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AgScience

Inside

The New Zealand Institute of Agricultural & Horticultural Science Inc

End-of-year reflections

I AM DELIGHTED to present this issue of *AgScience*, which focuses on Agriculture and the Emission Trading Scheme. It relates to our forum on this issue, which was held in Wellington on 14 September. The speaker line-up focused on how science can help farmers respond to the challenge of reducing greenhouse gas emissions. We had presentations from three political parties, the Parliamentary Commissioner for the Environment, the Ministry for Primary Industries, the Biological Emissions Reference Group, the Pastoral Greenhouse Gas Research Consortium and many of the major agricultural industry groups. We sent you a summary of all the speakers and what they said in an e-newsletter on 27 September. In this issue, we cover the points from a few of the speakers in more detail.

While New Zealand's contribution to global greenhouse gas emissions is less than 0.17%, agriculture accounts for the majority of those emissions and the New Zealand Government intends to make a strong contribution to greenhouse gas mitigation. Read more on this issue inside.

As we near the end of the year, it is a good time to reflect on our activities over the past 12 months. In addition to the forum on the Emissions Trading Scheme, the Canterbury Section held a very successful forum on "Water in Canterbury – our vital resource". You should have received a summary of this forum in a recent e-newsletter.

Our Council met three times this year, twice by video conference and once face-to-face just prior to our annual general meeting in Auckland in November. Council members are responsible for overseeing the activities and management of the Institute and they take their responsibilities diligently.

One important activity that was completed this year was the refresh of our website, which now looks really modern and is easy to navigate. I recommend you check it out at www.agscience.org.nz. There you will find a lot of useful information including back issues of *AgScience*, a form for new members, a link to our blog which is ably run by Bob Edlin, information on our awards and the NZ Horticultural Science Advancement Trust and upcoming events. I also encourage you to follow us on Twitter and Facebook.

NZIAHS representation extends globally. We appoint three members to represent New Zealand on the Council of the International Society for Horticultural Science (ISHS). This Council meets biennially and has representatives from around the world. ISHS has a Board of Directors, whose members have governance responsibilities for the running of the society on a day-to-day basis, in the same way as the Council of NZIAHS. But the ISHS Board must report to their Council and follow their guidance.

The Council met this year prior to the International Horticultural Congress in Istanbul, Turkey, and two of our representatives, Dr David Lewis and Dr Ben van Hooijdonk, participated. At that meeting, I completed a four-year term on the Board, and was honoured to be elected as Vice-President for the next four years.

One of the major activities of ISHS is organising international symposia, and two large symposia are planned for New Zealand in the next few years. The IX International Postharvest Symposium will be held in Rotorua in November 2020 and the XI International Kiwifruit Symposium will be held in 2023.

NZIAHS held two award events, to present awards to our worthy recipients. It is always a great pleasure to give out awards and acknowledge our colleagues for hard work and success. I strongly urge you to consider nominating worthy colleagues next year.

Looking forward to next year, I suggest you block out 2-4 July 2019 so you can attend our biennial Plant Science Central conference. This has been a series that has proved extremely successful and is co-organised by the Institute together with the New Zealand Branch of the International Association of Plant Biotechnology and the New Zealand Society of Plant Biologists.

Finally, I wish to thank Jenny Taylor, who runs our Institute as the Secretariat so diligently and efficiently. We are very lucky to have her keeping us on track. And all the best to all members for the festive season and for a successful New Year.

– Jill Stanley
President

Forum addresses climate-change challenges

By Bob Edlin

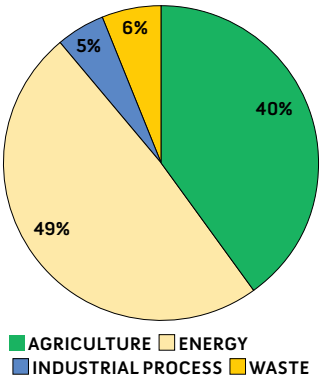
The NZIAHS forum in Wellington on September 14 addressed agriculture and its place in the Emissions Trading Scheme and examined how science can help farmers respond to the challenge of reducing greenhouse gas emissions.
Four key themes were:

- *What political parties are proposing for agriculture;*
- *The entry of agriculture into the emissions trading scheme;*
- *Finding agricultural solutions to enable farmers to reduce their greenhouse gas emissions;*
- *Considering how agricultural industries can mitigate emissions.*

IN HIS INTRODUCTORY remarks, forum co-chairman Dr Jim Salinger summarised recent modelling studies. This article reiterates what he told the forum and updates his remarks with the latest science on methane…

The Paris Agreement target is to keep global warming less than 2°C. This will require a reduction of more than 50% in anthropogenic methane emissions.

Agriculture makes up about 50% of New Zealand's greenhouse gas profile (see chart left) and meat production makes up about half of agriculture emissions. Reducing these emissions calls for a major change to production and biogenic processes. Offsets of livestock methane (CH_4) will be critical to this reduction – methane is a short-term warming agent and reductions will rapidly reduce the contribution of agriculture to further warming.



Referencing Manning *et al* 2018, Dr Salinger told the forum CH_4 emissions do not have to be reduced to zero to stabilise the climate, but all scenarios that are consistent with the 2°C target have more than a 50% reduction in them. This means that for meat and dairy agriculture to be consistent with the Paris Agreement target of keeping global warming less than 2°C there must be a significant reduction in their production or in the animal biogenic processes that produce CH_4.

In 2016, a major update to the radiative forcing – or climate forcing – caused by methane (Etminan *et al*, GRL, 2016) showed this was nearly 25% larger than had been used in the climate models. And the latest science from Nisbet, Manning *et al* shows that since late 2006, methane has been increasing at rates nearly as fast as in the 1990s.

There needs to be a much better understanding of the cause before we know how far this will go and to what extent it may affect attempts to keep to the 2°C target. But their latest paper, just finished for *Global Biogeochemical Cycles*, is showing two sharp steps in the methane budget in 2006 and then 2013/2014, with at least the first of these starting in the southern hemisphere tropics.

This is not a repeat of fossil fuel-related sources, as in the 1990s, but probably of either increased wetland emissions or reduced atmospheric removal rates, both of which were explicitly ignored in the model runs done for the most recent Intergovernmental Panel on Climate Change (IPCC) assessment. If this is a decrease in removal rates, as some other trace gas data also suggest, then the lifetime for methane has increased quite rapidly.

One question this raises is the effect on the Representative Concentration Pathway (RCP) 2.6 scenario. The Representative Concentration Pathway is a greenhouse gas concentration (not emissions) trajectory adopted by the IPCC in 2014.

A first estimate is that the methane increase means the maximum CO_2 concentration must drop from about 442 ppm in the 2050s to about 428 ppm to keep to the same total radiative forcing.

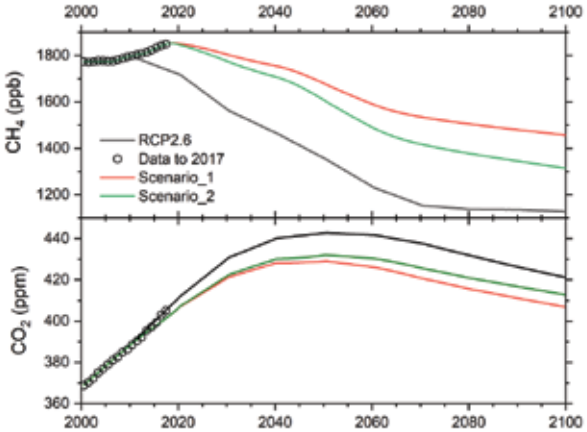
Dr Salinger also referenced the report from the outgoing Prime Minister's science adviser, Sir Peter Gluckman, published in September. In the report, Sir Peter says:

"While I note the current consultation on a pathway to

net zero carbon by 2050, the arguments for focusing on carbon dioxide and nitrous oxide and giving less emphasis to methane are in my view counter-productive, and this report does not favour avoiding a focus on methane, despite the challenges such a focus creates. It is unrealistic, however, to imagine that we can get to a GHG-neutral profile from agriculture without offsets in various forms.

"Methane is a very potent warming agent in the short term, so it is contributing significantly to current warming trends. Any sustained emissions of methane will continue to contribute to warming but reducing emissions will rapidly reduce the contribution to further warming.

"New Zealand's most important contribution to this effort will be in effectively reducing biological emissions from agriculture – an area where we are positioned to be world leading. Driving emissions mitigations from the agricultural sector is thus critical to the government's commitment to act domestically against climate change."

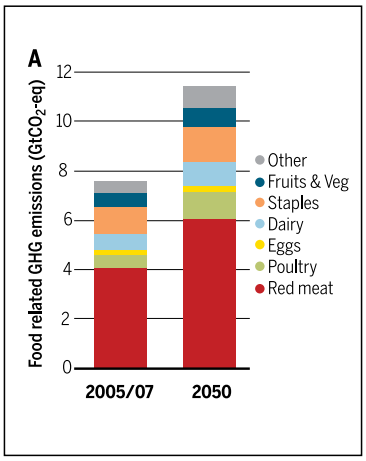


The diagram above is from the Manning *et al* submission on the Zero Carbon Act. Black lines in both panels show methane and CO_2 concentrations used in the last IPCC assessment for the RCP2.6 scenario consistent with keeping global warming to less than 2°C. Open circles show observed global average concentrations to 2017 provided by the US National Oceanic and Atmospheric Research's Earth System Research Laboratory.

Coloured lines in the upper panel show projections for how the methane concentration will change if the increase is due either to natural emissions that stop increasing in 2018 (red) or a delay in reducing anthropogenic emissions (green). The lower panel shows the decrease in CO_2 concentrations needed to keep to the same total radiative forcing of the climate system and Scenario 2 reduces cumulative CO_2 emissions from 2010 to 2050 by about 20%. This means that an almost impossible reduction in CO_2 emissions is required.

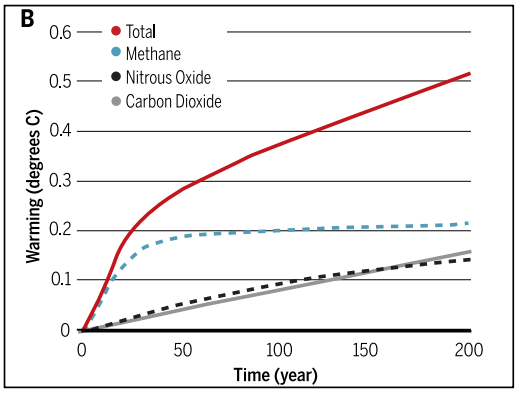
Nisbet and Manning *et al* conclude: "We need to manage each of the greenhouse gases and bring them down wherever we can, and quickly." Delaying any CH_4 emissions is very problematic.

Finally animal-sourced foods are the major source of food-system greenhouse gases, which means their relative importance is likely to increase in the future.



This is illustrated in the charts left and below from Goffray *et al* (2018).

On (A) left, we can see GHG emissions production of different food types in 2005–2007 and projections for 2050 (assuming an emissions pathway that would keep global temperatures below 2°C).



On (B) above, the three major GHGs have quite different effects on climate. Emissions from livestock operations introduced in Year 0 are thereafter held fixed whereas the warming due to CH_4 is substantial and rises quickly then ceases growing after 20 years. Warming due to CO_2 and N_2O continues to grow with the latter leveling off.

Dr Salinger referenced Goffray *et al*, too, on a scenario which assumes the predicted change in price and consumption of different food types after the introduction of a globally uniform tax related to GHG emissions. Meat products are some of the most strongly affected food types.

History suggests that the change in dietary behaviours in response to interventions is slow. But social norms can and do change, and this process can be aided by the coordinated efforts of civil society, health organizations, and government.

Taking a hard look at Overseer

DR PHILIP WILES – discussing how the Biological Emissions Reference Group was meeting the challenge of measuring emissions at a farm level – said New Zealand was at the leading edge of the research on this and had some great tools such as Overseer.

Guy Salmon, executive director of the Ecologic Foundation, at question time referenced Sir Peter Gluckman, whose final report as the Prime Minister's Chief Science Advisor earlier this year said Overseer isn't suitable for hard regulatory reporting of greenhouse gas emissions. So what were the strengths and limitations?

In response, Dr Wiles said BERG's findings are that Overseer can be suitable for use at farm level. He acknowledged there is uncertainty within Overseer estimates but the technology is evolving as new science becomes available.

Caroline Read, chief executive of Overseer Ltd, agreed that using the technology to help change on-farm management practices by recording emissions and nutrient losses had been difficult with software that had evolved over time and become more complex to embrace more farm practices.

But new software – released in June – has been designed to reach farmers much more easily.

Many more farmers were now using the tool, helped by their farm advisers and nutrient experts to change their system and make gains for their businesses.

Farmers can use Overseer to look either at separate blocks or at their whole farms over time, Ms Read said.

Since about 2009, regional councils had been using Overseer in their water quality management. Overseer had been used in shaping greenhouse gas emission profiles on farms, too, over that period.

"Everything came together for Overseer to be able to give a fairly full environmental picture to a farmer," Ms Read said.

"So we completely redesigned it to enable a much more intuitive data entry.

"We want to be able to provide information to farmers to enable them to make changes so we have created software that we think is going to help them do that really well."

Work is under way to recalibrate Overseer against available farmer information and other information that has become available since 2012, when it was last calibrated.

Overseer staff also have been talking with the Parliamentary Commissioner for the Environment, whose office has been examining the technology, to determine what other areas of validation are needed and understand different types of uncertainty in the tool.

Mike Manning, general manager innovations & strategy at Ravensdown, reminded the forum that Overseer was originally designed as an environmental reporting tool and was subsequently picked up to be used for other uses.

"Yes, it can be used for greenhouse gases provided you have good on-farm data and good practitioners," he said.

"It is probably the best-in-class tool and it is globally

recognised – so bring it on as far as I'm concerned."

Andrew Hoggard, national vice-president of Federated Farmers, said Overseer gives farmers a good start in reducing greenhouse gas emissions.

He found nitrogen recording simple and said he thought it would help farmers if they could use it not just to measure what's happening on their farms but also to run scenarios showing what would happen if they made changes.

"That's very important," Mr Hoggard said. "It's one thing to know what your number is but a different thing to determine how to make changes."

Dr Alison Stewart, chief executive of the Foundation for Arable Research, said farmers in her industry spend a lot of time working out how to measure and monitor their performance and determining how to make better fertiliser decisions.

When Overseer first became available, she recalled, there was a great deal of scepticism about its value in the arable crop sector, but "I take the view it is a valuable tool".

She expects it will be used extensively in New Zealand for a wide range of purposes and said "the arable sector has to buy into working with the Overseer group in developing improved models that will better reflect and translate arable systems.

"We are not there yet but we do see Overseer can be used effectively to help us manage our nutrient budgets for arable crops."

The Parliamentary Commissioner for the Environment, Simon Upton, told the forum he has been studying Overseer for a report that should help resolve key differences of opinion.

The first part of the report would look at the Overseer model and its fitness for purpose, given its use as a nutrient budgeting tool (to help farmers improve their productivity and their profitability) and as a tool to limit unwanted leakage of nutrient.

"It has grown organically over the years," Mr Upton, told the forum.

"If it is to be used in a regulatory context, what can we say about the model?"

The second part of his report would deal with Overseer's focus "on something that goes as far as the bottom of the root zone." Mr Upton said this was a 60cm deep slice of agricultural pasture and he would examine how it meshes with what happens at the catchment level.

The third part would ask if current governance and ownership model is appropriate.

Greater transparency urged

Overseer must be made much more transparent if the Government wants it used as a regulatory tool to help clean up New Zealand's rivers and lakes, says Simon Upton, the Parliamentary Commissioner for the Environment.

At the NZIAHS forum in Wellington in September, Mr Upton had said he was working on the report and was determined to produce it before Christmas. He succeeded.

To ensure cleaner water, farmers and regional councils need to be confident that Overseer's outputs are reliable, the report says.

To help build confidence there needs to be more transparency around how the model operates.

Any model operates with a measure of uncertainty. The question is whether the level of uncertainty is an acceptable one.

"It will take time to improve Overseer and provide transparency around how it operates," Mr Upton said in a press statement when releasing the report. "In the meantime, regional councils can continue to use it but they need to be aware of its limitations."

The report finds that important elements of the model are not open for review, and some gaps and shortcomings need to be addressed.

The report recommends that if the Government wants to have Overseer used as a regulatory tool, it must address several issues. These include:

- commissioning a comprehensive evaluation to ensure the Overseer model is independently peer reviewed, and is subject to sensitivity and uncertainty analysis;
- providing greater transparency around how the model works;
- aligning Overseer's ownership, governance and funding arrangements with the transparency required for it to be used as a regulatory tool;
- providing official guidance on how Overseer should be used by regional councils.

LINK

The Commissioner's report, Overseer and regulatory oversight – Models, uncertainty and cleaning up our waterways

What the scientists are doing to help farmers and growers

FINDING HOW TO mitigate greenhouse gas emissions in the primary sector – and potential ways of mitigating those emissions – is the challenge being tackled by industry groups and organisations such as the Biological Emissions Reference Group (BERG) and the Pastoral Greenhouse Gas Research Consortium (PGgRc).

The industry's role in this research is critical, the NZIAHS forum on agriculture and the emissions trading scheme was told.

As PGgRc general manager Mark Aspin put it, "we are talking about farm businesses and we have to ensure we get mitigation technologies to work".

Mr Aspin, general manager of the PGgRc, said his organisation's research has focused mainly on methane and on four key areas: animal genetics, low GHG feeds, a methane vaccine and methane inhibitors.

"When we started in 2003 one of the big concerns was that if you mess with the rumen, you are going to mess with fermentation, you are going to mess with digestion, and you may not be able to get ahead," he said.

It would be "a hard sell", trying to tell farmers the emissions problem can be eradicated but their animals won't produce anything.

But a range of options for New Zealand livestock farmers is being explored or developed.

Genetics: The research is well understood and likely to be rolled out with sheep but with cattle and deer it is still to be proven.

In 2002-03 the consortium spent two years measuring 700 cows in milk to try to find differences but their methods weren't accurate enough for methane.

The consortium more successfully screened 1,300 sheep using respiratory chambers in enclosed boxes where emissions are measured every six minutes. From this a low and high methane flock was identified.

Over two and half to three generations a 10% difference

in emissions between the high- and low-methane sheep has been demonstrated. About 20% of the variation can be explained by genetics. In animal production terms that's a reasonable heritability, Mr Aspin said.

The low-methane sheep had a smaller rumen but their productivity has been good.

The researchers have looked at feed efficiency – the idea that if one sheep eats more than another to get the same level of production, the one that eats less is preferred for breeding.

Work on validating this is under way in the breeding industry and the consortium hopes the results will be widely adopted in 2020.

Mr Aspin emphasised that this does not mean a 10% reduction in emissions can be achieved by farmers switching to low-methane animals. When selecting their animals – sheep or cattle – farmers will take several traits into consideration.

"Over time, yes, we can reduce the emissions but it needs to be thought about realistically and it's not going to solve our problems if we are chasing a 30% reduction in methane," Mr Aspin said.

Feed: The options are limited with New Zealand's pasture-fed systems.

The idea is that the more stock eat, the greater is the chance of them producing more methane.

The researchers have spent a lot of time identifying feeds and plant characteristics to see if they could find what makes this happen. But for 90% of the time New Zealand animals eat grass and the researchers haven't found anything that will change the ratio of methane from grazing animals in pastures. Moreover, the methane from pasture-fed stock is consistent regardless of the season.

Work has been done on an array of plants. The only crop to consistently give encouraging results is brassica rape – a 100%

The Biological Emissions Reference Group was set up in 2016 to bring together a wide range of agricultural, horticultural and farming stakeholders to collaborate with Government and build a solid evidence base to help support New Zealand reach its climate change goals and reduce biological greenhouse emissions.

An initiative of Paula Bennett when she was Minister for Climate Change in the previous government, it is funded by the Ministry for Primary Industries and its objectives are to: –

- Build trust and confidence between the primary industries and government departments.
- Increase the understanding across industry, government and the public about the current and future sources and drivers of biological emissions and their mitigation potentials.
- Build an agreed and robust understanding of what can be done to reduce biological emissions and identify the costs and opportunities.

It is an advisory group which doesn't develop policies and recommendations.

The Pastoral Greenhouse Gas Research Consortium was established in 2003 to provide knowledge and tools for New Zealand farmers to enable them to mitigate greenhouse gas emissions from the agricultural sector.

Its goal is to reduce agricultural emission intensity by 2.5% a year from 2020 – 1% through increased efficiency (continuing historical trends and relying on industry drivers) and 1.5 % through additional direct mitigation options

Under a memorandum of understanding with the government, while farmers invested in emissions-reducing science the government wouldn't levy the industry.

Funded by eight agricultural-sector partners and working in collaboration with the Government, the consortium invests about $5 million a year in greenhouse gas research. It owns and directs the intellectual property it creates.

Together with the New Zealand Agricultural Greenhouse Gas Research Centre, it has produced a series of fact sheets, to help people.

LINK
Fact Sheets

diet of brassica rape can result in 25%-30% reductions in methane.

But only around 2,000 hectares of rape are grown in a year in New Zealand. Our pastoral industry is about 10 million hectares, so while a 30% reduction from rape is extraordinary the impact at a national level is small.

At the farm level, farmers are unlikely to claim a credit for a three-hectare brassica rape paddock which they feed out – let's say – for just six weeks a year.

Work on fodder beet shows promise at high diet levels, over 70%. It seems this does have an impact on methane. Work is continuing in the dairy industry to learn more.

But the nitrous oxide side of the equation must be brought into considerations. Work is now being done on rape for nitrous oxide effects. Results from both are needed to make a crop count in the national inventory

The inventory, the system used to account for all GHG emissions, is updated every year and submitted to the UN as part of New Zealand's obligations as a member country of the UN Framework Convention on Climate Change (UNFCCC). It covers the national economy and its GHG emissions and is scientifically peer-reviewed to provide the basis for establishing global GHG emissions.

Inhibitors: This is the most likely option to be adopted in the foreseeable future to reduce methane emissions but substantial technical, cost-of-delivery and consumer risks remain to be addressed.

Scientists have identified chemical compounds that simply stop methanogens from working, shutting down the process of methane production. A Dutch company is developing an inhibitor that works in a feedlot total mixed ration (TMR) system, where it can be mixed with feed and consumed continuously.

But this isn't practical in New Zealand's pasture-based system. A practical delivery mechanism is therefore one of the challenges. Options, such as slow release capsules, are being investigated.

The consortium is talking with potential commercial partners but testing to rule out any adverse effects on animals' health, welfare and productivity needs to be carried out and assurances are needed that there are no residue or food safety concerns.

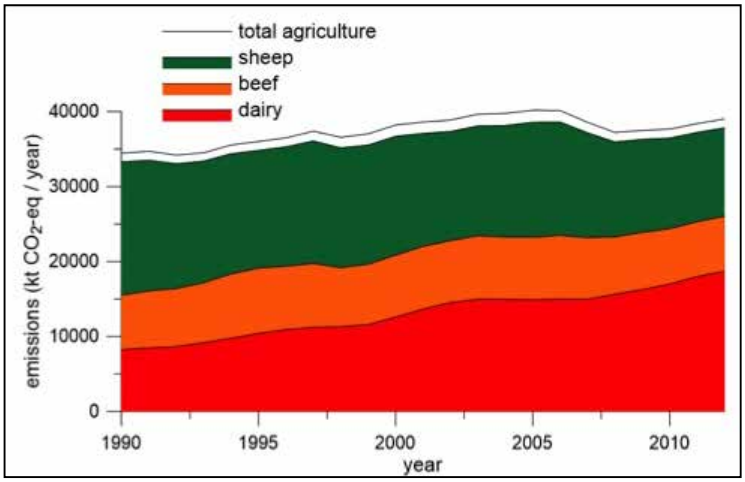
Work on inhibitors is focused on dealing with archaea, ancient organisms that are different from other bacteria. Millions of compounds, first screened through computers, gradually are reduced in laboratory tests and the researchers identify a small number of candidates that are safe to be used in animal trials to see if they work.

Two-day respiration chamber trials in sheep help to refine the selection further and researchers have identified five substances that show methane inhibition of 30% without affecting general rumen function.

"We do have some leads that are promising but we could lose those in one test," Mr Aspin said.

The challenge is not only to find an inhibitor but to deliver it to a grazing animal – it has to be in the rumen when stock are fermenting their feed to make the most of the opportunities to reduce emissions.

Beyond proof of concept with regulatory and manufacturing requirements "we are talking probably six to 10 years", Mr Aspin said.



"We went to know what happens to the farm system and animal system so there is quite a lot of work to be done before we have anything going into the hands of farmers.

"We've got to know we are not playing with the reproductive rate or that we've got milk residues or meat residues or issues that are going to affect the product."

Methane vaccine: This has the potential to be widely used in all species but – technically – it is proving highly challenging. Nevertheless "we believe it is still achievable", Mr Aspin said.

The CIRO in Australia took out a patent in 1995 and claimed they had a vaccine approach that could reduce methane emissions by 6% to 7%. The consortium tested that in 2003 and got nowhere near the Australian result, "but we did get some nasty lesions on the animals that were tested".

The lure of a vaccine for all farm systems remains.

Methanogens, the bug that creates methane gases, create antibodies when injected into a ruminant animal. The antibodies circulate in the blood and get into the saliva.

The hypothesis is that if enough antibodies against methanogens can be got into the saliva, they can be used to inhibit greenhouse gases.

The research has established that antibodies can be added to pure cultures and will stop pure cultures from continuing to grow. But a proof of concept that an animal's methane emissions can be reduced has yet to be established.

"It's still hypothetical but I can say biologically we have shown it is possible to have antibodies that will restrict methanogens," Mr Aspin said.

Nitrous oxide: The research shows nitrification inhibitors can make an impact but require new compounds. Work here is linked to the work in nitrate reduction and effective use of feeds.

The consortium is not active in this "but I do know it is still ongoing and there are smart technologies able to identify urine spots and being able to target with them," Mr Aspin said.

Soil carbon: More research is needed for carbon management to be understood.

Current research is focused on nitrogen and carbon interactions, the optimisation of irrigation, increasing the roots inputs of carbon and biochar.

Increasing the quantity and stability of carbon stored in agricultural soils can offset emissions but soil carbon levels in New Zealand already are relatively high, a result of this country coming out of bush only 100 to 150 years ago, whereas the likes of European soils have been cultivated for many hundreds of years.

But it is hard to measure soil carbon, let alone measure what is lost or gained through ploughing, or not tilling the land.

New Zealand decided not to include soil carbon in its Kyoto Protocol climate change commitments because of concerns about measurement and the cost of an inclusion.

"Soil carbon is a very useful thing but we don't know enough about it in New Zealand," Mr Aspin said. "It needs a lot of work.

"Maintaining soil carbon for soil health is important for soil productivity but whether it has value in managing carbon – I don't think it's got there. We have a lot of research to do to build on that yet."

The Biological Emissions Reference Group – at the time of the forum – was preparing a report on potential mitigations. The report was released early this month.

BERG has commissioned work on:–

- Current and future mitigation potential;
- Measuring emissions;
- The possible economic and social implications of both land-use change and on-farm mitigation;
- Costs and barriers of hypothetical policy options;

- What drives farmers' decision making in relation to climate change?

Issues examined include moving to once-a day milking, the increased use of supplementary feeds, increasing the supply of animals from the dairy herd to the beef industry, vaccines and inhibitors.

Further considerations are whether emissions can be measured both at the farm and national levels and the possible economic and social consequences of on-farm mitigation actions and land-use changes.

"We know some mitigation actions are win:win – by some actions we can reduce emissions and increase profit and we know some actions do recover the costs," Ministry for Primary Industries scientist Dr Philip Wiles told the forum. The final big question is what drives farmers' decision-making in relation to climate change?

Farmers aren't always driven by profit; other considerations can influence what they do.

Dr Wiles expects the group's reports will enable both industry and Government to develop their policy positions.

"But it will also allow us to engage with each other, speaking a common language and using assumptions that tell where we are coming from," he said.

The work has already been referenced by the Productivity Commission report on achieving a low-emission future and the Prime Minister's Chief Science Advisor's report on mitigating agricultural greenhouse gas emissions. It also is informing government processes such as decisions around zero carbon and the work of the Climate Change Committee.

Mitigation options now available could reduce methane emissions by around 5%-10% without reducing on-farm profitability, Dr Wiles said.

Findings from work on on-farm vegetation – riparians and tree lots – show this could offset a very small proportion of agricultural emissions.

"If we planted 10 metre riparian strips on half the streams in New Zealand we get about 700,000 megatonnes," Dr Wiles said. "This compares to 40 million tonnes of overall agricultural emissions."

Work commissioned on farm-level reporting of emissions found Overseer can be suitable for farm level emissions reporting. But administrative costs can vary significantly, depending on the management policies being implemented.

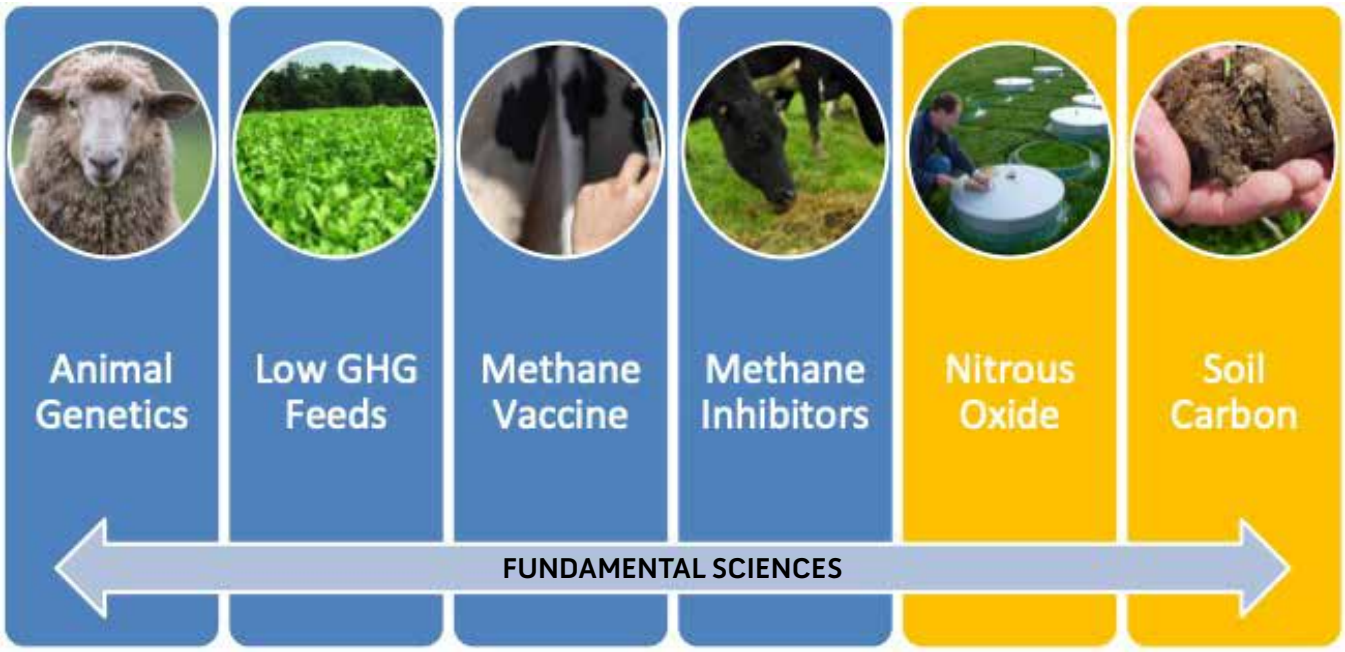
"Overall the work shows there are solutions to reducing New Zealand's farm emissions," Dr Wiles said.

"They indicate that a mixture of on-farm management change and land-use change will be required to meet the proposed government targets.

"But the policies to achieve these objectives will need to be well thought out.

"And the work that BERG has done should help ensure the debate around policies isn't bogged down in misunderstanding or bad information."

LINK
Biological Emissions Reference Group



The shaping of a consensus

A CONSENSUS WAS shaping on the climate-change challenge, business commentator Rod Oram ventured after three MPs had made presentations to the NZIAHS forum, *"Agriculture and the ETS: How do we enable Farmers to respond?"*

But it was consensus at a very high level, Mr Oram said, and "as we work more on the science and the policy and the practicalities of this, I'm sure there are going to be some very intense debates about keeping that consensus together."

Kiritapu Allen, a Labour MP speaking on behalf of Agriculture Minister Damian O'Connor, apprised the forum of the Government's international obligations (the Paris Climate Agreement and the 2030 Sustainable Development Goals) and its commitments to providing the research, tools, frameworks and policies that will enable farmers to reduce their on-farm emissions and switch to more sustainable land-use practices.

The objective is to reduce agricultural emissions while maintaining strong economies and productive and resilient sectors capable of meeting the food demand of an exponentially growing world population.

On the home front, the Government supports a substantial domestic research programme through the New Zealand Agricultural Greenhouse Gas Research Centre, which addresses "public good" research, and through the Pastoral Greenhouse Gas Research Consortium (jointly funded by government and industry), which focuses on "'industry good" research and commercialisation.

New Zealand also leads international efforts through the Global Research Alliance on Agricultural Greenhouse Gases, established in 2009 to promote increases in global investment in research to develop practices and technologies to reduce emissions from food production. New Zealand has invested $65 million in the alliance.

"There has been steady progress on the science both internationally and domestically, but no 'silver bullet' to reduce greenhouse gases from animals has yet been identified," Ms Allen said.

At the time of the forum in September the Government had recently completed public consultation on the Zero Carbon Bill and the former Chief Scientist to the Prime Minister, Sir Peter Gluckman, had released a report which complemented a growing base of information and advice, including 15,000 submissions, which the Government is using to draft the Zero Carbon Bill.

The Bill is scheduled to be enacted in 2019.

Through the Zero Carbon Act, the Government will establish an independent Climate Change Commission to advise the Government on the policy issues. A priority will be to provide analysis on how surrender obligations could best be arranged if agricultural methane and nitrous oxide emissions enter the Emissions Trading Scheme.

Gareth Hughes – speaking as a Green MP and someone who has worked on climate change for years – said he was glad New Zealand has moved on from the denialism debate, about the need for a carbon price, "but the next sacred cow is the debate around emissions and agriculture".

New Zealand didn't have the coal-fired power stations or mega factories of other countries, he said, "but our farms, milk dehydrators and farming practises are our equivalent".

Mr Hughes acknowledged sectoral leadership and initiatives:

- Beef+Lamb NZ is aiming for carbon neutrality; and
- Landcorp is committed to being carbon neutral by 2025

But he advocates a reduction in cow numbers.

"For decades we've crammed more cows on our paddocks, piling on the nitrogen, intensifying with PKE and now we are seeing the limits – both in terms of emissions but also our waterways," he said..

In contrast, there was no limit to the export of traceable, branded high-value products which brought several benefits, including cleaner rivers, a better environmental reputation and brand and a better economy.

Former Primary Industries Minister Nathan Guy endorsed the importance of investment in research and development, particularly to have work broken down to farm level.

Farmers learned and changed their behaviour from their peers, Mr Guy said.

It was pointless for scientists or politicians to tell farmers what must be done.

"It actually needs to come from the grass roots up…"

This called for key-lead farmers to take the initiative and prove what can be done.

"Farmers adapt to technology and research when they get the right signals," Mr Guy said.

Simply imposing taxes won't trigger the necessary behavioural change – "you need to be looking at a long term gain and thinking about solutions".

Our landscape depends on what course we take

This is an abridged version of Simon Upton's presentation to the NZIAHS forum in response to the question: "How do you see the responsibility of your office in regard to protecting the New Zealand environment in the context of having agriculture enter the ETS?"

THE QUESTION I was asked to address seems to assume that agriculture will enter the ETS. That's perhaps understandable, given the Government has asked the Interim Climate Change Committee how it should enter the scheme. This replaces the discussion over preceding years about whether agriculture should be 'in or out' of the emissions trading scheme.

But there is no single way of dealing with agricultural emissions. Bringing them into the ETS is just one of many different approaches that could be taken.

The question should be about how best we can mitigate agricultural emissions.

There is no easy blueprint to follow for reducing them and no single policy will be sufficient. New Zealand must chart a path forward that makes sense of our national circumstances and international commitments, and that is grounded firmly in science.

For that reason I am working on an in-depth investigation into the treatment of biological sources and sinks across New Zealand's landscapes, as part of New Zealand's climate policy. As part of that inquiry I will seek to highlight key issues to consider as an approach is developed.

It is clear that any debate around alternatives should command a solid scientific basis and explore the potential consequences of different approaches for a wide range of environmental outcomes and our landscapes. I'm in no position to share many conclusions at this stage but I can say a few words about methane, emissions pricing and forest sinks.

METHANE

To help clarify the science around methane, I recently released a "A note on New Zealand's methane emissions from livestock" along with modelling work I commissioned from Dr Andy Reisinger, examining the warming impacts of New Zealand's livestock methane. At that time discussions were already under way about the form New Zealand's climate target should take, particularly how methane should be treated as part of the target.

Dr Reisinger's modelling showed that holding New Zealand's emissions of livestock methane steady at current levels would not be enough to avoid additional warming from this source. This is due partly to the inertia in the climate system and partly because methane emissions disrupt the global carbon cycle, causing more CO_2 to enter the atmosphere.

The modelling also showed that if the goal was no additional contribution to warming above the current level – the "if" is important – then New Zealand's methane

emissions from livestock would need to be reduced by 10%-22% below 2016 levels by 2050, followed by continued reductions after 2050.

If other countries take strong climate action to meet Paris Agreement goals, New Zealand's emissions of livestock methane would need to be reduced by about 22% by 2050 to avoid additional warming. Counter-intuitive though it may be, if other countries only take some action but not enough to achieve well below 2°C, then New Zealand emissions from methane would need to be reduced by only 10%. That's because the potency of our emissions depends on total atmospheric concentrations of the entire cocktail of greenhouse gases.

Given that the Zero Carbon Bill is intended to be aligned with the Paris Agreement, an assumption that other countries will act to achieve its goals seems appropriate.

Another point worth noting is that many people misinterpreted the impact of the reductions required. Dr Reisinger's modelling, which was not economically optimised, showed that the emission trajectories required to meet the 'no additional warming' objective were not linear: deep initial reductions in livestock methane would be needed.

Yet many people interpreted the 10%-22% requirement as being achievable through straight line, incremental annual improvements in emissions intensity. To meet a 'no additional warming' objective, however, larger reductions would be needed by 2050 if the deep initial reductions shown in the modelling were not achieved. This may or may not be realistic.

The key thing is not to be too hung up on the exact number in 2050. Rather, our efforts should simply focus on working together to start reducing our methane emissions. I hope my report will shed similar light on nitrous oxide.

EMISSIONS PRICING

New Zealand's preferred policy approach has always centred around putting a price on emissions, to reduce emissions at least cost. But it has never been fully implemented.

The ETS has been in place 10 years but 'transitional measures' only now are being phased out. These measures partly explain why we don't yet have an emissions price capable of changing behaviours and investment patterns.

If fully implemented in its purest form, an 'all gases, all sectors' ETS is built around the concept of complete fungibility between gases. But we know that methane and nitrous oxide are quite different from carbon dioxide in terms of their lifetimes, potencies and broader impacts on the environment.

The Productivity Commission recommends that carbon dioxide and nitrous oxide, as long-lived gases, should be placed into the ETS, and their combined emissions reduced to net zero by 2050. They recommend methane should be treated differently because it is a short-lived gas and call for a different policy approach. I found their policy suggestion of a methane quota scheme particularly interesting.

But I remain uncertain about this split. Simply because nitrous oxide is a long-lived gas it does not necessarily mean it should be placed into the ETS. A better split might be to have one basket based on agricultural emissions and the other on fossil emissions.

A critical determinant of if and how we construct a two-basket approach is the way we address forestry.

FORESTRY

In New Zealand, a pricing signal from the ETS coupled with unlimited access to forestry credits is expected to result in a huge increase in afforestation between now and

2050. Recent modelling indicates that up to an additional 2.8 million hectares in forests will be needed to reach net zero emissions by 2050. To achieve this, a planting rate similar to the highest ever recorded in New Zealand would likely need to be sustained for decades.

But this heavy reliance on forestry comes with genuine risks.

First, there is a limited amount of land available that is suitable and economically viable for conversion to forest. At some point, carbon sequestration through afforestation will reach a limit as the most economically viable areas are used up.

Second, the permanence of forest sinks cannot be guaranteed, especially given that climate change is expected to exacerbate the risk of damage from fire, diseases and storms. If we are going to start relying heavily on carbon sequestration in standing stocks of forest, we had better take care to ensure the risks are appropriately matched.

Finally, relying heavily on forestry could further delay action to reduce gross emissions. For many years, forestry has been viewed as a 'bridge' option to buy us more time. But it is a bridge we haven't managed to build, let alone use. Each tonne of carbon dioxide offset through forestry is a tonne not reduced at source. If gross emissions remain high in the near to medium term, it could be even more difficult and costly to achieve deep reductions in gross emissions in the longer-term.

I believe trading forest sinks against fossil emissions may send the wrong signal in a world that needs to significantly reduce its reliance on fossil fuels. Perhaps there should be limits on the extent to which forests should be tradeable with fossil fuel emissions. Why should the transport decisions made in Auckland strongly influence the land-use and landscapes in Otago?

We need to consider the consequences of large-scale afforestation on our landscapes. I don't doubt that converting land to forestry can provide significant co-benefits if the right tree species are planted in the right places, such as water quality and erosion control. But it will not be without consequences for our landscapes and communities.

I therefore suggest we need to consider other environmental objectives in the mix when developing climate policy. This means we need to think carefully about the interactions between climate policies and policies in other domains. I hope to be able to offer some thoughts on this in my report.

CONCLUSION

New Zealand's emissions profile reflects the way we have managed our land over the last 170 odd years.

Challenging as it is, climate change is not a problem that can or should be viewed in isolation from other environmental issues.

Do we want a least-cost approach to reaching our climate goals to determine what our landscapes look like? Or should other factors be considered when developing an approach to reducing emissions? And how do we manage the risks associated with sources and sinks with very different time horizons?

I hope to shed further light on these questions but I won't be offering specific policy recommendations. Rather, the intention of the report is to highlight key issues to consider in developing approaches to mitigating agricultural emissions.

The nature of the challenge means that our policy makers will have to make compromises and we need to help them to do so because long-term challenges require steady, long-term responses. There is no simple, textbook way forward.

Before we embark on the next significant land-use change, we must think carefully about the environmental consequences of our proposed climate policies and the interactions of these policies with other domains. Our landscape depends on this.

How farmers' choices can make a difference

Just under 50% of New Zealand's total greenhouse gas emissions are from agriculture and about 46% of agriculture's GHG emissions are from dairy. But farmers have options that can make a difference, as we learn in this edited version of the presentation to the climate change forum by Dr Robyn Dynes, science impact leader at AgResearch.

NEW ZEALAND'S ADVANTAGE with agriculture is its temperate climate and young soils and its abundance of pasture. Together with the rumen and its microbial community, these produce the finest grass-fed meat and milk in the world.

Ruminants – the backbone of the economy – are remarkable animals, producing the meat and milk from feed we cannot eat and supporting our resilient rural communities.

How these animals will contribute to the country's greenhouse gas targets depends on the farm management options available for farmers. Each sector has different options.

Farm management is about people. The choices which farm managers make for their businesses, the constraints they must address and the values they bring to their decision-making will be different for every one of our 12,000 sheep and beef and 12,000 dairy farmers.

The value of what farmers produce must outweigh the risk, the complexity and the cost.

Some systems that will deliver a lower greenhouse gas footprint will also deliver a lower environmental footprint. They will be profitable, too – but they will also be more complex and demand greater technical expertise.

The options for dairy are more clear-cut than for sheep and beef farmers, when deciding how to reduce the GHG footprint. Dairy farmers need to focus on being better than ever before at managing pasture.

In the sheep and beef sector, resilience is vital. Farms need to be highly productive and profitable within their natural productive feed supply cycles, focusing on high-quality feed in the right quantity.

What we must remember is that many farmers have already hit the target – they are achieving results of the sort I describe here and are implementing these types of systems. The challenge for policy makers and science is to learn from the leaders.

Dairy

Dairy farming accounts for about 2.5 million hectares of the country's farmed land.

In the 10 years from 2002, the Lincoln University Demonstration Farm (LUDF) on the Canterbury Plains was at the leading edge of dairy farming systems, demonstrating the profitability gains that could be made from irrigated dairy farming.

More than 20,000 farmers went through the Demonstration Farm during focus days and asked challenging questions about management practices. Which involve taking risks and pushing the boundaries.

Five years ago, the farm was challenged with how to be relevant for the next decade by maximising sustainable profit without increasing the environmental footprint,

setting excellent animal welfare standards and operating a system which would provide a model for farmers coming through the gate.

The LUDF was able to tap into research generated from the Pastoral 21 programme, a partnership between government, Beef+Lamb NZ and DairyNZ, which had its Canterbury site just over the fence. The programme in Canterbury was trialling a low-input highly efficient system aimed at lowering nitrate leaching while maintaining productivity.

LUDF was able to take this research and apply it on a full commercial scale in a low-input farm system. Funded by New Zealand Agricultural Greenhouse Gas Research, it developed a new approach to farm management decisions focusing on environmental outcomes and productivity. It achieved a 25% reduction in nitrogen leaching and a 20% reduction in the greenhouse gas footprint.

LUDF now produces around 14 tonne CO_2 equivalents per hectare, 3-5 tonnes lower than most other Canterbury farms with similar production of milk solids, about 1,750 kilos per hectare.

The Pastoral 21 farmlets in Waikato, Canterbury and South Otago were designed to reduce nitrate leaching. They in fact reduced GHG emissions by 4%-18%.

To examine what has happened at LUDF, it is helpful to think of the total feed intake being provided in three buckets. Farm management decisions determine their contribution to GHG reduction.

The first bucket is the pasture, a function of location – a combination of soils and climate. In Canterbury, irrigation is another ingredient.

= TOTAL FEED INTAKE

	2011-2014	Current
Targeted Milk production	Max 1878	1750
kg MS/Cow	477	500 ↑
Cows/ha	3.9	3.5 ↓
Max Cows	630	560 ↓
Return on Assets	6 - 10	6
N fertiliser	250 - 350	175 ↓

The second bucket is the nitrogen fertiliser used. Farmers would expect about 10kg of pasture for every 1kg of nitrogen applied.

The third bucket is supplementary feed. Farmers have the option of buying in supplements – maize silage, pasture silage or grain supplements. This gives us the total feed intake.

We can see from this that management decisions can be made around the second two buckets.

LUDF is a low-input system with no barn and no standoff pads, so the cows are grazing throughout lactation and winter. On the other hand it is a more complex system than other farms, requiring skilled operators. Establishing it was challenging. Less nitrogen fertiliser than on a typical farm was applied and less supplement was bought in. This required a reduction in the number of cows in the herd and a reduced stocking rate.

But when you need to cull cows, you can keep those with the highest breeding worth. This builds a herd with a higher breeding worth and higher per-cow production enabling the farm to meet its targeted milk production and maintain profitability.

The target was lower than had been achieved in the past but was set at a level that satisfied economic objectives while generating environmental benefits.

LUDF demonstrates to dairy farm managers that low-input systems are highly efficient and have a real a win-win potential for the environment, reducing the footprint both to air and water.

Sheep and beef

Sheep and beef farms account for almost 9 million hectares of New Zealand's pastoral land, much of which can't be used for plant-based protein or dairying. Sheep and beef farmers have different systems, constraints and opportunities.

Bill and Shirley Wright bought their South Canterbury sheep and beef farm in 1991. Because they had worked on other farms in the area, they went on to this traditional sheep and beef breeding and finishing farm fully aware of the challenges of farming in the South Canterbury foothills. This is a productive landscape with cold winters, plenty of frosts and some heavy falls of snow. Most summers are hot and dry – spring droughts are not uncommon.

Their goals are to be innovative and flexible and they wanted a high level of profitability from producing high-quality products in high demand with the market.

In their system, over time they have targeted efficient dry matter production with high nutritive value feed throughout the year.

The farm has been transformed during their ownership. It is now dominated by cattle (around 70% of their livestock), there are no breeding cows, and they have a mix of trading cattle and dairy support.

The farm has a diversity of pastures, selected for quality and persistence and including lucerne, tall fescue and Italian ryegrass. They maximise the capture of sun and rainfall by using fodder crops – fodder beet and kale and grazing maize, a remarkably flexible crop for them in summer and autumn. It is not only a low-nitrogen crop but there can be an abundance of it through that dry summer/autumn period.

Unlike dairying the Wrights have only one bucket – the feed they naturally grow. There is no irrigation, it is not economic to use much nitrogen fertiliser and feed is bought in only during the extremes of drought or where there is a risk to animal welfare. Maximising profitability and productivity for this business requires the feed bucket to be well utilised every season. The size of the bucket is highly variable with the season and year.

The real challenge for farm management in this type of environment – and most of New Zealand's sheep and beef environments – is that managers must keep that bucket well utilised with the right quality of feed.

In 1990 the farm produced 245kg of product per hectare, leaching was modest at 10kg of nitrogen and GHG 4.4 tonnes of CO_2 equivalents per hectare. The emissions intensity of GHG was 18 kg of CO_2 equivalent per kilogram of product.

In 2013/14 – the first year AgResearch partnered with them – the farm added 150 hectares. Animal product per hectare increased by 100 kilograms, but leaching losses increased to 17kg and GHG emissions by 300kg per hectare.

But the GHG emissions intensity has been reduced to 13.8kg of CO_2 equivalent per kilogram of product. This makes the farm much more efficient and resilient: they have increased lambing percentages and have higher genetic merit stock and forages.

Management decisions have shaped a new system and future and the productivity gains have been significant.

These farmers have high-performing flocks and their lambing percentage is high. They only trade stock when they know they can put weight on and they are prepared to make changes to ensure they keep high performances from every animal on the farm within the constraints they are always considering.

In a spring drought followed by a summer drought, total production was reduced by 30% and nitrate leaching losses fell. There was a big drop in greenhouse gas emissions, too, but the farm remained highly efficient.

Bill and Shirley anticipated the *El Nino* in the year it was forecast to arrive and implemented measures to manage it, such as early weaning and selling store lambs that they knew would never put weight on. They kept only the best stock and changed their trading policies. They were locked into dairy support but worked other practices around it.

The lesson for farm management for sheep and beef farmers is that they must focus on the efficient conversion of forages: product ratio. The less time any animal is on farm, the less methane is produced. Success is about the right quality feed for the right class of stock.

= TOTAL FEED INTAKE

	1990-1991	2013-2014	2015-2016
Effective area	208	360	360
Animal production (kg product)	246	344	241
N leaching losses (kg N/ha)	10	17	13
Total CO2 equivalents (kg/ha)	4,440	4764	2746
GHG emissions intensity (kg CO2-e/kg product)	18.1	13.8	11.4

The case for more funding

A REPORT FROM the Biological Emissions Reference Group, published this month, shows many farmers want to reduce emissions, but need more information about what steps they can take.

It also shows that if all farmers operated using today's best practice, emissions might be reduced by up to 10%. Continued funding for research into new, novel technologies will be important for reducing emissions further.

The report was being prepared and its publication was portended when Dr Philip Wiles, from the Ministry for Primary Industries, addressed the NZIAHS forum in Wellington. It is the culmination of two years of research into the opportunities, costs and barriers to reducing biological emissions in New Zealand's primary industries.

Penny Nelson, deputy director general policy and trade at MPI, says the group recognised the need for a good evidence base to support the sector to address some key climate challenges.

"Farmers were asking what practical things they can do to reduce their emissions," she said. "We needed to improve our shared understanding of the possible innovation and solutions, and the barriers standing in farmers' way."

The BERG plans to host an event in early 2019 to discuss the analysis and findings in more depth.

Readers can go online to learn more about Biological Emissions Reference Group reports and research.

LINK
Biological Emissions Reference Group

A Christmas challenge: reducing Santa's emissions

WE WRAP UP this issue of *AgScience* with a suggestion for the Biological Emissions Reference Group, the Pastoral Greenhouse Gas Research Consortium, the Parliamentary Commissioner for the Environment or any of the many scientists involved in research related to climate change, greenhouse gas emissions and ruminants.

It is Christmas and any day soon a snowy-bearded gent in a red suit will dash through the country delivering presents to children. He will ride through the sky in a sleigh pulled by a team of reindeer, a phenomenon which raises biosecurity concerns as well as physics-related questions. By the time biosecurity officials have been alerted, this fellow and his team will have gone as they have done on Christmas Eve for as long as anyone can remember.

Some questions have been addressed already in "The Physics Of Santa Claus" (in Forbes magazine) and "The science of Christmas: Santa Claus, his sleigh, and presents" (The Daily Telegraph).

AgScience's interest was triggered by an article in The Scotsman, headed "Santa told to sack his gas-emitting team of reindeer". The writer criticises reindeer-drawn sleds as environmentally unfriendly because the carrot-munching ruminants produce methane in their wind. Santa accordingly was urged to ditch his sleigh team and start travelling on public transport to cut down on greenhouse gas emissions.

The article referenced a calculation showing Santa's team of nine reindeer would emit methane with a global warming impact equivalent to more than 40,600 tonnes of greenhouse gases on the 122 million-mile Christmas Eve dash to deliver presents around the world.

Mind you, his marathon sleigh ride is not as environmentally damaging as an aircraft, which would produce approximately 41,500 tonnes on the Christmas Eve trip.

Whatever the environmental damage, at *AgScience* we are confident our scientists can help. If they can find ways of reducing emissions from sheep and cattle, they can find ways of reducing the emissions from reindeer too.

On the other hand, we spotted a study titled "Methane emissions from reindeer – do reindeer fed lichens emit less methane than reindeer on a pelleted feed diet?" This raises questions about feeding lichens to dairy cows. It also suggests scientists overseas are already on the case to reduce methane from reindeer and make Santa more environmentally acceptable.

New members We welcome

Kristie O'Donnell (Auckland)
Nathan Balasingham (Auckland)
Miranda Cahn (Auckland)
Simona Nardozza (Auckland)
Casey Flay (Bay of Plenty)
Michael Kramer (Bay of Plenty)
Bala Tikkisetty (Waikato)
Fiona Calvert (Waikato)
Keith Holmes (Waikato)
Benjamin Meehan (Waikato)
Shuang-Xi Zhou (Hawkes Bay)
Xan Harding (Hawkes Bay)
Alyssa Ryan (Wellington)
Mary Gower (Canterbury)
Cameron Henderson (Canterbury)
Mark Grenside (Canterbury)
Andrew Mari (Overseas)

Corporate members

- AGMARDT
- AgResearch
- Ballance Agri-Nutrients
- Plant & Food Research
- DairyNZ
- Federated Farmers of New Zealand
- Horticulture New Zealand
- Lincoln University
- Massey University
- PGG Wrightson Seeds
- Ravensdown Fertiliser Co-op
- Zespri International

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