soil. The degree of accumulation or loss of organic carbon in pastures depends on the relationship between carbon inputs to soil from roots and surface litter, and decomposition rates of soil humus. Shifts in this balance between gain and loss of carbon result from a complex interaction of ecosystem processes influenced by, for example, climate, soil type, landscape position, land use and soil management. As the rate of carbon input approaches that of decomposition, soil carbon concentration stabilises.

Cultivation of soils under pasture or forest into cropping causes a significant loss (30-50%) of soil carbon and increases carbon dioxide emissions into the atmosphere. The reasons for soil carbon loss are an accelerated decomposition of the existing organic matter in soils on the one hand, and reduced input of plant material into the soil on the other.

The restoration of soil organic matter, depleted through cultivation of agricultural soils to near their original level, appears to be a realistic opportunity. Improvements of agricultural soils beyond the original level of soil organic matter through soil improvement may also be possible and can help to sequester more carbon. Among the options of restoring soil carbon in cropland soils are: adopting conservation tillage practices and crop residue management; intercropping; growing winter cover crops; green manuring; fallowing; establishing shelter belts and windbreaks; and retiring erodible lands from cultivation.

What should also be kept in mind are the additional requirements of fertilisers and fossil energy to achieve such soil carbon sequestration, and increased nitrous oxide emissions from nitrogen-enriched soils. Secondly, this carbon sink option is of limited duration because any subsequent poorer soil management may well cause another significant drop.

No-tillage management has the potential to sequester carbon. In some cases, soil carbon can be augmented up to

50 percent due to smaller carbon losses in crops grown under no-tillage than under conventional tillage. But nationally, the scope for sequestering carbon in New Zealand cropping soils is negligible, because of the small area covered (0.21 million hectares) and the commonly practised pastoral-cropping rotation. There is very little information on nitrous oxide emissions in New Zealand cropping soils. No differences in nitrous oxide emission between conventional and no-tillage were observed after five years of cultivation. However, the cropping land management effects on nitrous oxide emissions are insignificant in comparison with national estimates, which are mainly attributed to dairy grazed pastures.

Where no major disturbances such as soil erosion occur, pastoral farming impacts on soil organic matter are so slow they are obvious neither to the landowner nor to outside observers. Such changes in soil carbon are likely to be too small to measure. New Zealand has a large reservoir of carbon that can vary widely spatially and temporally. Soil carbon levels of grazed pastures represent different slope and aspect categories. Research by Landcare Research and others suggests that soil carbon levels under established pastures in New Zealand may have reached a near steady state.

If the farmer starts from an unimproved pasture (with low soil fertility), then there may initially be a small increase in soil carbon after the soil is ploughed out of an unfertilised, low-fertility pasture, sown to permanent ryegrass-white clover pasture, and fertiliser is applied. But this situation is not common these days – little unimproved grassland is being broken in for pastoral farming. The baseline for most farmers in dairying, for example, is a high-fertility soil, and our research has shown that adding fertiliser generally has no detectable effect on soil carbon content. There is some evidence that soil carbon levels can at times decline slightly if already fertile pastures receive more fertiliser. Research, however, generally shows that fertiliser addition not only produces more pasture and adds more carbon to the soil, but also enhances soil carbon decomposition. The net result of fertiliser application is that only the quality of soil humus may improve without any quantitative increase in soil carbon.

The development of agriculture in New Zealand differed from that in most other countries: forest clearing after Polynesian and European arrival resulted mainly in pastoral farming rather than in arable cropping. New Zealand soils already had high carbon contents under forest, and the introduction of pastures tended to increase mineral soil carbon, so that opportunities for sequestering more carbon in pasture soils are limited unless the eroded land is re-vegetated. Our soils already have higher soil carbon levels than the world average. This historic build-up in soil carbon results partly from the predominance of pastoral use, which conserved and even increased carbon, and partly from the relatively slow decomposition of the soil carbon stored during millennia under forest.

At the national level, our pastoral systems are therefore unlikely to sequester more carbon into soils, and the scope for cropping soils is also negligible. Hence opportunities for increasing soil carbon stocks, at the national level, through changes in land use and land management, are small.

[1]Saggar S (2002) Can soil carbon be increased to offset methane and nitrous oxide emissions from pastoral agriculture? *AgScience*, Issue 6, March 2002 (in press).

[2]Saggar S, Tate KR, Hedley C, Perrott K, Loganathan P. Are soil carbon levels in our established pastures at or near steady state? *New Zealand Soil News* 49(4), 73-78.

Dr Surinder Saggar
Senior Scientist, Landcare Research, Palmerston North
SaggarS@LandcareResearch.co.nz
Surinder is actively involved in the study of soil carbon and nutrient transformations in relation to greenhouse gas emissions and sustainable management of land-use systems. For over 29 years, he has studied soil issues related to cropping, pastoral land, tussock grasslands, and plantation forestry, and has been involved in the development of management strategies for sustainable land use. His current research features the development of a modified process-based model to estimate accurately nitrous oxide emissions for New Zealand soils, climatic conditions and pastoral systems.

Methane and Nitrous Oxide Mitigation Options

***Methane and nitrous oxide emissions have the potential to be a major issue for New Zealand's primary production sector. The following article by Harry Clark and Cecile De Klein presents the results from a MAF-commissioned report* Potential Management Practices and Technologies to Reduce Nitrous Oxide, CH4 and Carbon Dioxide Emissions from New Zealand Agriculture.**

Introduction

Ratification of the Kyoto Protocol will commit New Zealand to reducing its average greenhouse gas emissions between 2008 and 2012 to 1990 levels. Emissions of methane (CH_4) and nitrous oxide (N_2O) from the agricultural sector make up about 54 percent of New Zealand's total emissions and these are forecast to rise by 2010. This presents a considerable challenge to New Zealand if it wants to avoid having to potentially obtain "carbon credits" to offset any excess emissions.

What is the Source of CH4 and Nitrous Oxide Emissions?

Almost all of the CH_4 arising from agricultural sources is a by-product of the fermentation of feed, especially fibrous feeds, in the rumen. Micro-organisms in the rumen break down feed to produce volatile fatty acids, which are utilised as an energy source, and carbon dioxide (CO_2) and CH_4, which are expelled in the breath.

N_2O emissions from agriculture are produced by soil bacteria, that transform nitrogen, mainly from animal excreta, into N_2O via the soil processes denitrification and nitrification.

How can Methane Emissions be Reduced?

Reducing animal numbers is one obvious solution, although this is only guaranteed to reduce CH_4 emissions if the productivity per animal remains unchanged. This has, however, major financial consequences, as farm revenues will fall in direct proportion to the reduction in product output.

Improving the quality of the diet of ruminants tends to result in higher feed intakes, which in turn tends to increase productivity and CH_4 output per animal. However, if CH_4 is expressed per unit of product, then using a smaller number of high-producing animals to produce a given amount of product emits less CH_4 than using a larger number of lower producing animals. This is because a smaller proportion of the feed eaten is required to maintain the animal and because high feed intakes tend to reduce CH_4 yield per unit of feed eaten. Concentrate diets produce less CH_4 than forage diets but are too expensive for extensive use in New Zealand. Research undertaken by AgResearch and Dexcel indicates that certain forage species e.g. white clover, lotus and sulla, improve animal performance and produce less CH_4 per unit of feed eaten. Experiments are currently underway to look at whether ryegrass cultivars selected for improved animal performance also result in lower CH_4 yields per unit of product.

It may also be possible to reduce CH_4 by directly influencing the rumen fermentation process through feed additives. A group of commonly used compounds, ionophores, have, under some circumstances, been found to reduce the amount of CH_4 emitted per unit of product and to decrease the amount of CH_4 produced per unit of feed eaten. There is also some evidence that they reduce the amount of nitrogen excreted and can therefore reduce N_2O emissions from pastures. Unfortunately very little of the evidence comes from the type of diets commonly consumed by New Zealand ruminants and the extent to which ionophores will reduce CH_4 emissions is difficult to quantify under our conditions. There may also be some consumer resistance to their use as they are a type of antibiotic. A second group, probiotics, are microbial feed additives that can increase feed conversion efficiency and perhaps reduce CH_4 production per kg of feed. However no information is yet available from controlled trials carried out under New Zealand conditions.

Extensive publicity has been given to a vaccine being developed in Australia that is claimed to reduce CH_4 production per kilogram of food by 11 percent to 23 percent. This approach shows great promise as it may involve a once-in-a-lifetime injection and be applicable to all classes of ruminants. It is, however, still at the development and testing stage and is unlikely to be available, even for evaluation, for another three to four years.

How can Nitrous Oxide Emissions be Reduced?

The single largest source of N_2O in New Zealand's pastoral systems is animal excreta and therefore reducing the amount of excreta nitrogen has the largest potential to reduce N_2O emissions. This can be done by reducing the number of animals or by reducing the amount of nitrogen excreted per animal. As with CH_4, producing a given amount of product from a smaller number of high-producing animals reduces N_2O emissions. Options for reducing the amount of nitrogen excreted per animal include the replacement of nitrogen-boosted grass with low-protein feed such as maize and the breeding of grasses that have a better balance between energy and protein so that they reduce the amount of nitrogen excreted and at the same time improve animal performance.

N_2O emissions can also be reduced by increasing the efficiency with which excreta and applied nitrogen are utilised. N_2O emissions from dung and urine patches are highest during the wet autumn/winter period. If dairy and beef cattle are kept on feed-pads during these high-risk periods and the excreta collected and re-utilised as effluent, emissions could be reduced as emissions from excreta are higher than for effluent applied to the soil. This management practice could also reduce nitrate leaching losses. Other options include the substitution of synthetic fertilisers by effluent wherever possible, timing nitrogen applications so that they do not occur after periods of heavy rain or onto wet soils and, in the future, the incorporation of specific nitrification inhibitors into synthetic fertilisers.

Recent New Zealand research has found that N_2O emissions from urine patches on poorly drained soils are much higher than from free-draining soils, suggesting that improving drainage can help to reduce N_2O emissions. However, improved drainage could increase nitrate leaching. Soil compaction can also increase N_2O emissions and minimising treading damage by cattle is therefore beneficial. Liming can also decrease N_2O emissions from soil but this is offset by CO_2 emissions from the lime itself.

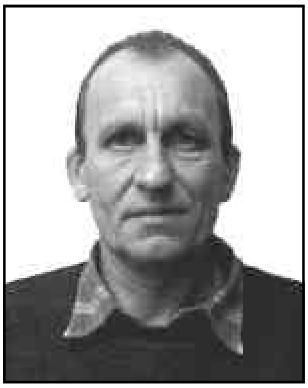
Summary

There are a variety of options for reducing CH_4 and nitrous oxide emissions from agriculture but it must be emphasised that it is a complex problem and we should be wary of simple solutions. No single approach is likely to be suitable for all circumstances and reductions are likely to require a basket of reduction methods. Some of these have been outlined above and others will emerge from current research and development.

An important issue is that emissions of N_2O and CH_4 should not be viewed in isolation from each other as some of the potential options for reducing emissions of one gas can affect emissions of the other. This reflects the complexity of farming systems and the tradeoffs in greenhouse gas mitigation options that are likely to arise in practice. The Kyoto protocol sets emission targets for the total quantity of greenhouse gases emitted by a country, not targets for specific gases, and potential mitigation options therefore need to be evaluated at a farm scale and for all greenhouse gases collectively.

Harry Clark

Harry joined MAF Tech (now AgResearch) in 1991 after spending six years working for MAFF, UK as a specialist livestock adviser. His current research involves quantifying CH4 emissions from grazing ruminants and the development of more accurate methods for estimating CH4 emissions from ruminant livestock at the national scale. He trained at the University College of North Wales, Bangor.



Cecile de Klein

Cecile de Klein is a soil scientist with AgResearch's Land & Environmental Management Group. Her current research involves quantifying nitrous oxide emissions from soils, to develop more accurate estimates of agricultural nitrous oxide emissions, and management practices for reducing nitrous oxide emissions. She was trained at the University of Utrecht in the Netherlands and has been working with AgResearch since 1995.

Bio-ethanol as a Transport Fuel?

The following article by Emily Rudkin presents the results from work on the possibility of using bio-ethanol as a transport fuel and the implications for New Zealand.

Ethanol is a simple alkyl alcohol that can be used as a transport fuel in spark ignition engines. It has high octane levels and can be either blended into petrol and used in unmodified vehicles, or run as 100 percent ethanol in a converted engine. Ethanol can be a renewable fuel if it is produced from agricultural biomass, i.e. bio-ethanol.

Bio-ethanol is probably the most cost-effective renewable transport fuel, and as such the Energy Efficiency and Conservation Authority (EECA) commissioned a study into the implications of its introduction to New Zealand. The information from this report has assisted in refining the Government's preferred target for renewable energy, as stated in the National Energy Efficiency and Conservation Strategy. The renewable energy target is structured around a sector approach, one of which is transport fuels.

The main considerations with the introduction of bio-ethanol into New Zealand include the cost and source of the ethanol, distribution of the fuel, performance of vehicles, and safety and environmental issues.

Ethanol for transport fuels is most commonly produced from sugar crops by fermentation and distillation. The most effective crops that can be used to produce ethanol in New Zealand are maize and sugar beet. Ethanol can also be produced from woody biomass but at a significantly greater cost. Currently New Zealand produces ethanol from whey, a by-product in the dairy industry.

Generally blends of up to 10 percent ethanol in petrol (E10) can be used in modern vehicles without any appreciable changes in performance. Studies in the 1980s identified that there is potential to produce enough maize and sugar beet to replace all petrol in New Zealand with an E10 blend many times over, although this would require substantial changes to farming patterns.

There are well established procedures for mixing, distributing and storing ethanol and ethanol blends. Ethanol is readily miscible in water, so all ethanol (and ethanol blend) distribution and storage systems must be kept "dry". The addition of ethanol to conventional petrol is likely to take the resulting blend outside the petrol specification due to increased fuel volatility, so that a specially tailored hydrocarbon blend stock would likely be required. Some countries allow "splash blending" where ethanol is blended with conventional petrol during truck loading. This is permitted by a waiver on the fuel specifications. The best locations for blending ethanol with petrol are likely to be at the regional bulk storage terminals or at the refinery. Blending equipment and further storage and dispensers would be required.

Engines running on 10 percent ethanol blends will have a slight increase in volumetric fuel consumption due to the lower energy content of ethanol compared with petrol. Although energy efficiency should be similar for blends and petrol, energy efficiency gains of about 1 percent have been reported, particularly in older vehicles due to the leaning effect of ethanol. Driveability may be impaired in older vehicles, although altering the fuel settings can restore this. A small number of older vehicles may be susceptible to paint and fuel systems materials, degradation. Generally the health and safety aspects of ethanol and ethanol blends are similar to petrol.

Exhaust emissions from modern vehicles do not differ significantly when using ethanol blends. In older vehicles, without catalysts and fully functional emission control systems, ethanol may result in reduced emissions of carbon monoxide, slight reductions in hydrocarbons and slight increases in NOx. They do however result in significantly increased engine aldehyde emissions, although these are largely destroyed by exhaust catalysts.

The rationale for assessing the potential of bio-ethanol is largely due to climate change benefits. As bio-ethanol is renewable, CO_2 emitted during combustion is taken up in the biomass feedstock. However as energy is consumed during the manufacture of ethanol, it is not completely carbon neutral. CO_2 emitted during manufacture is between 30 percent and 90 percent of the CO_2 emitted during combustion of ethanol, depending on the process technologies. On this basis, and assuming a slight improvement in efficiency, an E10 blend results in net CO_2 savings of between 1.5 percent and 5.5 percent compared with petrol.

There are two well established programmes overseas using bio-ethanol blends. In Brazil, blends of 22 percent ethanol are required, with vehicles specifically designed to use this fuel. In the USA, ethanol may be splash blended into petrol to a concentration of 10 percent. More recently European countries allow up to 5 percent ethanol in petrol. Australia has an active programme supporting bio-ethanol where currently splash blending into specification grade petrol is permitted.

Full details of the study will be available as a supporting document to the Renewable Energy consultation on the EECA website www.eeca.govt.nz.

Emily Rudkin
Energy Efficiency and Conservation Authority

Emily is a mechanical engineer with five years' experience in the renewables industry in both the United Kingdom and New Zealand. She has a Master's degree in Renewable Energy and the Environment from Reading University, UK. Emily is currently employed in Wellington by the Energy Efficiency and Conservation Authority (EECA), the government entity encouraging, promoting and supporting energy efficiency, energy conservation and the use of renewable sources of energy. She is committed to seeing renewable energy become New Zealand's mainstream energy source.

Water Conference

The Ministry of Agriculture and Forestry and the Ministry for the Environment are holding a water conference on 23/24 July in Wellington. Its purpose is to present papers on recent research and policy studies conducted over the last three years in the area of fresh water allocation.

Water is valued by New Zealanders for many reasons:

- economic – for irrigation and industry;
- environmental – maintaining life in streams;
- health – for water supply and safe swimming;
- cultural – mahinga kai and mauri;
- recreation – for fishing, boating and canoeing.

Demand for water for all purposes is increasing. This in turn is leading to increasing public debate on the uses to which water is put, and how much is available for different purposes. The conference will present overviews of these differing perspectives, and possible ways of meeting multiple demands. The conference will consider issues of strategic water use, large-scale irrigation developments, the economics of efficient water use, and the importance of instream values. Speakers will present the views of regional councils, industry, scientists and stakeholders. Proceedings of the two-day conference will be published electronically as extended abstracts. For more information including conference agenda refer to the Royal Society website: www.rsnz.govt.nz or contact Catherine Ibell on 64 4 470 5770.

	Address	Telephone	Facsimile
WHANGAREI:	Cnr Dent & Finlayson Sts PO Box 503, Whangarei	64 9 430 7305	64 9 430 7390
HAMILTON:	Ruakura Research Centre, East St Private Bag 3123, Hamilton	64 7 856 2832	64 7 838 5921
ROTORUA:	Forest Research Campus, Sala St PO Box 1340, Rotorua	64 7 348 0089	64 7 347 7173
HASTINGS:	5th Floor, Tower Building, Cnr Lyndon & Railway Rds Private Bag 9024, Hastings	64 6 870 6304	64 6 870 6305
PALMERSTON NORTH:	Batchelar Agriculture Centre, Tennent Dr PO Box 1654, Palmerston North	64 6 351 7925	64 6 351 7929
WELLINGTON:	ASB Bank House 101-103 The Terrace PO Box 2526, Wellington	64 4 474 4100	64 4 474 4206
NELSON:	Village Mall Queen Street PO Box 3318, Richmond	64 3 543 9182	64 3 544 6826

	Address	Telephone	Facsimile
CHRISTCHURCH:	14 Sir William Pickering Dr PO Box 20-280, Bishopdale Christchurch	64 3 358 1860	64 3 358 1861
DUNEDIN:	Cnr Portsmouth Dr & Strathallan St PO Box 5648, Dunedin	64 3 477 8454	64 3 477 9144

All enquiries on this quarterly newsletter should be directed in writing to:

The Editor,
MAF RM Update
Ministry of Agriculture and Forestry
PO Box 9024
Hastings

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