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SMARTER FARMING FOR A BETTER NEW ZEALAND

ground EFFECT

Spring 2022
EDITION 15

"We are not spending money on nutrients we don't need"

Land of plenty for award-winning dairy farming couple

Making the case for robust science

Supporting better decisions for the primary sector

Alternative protein reality check

Sorting fact from fiction

VELVET STAGS AT HALDON STATION

Welcome to the 15th edition of Ground Effect®

Most Ground Effect readers will be well acquainted with the reasons that New Zealand's primary producers lead the world, optimising productivity while striving to safeguard long-term sustainability.

Farmers and growers make decisions based on science, research, and market signals. Their continuing mission is to weigh these factors alongside each other, to reach a practical and profitable formula for their own land use. This is without the subsidies that cushion most of their counterparts elsewhere in the world. Responses are often finely calibrated, engaging innovation that yields measurable benefits.

Given the quality of food we produce, our sustainability credentials are among the best in the world, which makes continuing improvement a demanding challenge. Where future gains will be made is in the connection between these factors: how can science and research be best applied on farm in ways that both enhance productivity and minimise environmental impact.

Connections between people are what makes this work. Connecting a researcher with a farmer who can implement the results of research into practical use on farm, crystallising the environmental and production benefits.

This issue of Ground Effect, which is the publication's 15th edition, highlights connections and collaborations, potentially also providing a forum to initiate further engagements.

N-Vision NZ, Ravensdown's seven-year $22 million research and development programme, relies on growing those connections between science and practical farming.

Eastern Bay of Plenty farmers Fraser and Katherine McGougan are showing how careful analysis and the use of key technology are the practical connections to their farming philosophy – that you don't have to push production to be profitable.

Single superphosphate is another connection between productivity and reducing the on-farm carbon footprint.

Culverden dairy farmers Kevin and Sara O'Neill epitomise the connection between optimal production and the four 'R's of agri-nutrient application: the right product in the right place at the right time and the right amount.

ClearTech and EcoPond are outstanding examples of the connections between proven science and improved on-farm environmental outcomes.

Ground Effect contains plenty of examples of innovation and collaboration that focus on smarter farming for a better New Zealand. We publish Ground Effect to recognise, stimulate and encourage opportunities to improve information sharing between farmers, growers, researchers, scientists, agronomists, advisors and policy makers. We endeavour to provide food for thought. If you have an idea, or want to find out more, we would love to hear from you.

Best regards
Mike Manning
Ravensdown General Manager Innovation and Strategy

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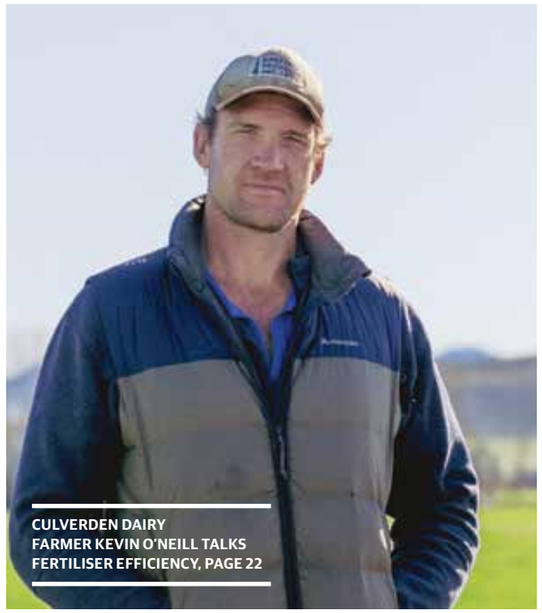


CULVERDEN DAIRY FARMER KEVIN O'NEILL TALKS FERTILISER EFFICIENCY, PAGE 22

This edition

Behind the scenes

RAVENSDOWN NZDIA COCKTAIL FUNCTION HELD AT BOTANIC, CHRISTCHURCH

NZDIA Awards 2022

The New Zealand Dairy Industry Awards (NZDIA) were held in May at the new Te Pae convention centre in Christchurch. The Canterbury/North Otago region had a clean sweep taking out the four major categories. As part of Ravensdown's sponsorship, finalists visited Lincoln University Research Dairy Farm to view EcoPond and enjoyed a Ravensdown-hosted cocktail function at Botanic Restaurant. Our congratulations to all the contestants and winners for 2022.

FROM LEFT: DAIRY TRAINEE OF THE YEAR, PETER O'CONNOR FROM PYE GROUP LTD; SHARE FARMER OF THE YEAR WILL GREEN FROM DAIRY HOLDINGS LTD, AND DAIRY MANAGER OF THE YEAR JASPAL SINGH FROM WAIMATE. THE FONTERRA RESPONISBLE DAIRYING AWARD WENT TO CRAIGMORE FARMING LTD.

New chair appointed

After 16 years on the Ravensdown board, John Henderson (pictured) has stepped down as chair, a position he held for eight years. Incoming board chair Bruce Wills likened John's time on the board to that of Richie McCaw – having completed 144 board meetings in his time, close to Richie's 148 test matches for the All Blacks.

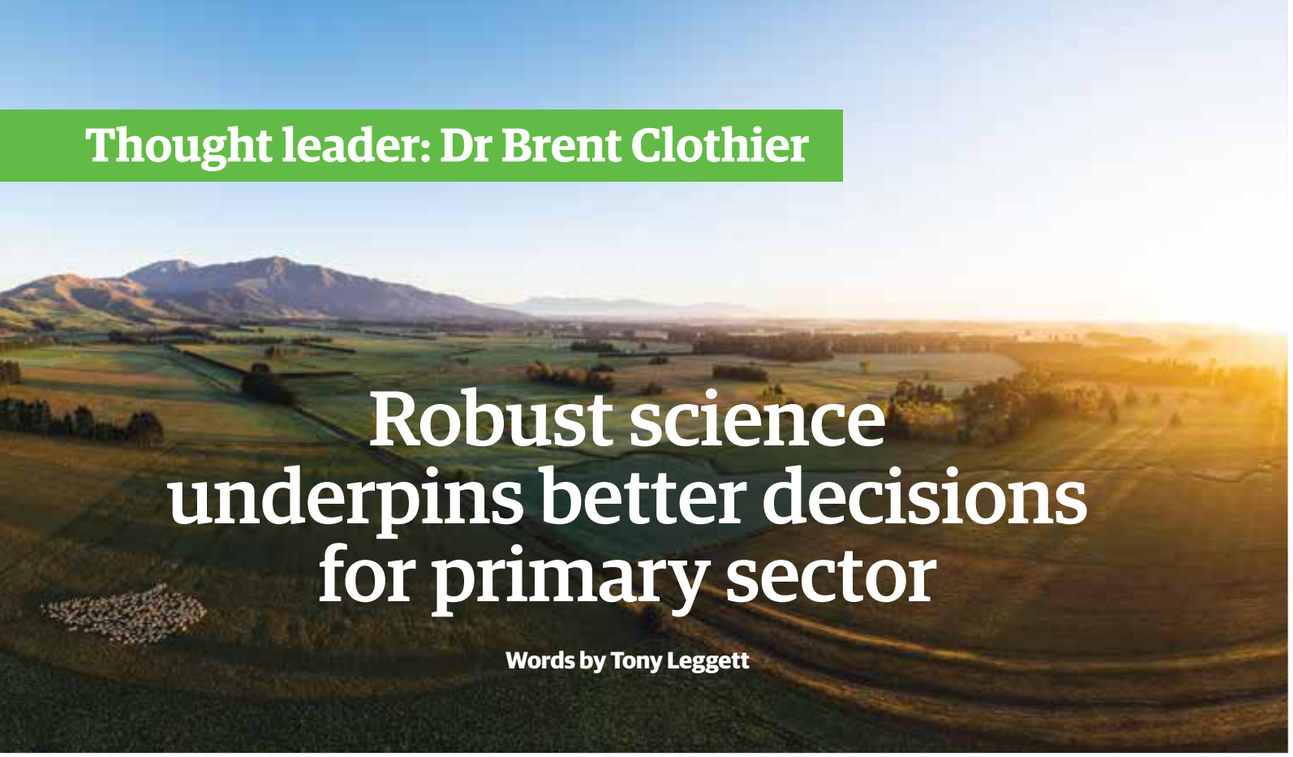
Ravensdown coal removal project recognised

Ravensdown's project to remove coal use at Dipton Lime has been announced as a successful recipient of the Government Investment in Decarbonising Industry Fund. The project will reduce Ravensdown's carbon footprint by about 10%. Congratulations to the team involved in project development and the submission process.

Working together to achieve outcomes

Ongoing collaboration is underway to ready HawkEye for the first round of N fertiliser cap reporting from 31 July 2022. Members of the HawkEye and Environmental team have been collaborating with primary sector and 'R 16' (representatives from each of the 16 regional councils) to develop HawkEye for new reporting requirements requiring dairy farmers to report N fertiliser use against the N-190 cap. This work has been a great example of collaboration between primary sector and regulators to gain efficiencies through a nationally consistent reporting format.

RAVENSDOWN GRADUATES LIAM CHATTERTON AND CLAIRE GORDON HOLDING AN IMPRESSIVE SWEDE ON SHAREHOLDERS STU AND JAN MOIR'S WEST COAST PROPERTY. THIS PADDOCK CAME IN AT 22TDM/HA.



Thought leader: Dr Brent Clothier

Robust science underpins better decisions for primary sector

Words by Tony Leggett

DR BRENT CLOTHIER, PLANT & FOOD RESEARCH

Little is left to chance or challenge in Dr Brent Clothier's work life. And that is just how he wants it.

As one of Plant & Food Research's (PFR) principal scientists, Brent is a firm advocate of robust science supporting better decisions for the primary sector.

Without exception, science produced at PFR takes a defined, rigorous journey from hypothesis to its final delivery point.

It is one of seven Crown Research Institutes (CRI) owned by New Zealand taxpayers, but only about a third of its research is funded directly by Government. The rest comes from commercial contracts with private companies and the reinvestment of royalty incomes from its many plant variety rights.

Regardless of the diverse source of the funding, the process is similar.

For publicly funded work, the findings are scrutinised internally and peer reviewed externally before being published in an academic journal. Sometimes results are delivered at an international conference or direct to the sector.

With commercial clients, the internal peer review process takes on greater significance.

"I've just been part of a group of six PFR scientists involved in a very robust exchange over a private contract report," says Brent. "We get in a room, and it could be a virtual room, shut the door and argue about what it is the evidence base is saying."

Brent says it is rare for a private client to insist on confidentiality if the immediate results prove unfavourable to them. A more likely outcome is a request for further collaborative work to probe deeper into reasons why the results might have been surprising or unexpected.

"And some of our private clients are happy for us to publish results in an international journal so they can say it's been peer reviewed and that's the hallmark of quality."

He is comfortable with the expectations from private clients and says the outcomes are always presented to them "warts and all", regardless of who is funding the work.

"We say we're the science providers for your sector, and your success determines our success, so we'll give them the best advice we can based on robust science that has been through our internal channel where it is challenged vigorously by peers.

"Yes, it is a partnership between us and our private client. But we're all working for the greater industry good, and when they succeed, we do too."

Most CRIs also have a science publication officer who reviews every paper before it's delivered either at an international conference, published in an academic journal, or presented back to a private client.

"So, we have an internal process that ensures our science is robust. That's brand 'Plant & Food', so it's absolutely imperative to have it in place because that's our personal and corporate reputation at stake."

External communications, including through social media platforms, are guided by an experienced communications team within each CRI.

Brent admits he's frustrated at times by "half-baked" claims made by people or companies on social media platforms. PFR engages frequently on social media channels, but every post is carefully curated to ensure the evidence base is referenced, and its brand and reputation are maintained.

He rejects the suggestions science is slow to move or that too many reports sit on shelves gathering dust. Delivering science on schedule is now embedded in every contract the CRIs sign, he says.

Milestones must be achieved, both for private and public-good projects, and most include an implementation pathway that sets out how the science must be delivered to the sector.

"It is a partnership between us and our private client. But we're all working for the greater industry good, and when they succeed, we do too."

"It's a bit of a throwback to the past to suggest now that science is not delivering."

Historically, a science paper would have been submitted to an international journal after being peer reviewed by at least two referees.

"Often they were the only two people who might ever read the paper!

"It's a record of achievement, which is great, and it remains in the literature accessible for all time."

EXAMPLES OF SCIENCE BEING MOBILISED QUICKLY ARE THE BACTERIAL KIWIFRUIT VIRUS PSA AND THE COVID-19 PANDEMIC

"Science is playing a big part in maintaining our primary sector's rock-star status by keeping food and fibre production sustainable, safe, efficient, and incredibly valuable."

Brent says research outcomes have improved since implementation pathways became a requirement of science because of the opportunity for scientist and the sector to interact directly.

"An email from two anonymous referees telling you to fix up your grammar is not very exciting."

Instead, these days, scientists are often called on to deliver their research directly to an audience of funders, such as a series of workshops around the country where they are engaging with people highly engaged in what has been discovered.

"Suddenly you've got a whole range of questions to answer over a half day or whole day, which is really great. You get questions like 'what didn't you find out?' or they'll say 'tell us more about this finding' and that feedback shapes our further research focus."

Two good examples of science moving quickly are the 2019 Covid-19 pandemic and the arrival in 2010 of Psa, the bacterial kiwifruit vine disease.

"In both cases, with our owner's [Government] consent, the CRIs were able to mobilise staff to provide the science," Brent says.

In the case of Covid, the Institute for Environmental Science and Research moved its available workforce on to wastewater testing and genome sequencing work. When Psa hit and started to spread quickly, PFR immediately shifted staff to new roles to help limit the spread and eventually eliminate the disease.

Brent says robust science is one of the big drivers of New Zealand's world-leading primary sector.

He notes the latest Situation Outlook for Primary Industries update from MPI has the sector set to provide a record $52.2 billion of export earnings for the country to 30 June 2022 despite the huge challenge from the Covid-19 pandemic. The primary industries will supply 81.8% of our merchandise exports.

"Science is playing a big part in maintaining our primary sector's rock-star status by keeping food and fibre production sustainable, safe, efficient, and incredibly valuable," he says.

Dr Brent Clothier is a Principal Scientist with PFR based in Palmerston North. He has published more than 300 scientific papers on the movement and fate of water, carbon and chemicals in the root-zones of primary production systems, irrigation allocation and water management, plus sustainable vineyard and orchard practices, including adaptation strategies in the face of climate change. He has also published on life-cycle assessment, carbon and water foot-printing, environmental policy, investment into ecological infrastructure, plus natural capital quantification and the valuation of ecosystem services.

Less is more in the Bay of Plenty

By Elaine Fisher

Despite decreasing their fertiliser spend, Fraser and Katherine McGougan have maintained production and improved pasture health on their 150ha Willowvale Farm in eastern Bay of Plenty. Careful management is crucial to the farming operation's success and its long-term environmental sustainability.

ANIMAL WELFARE IS AT THE FOREFRONT OF FRASER AND KATHERINE MCGOUGAN'S OPERATION

Decisions on the type and volume of fertiliser to apply are determined by the results from soil testing every paddock on Willowvale. Whole Farm Soil Testing (WFST) is carried out by Ravensdown every two years, but as pasture performance and continuity continues to improve across the farm, the McGougans may extend this to a three-year interval.

There are three soil types across the property: Whakatane fine sandy loam, Opouriao fine sandy loam and Rewatu fine sandy loam, and each behaves differently.

Paddocks on the lower contour are Whakatane fine sandy loam with a stony sub-soil, and they drain well, while the heavier Rewatu soils perform better after draining with Novaflo.

Before WFST the McGougans treated the farm as a series of blocks but embracing WFST has allowed them to be much more specific about how much fertiliser each paddock receives.

"We are looking for consistency of pasture growth across the entire farm and we're achieving that now," says Fraser.

"Liming helps nutrients from our acid soils so we may enhance the available nutrients simply by putting on lime."

The Olsen P target level for the farm is 33. Soil pH targets are addressed through a regular liming programme in accordance with soil testing. Shed effluent is used to complement the fertiliser programme across the effluent area, which extends to 48ha (35% of effective area) where currently no additional fertiliser is added. From the OverseerFM nutrient budget, 37kgN/ha/year is lost to water.

Fraser uses Ravensdown's HawkEye software along with his farm maps and a GPS system in his tractor to ensure nutrients are applied exactly where they are required and at the correct rate every time.

"We invested in our own fertiliser spreader so we can apply fertiliser at exactly the right time and the technology means anyone can carry out application exactly as it should be done.

"The drop in our fertiliser spend has been significant. We are not spending money on nutrients we don't need, and we are reducing emissions and nutrient leaching."

Farm Facts

Farm name	Willowvale Farms Ltd
Owners	Fraser and Katherine McGougan
Location	Opouriao Valley, Taneatua, Eastern Bay of Plenty
Area	150ha (136ha effective)
Topography	Flat
Soil type	Opouriao silt loam and Rewatu silt loam
Herd	420 head at peak (3.2 cows per ha)
Production per cow	367kgMS
Production per ha	1161kgMS
Production worth	160
Breeding worth	130
System category	System 2 (10% imported feed)

"We are not spending money on nutrients we don't need, and we are reducing emissions and nutrient leaching."

FRASER AND KATHERINE MCGOUGAN WITH CHILDREN, FROM LEFT, LIAM, EMILY AND ISAAC.

Fraser McGougan uses Ravensdown's HawkEye software along with his farm maps and a GPS system in his tractor to ensure nutrients are applied exactly where they are required.

Reducing nutrient loss and enhancing the environment are important to Katherine and Fraser who have continued to plant and fence out waterways, change drainage systems where needed, and they have decreased stocking rates.

"We're concerned about the potency of nitrous oxide as a harmful gas because of its warming potential and are trying to minimise this specifically," Fraser says.

"Also, we are working very hard on reducing our N loss numbers and the N loss in total, not just to water. This includes volatilisation as well. We would love to do some trial work on our soil types to find the true losses."

Saving on fertiliser spend is significant for the Willowvale budget, but money is not the main driver for Fraser and Katherine's decision making.

WHOLE FARM SOIL TESTING HAS ENABLED THE MCGOUGANS TO BE SPECIFIC ABOUT THEIR NUTRIENT USE

They are conscious that climate change, along with consumer attitudes to farming practices, pose threats to their business and they are proactive in addressing those issues, Fraser says.

"We no longer feed palm kernel because it's a threat to the New Zealand Inc brand as it's seen by the public as a by-product of an industry that has significant environmental impacts. No matter what we as farmers think, what we produce is a consumer product and we must pay attention to potentially adverse consumer perceptions of our industry."

That includes how animals are treated too, even though caring for their cows is second nature to the McGougans. They don't need public pressure to ensure they do the right thing as their approach to dairy farming is holistic.

Katherine and Fraser consider the health of their soils, waterways, native bush, wetlands, stock, staff and themselves in their management plans. Putting that into practice is among the reasons the couple won the 2019 Bay of Plenty Ballance Farm Environment Awards Regional Supreme Award and why Fraser is a DairyNZ Climate Change Ambassador.

"We are caretakers of the land, not its owners. One of the core things for us is that we don't have to push production to be profitable. We take a more rounded approach and have decreased pressure on the system. Animal welfare is at the forefront, which includes better pasture management and getting the pasture species' balance right," Fraser says.

"We do a lot of re-grassing and one of the strengths of the farm is that we can grow a lot of maize, between 26 to 27 tonnes per hectare, as part of the re-grassing programme."

Working together to achieve outcomes

Ravensdown has actively supported and encouraged Fraser and Katherine McGougan to reduce their nutrient inputs.

JOHN MCFADGEN, RAVENSDOWN'S SENIOR AGRI MANAGER BAY OF PLENTY, DISCUSSES THE PERFORMANCE OF WILLOWVALE FARM PASTURES WITH FRASER MCGOUGAN

"Ravensdown sees the big picture. It knows that the impacts of climate change and the requirements to reduce emissions under He Waka Eke Noa (the Primary Sector Climate Action Partnership), and new rules to protect and restore New Zealand's fresh water are affecting farming, so it's being proactive to help farmers meet those challenges," says Fraser.

Ravensdown has actively supported and encouraged Fraser and Katherine McGougan to reduce their nutrient inputs.

John McFadgen, Ravensdown's Senior Agri Manager for the Bay of Plenty, based in Te Puke, says as a farmer-owned co-operative, Ravensdown's role is to do what is best for its shareholders.

John says he takes personal pride in the performance of Willowvale farm and its pastures. "I enjoy problem solving and working alongside Fraser and Katherine to achieve the best possible results.

"It is also important that Ravensdown continues to do the right thing for the environment. At the same time, we're saving Fraser money through the efficient and targeted use of fertiliser."

The maize paddocks are also where much of the farm's cowshed effluent is spread.

Climate change is already exerting pressure on the farm. "We used to be summer safe here but that's no longer the case."

The area receives the same volume of rain in a year, but it's not regular, with longer dry periods and more extreme rain events.

"The biggest weather changes have been in the past 20 years, and I think the impacts will happen even faster in the next 20. We can't turn a blind eye to them," Fraser says.

The district's first frost of 2022 wasn't until May 12, almost two months later than usual. "We are not getting the chilling effects, which can help control pest pasture species so pasture management is getting harder."

Paspalum and kikuyu grasses, once never an issue, are now appearing in Willowvale paddocks. However, there's one success story for pest plant control on the McGougan farm. Thanks to Ravensdown's grass-friendly herbicide 'Multiple', Californian thistles are now under control. "We'd been battling them for 20 years without significant success," says Fraser.

"Global warming is absolutely affecting our industry and we can't keep doing what we've always done."

"Global warming is absolutely affecting our industry and we can't keep doing what we've always done."

PASTURES ARE REGULARLY REGRASSED, ALTHOUGH CHANGES IN CLIMATE ARE THROWING UP SOME NEW CHALLENGES

Once the milk pay-out drops, which it inevitably will, farmers will be forced to really focus on their pastures. The weather is changing and some places in New Zealand may no longer be suitable for dairying, while others may become better for it."

It's a source of pride for Fraser and Katherine that the family has been on the land since it was settled by Fraser's great grandfather in 1898. The couple hopes that tradition will continue well into the future.

A vision for N with new N-loss project

By Ravensdown Scientific Officer Dr Will Talbot

N-Vision NZ, a new $22m innovation to help farmers reduce nitrogen (N) loss, is Ravensdown's largest single investment in research and development. Established in partnership with the Government's Sustainable Food and Fibres Future (SFFF) initiative, N-Vision NZ seeks to develop new N-based technologies that support farmers to reduce their N losses, while maintaining production and profitability.

The 'N-Vision'

Ravensdown, alongside partners Lincoln University and Plant & Food Research (PFR), will develop innovative science in the areas of biological technology, nutrient management and precision agriculture, bringing practical applications to help farmers optimise environmental performance without compromising productivity. Over the next seven years Ravensdown has committed $11m in cash to N-Vision NZ, with MPI contributing $7.3m in cash to co-fund the innovation as part of the SFFF.

N-Vision NZ™

Why nitrogen?

Nitrogen is an essential nutrient for plant and animal growth. Estimates indicate that N fertiliser supports approximately half the global population's food supply. However, in pastoral farming systems N is deposited in urine patches at much higher rates than plants can utilise, with the excess N at risk of being lost to the environment through N leaching or nitrous oxide emissions. At present, some of the most effective methods to mitigate pastoral farming's environmental impacts and N loss are substantial land-use change, reducing livestock numbers or afforestation. Each of these methods may come at a cost to export income. Science-led innovations are therefore needed to create better N management tools, providing alternatives that, unlike the existing mitigation methods, do not compromise the capability of New Zealand farmers to provide food and fibre to global and local markets.

The science

Three complementary projects will explore and develop technologies to reduce greenhouse gas (GHG) emissions and N leaching. This programme promises to enhance the country's economic potential, while helping guide agriculture towards a future with lower carbon emissions and better freshwater health, therefore making New Zealand's pasture-based story even more compelling.

The three projects are:

N-Test

Helping pastoral farmers capitalise on the N already present in labile soil organic matter

In partnership with PFR, Ravensdown has developed the N mineralisation calculator, which interprets the lab Potentially Mineralisable N (PMN) test results for cropping soils, providing cropping farmers with typical N mineralisation values (kg N/ha/month). This allows farmers to amend their fertiliser N practices by amending the amount they would have applied by using a proportion of the N that will become available from soil organic matter mineralisation. This project aims to increase the utility of the PMN test.

The PMN test is a simple, reliable and cost-effective method to measure soil N that the microbiology may make plant available. It combines principles of precision agriculture with emerging knowledge of previously under utilised natural systems. As this innovation reaches the point where it can be applied on farm, farmers will have access to a tool enabling greater understanding of the organic N cycling in their soils, and how this understanding can help them better use the N they apply, therefore saving on N fertiliser cost and potentially reducing N losses to the environment.

N-Test™

N-Bio Boost

Harnessing the power of soil fungi to boost plant N-use efficiency and drought resilience

Lincoln University researchers have discovered natural strains of fungi that when applied to soil as either a prill or seed coating will reduce the activity of specific N-transforming microbes. By promoting the fungi, which occurs naturally in pasture at a relatively low level, farmers will be able to better manage the microbes that accelerate transformations in the N-cycle, therefore reducing GHG emissions and the leaching of nitrates to waterways. This research offers a practical method to reduce GHG emissions and N contamination of waterways, while increasing plant resilience in water and pathogen-stressed environments.

Farmers face considerable challenges around the environmental impact of their land use. Most specifically, these challenges focus on GHG emissions and N leaching, manifested in current and emerging government regulation intending to address these environmental impacts. N-Vision NZ seeks to apply leading edge science and technology to create or develop tools that farmers can use on farm. These tools will provide farmers with important options to maintain profitability while minimising the environmental impact of their land use. ■

N-Bio Boost™

N-Retain

Inhibiting the soil enzymes that lead to nitrous oxide emission and N leaching

In partnership with Lincoln University, Ravensdown is researching next-generation Nitrification Inhibitors (NI). These NIs have the potential to significantly reduce the environmental impact of New Zealand's grazed pasture systems, specifically by lowering nitrous oxide emissions and N leaching, which in turn will make the production system more sustainable without compromising productivity. The development of on-farm tools such as NIs will better equip New Zealand's agriculture sector to reduce GHG emissions, as well enabling farmers to adhere to increasingly stringent water quality standards on nitrate.

N-Retain™

Thought leader: Dr Jacqueline Rowarth

Feeding the world: the unintended consequences of agricultural system change

DR JACQUELINE ROWARTH

How can we feed an ever-growing global population with the least environmental impact? It has been a question occupying the minds of agricultural scientists for decades, and the improvements have been remarkable.

From Norman Borlaug's Green Revolution in the 1960s and 70s, to genetic technologies and precision agriculture, more people have been fed to a higher nutritional standard than ever before. Efficiency gains are apparent through productivity increases – more yield per hectare, hour and unit of agrichemical. Farmers have worked with the scientists and rural professionals, suggesting ideas and then adapting the research findings to suit their farm systems. The information flow has been in several directions, and New Zealand has shown other countries what can be done by working together.

Globally, including in Ukraine and Russia, wheat yields are 3–3.5t/ha. Eric Watson of Ashburton broke the Guinness World Record for feed wheat in 2020 with a crop of 17.398t/ha. His achievement is a testament to precision agriculture – right place, time, form and amount. Productivity gains in the primary sector have led the statistics (sometimes being beaten by retail and IT) and, against predictions, have continued to be a major provider of export income.

The success in the food production sector has been built on science and technology, targeted at New Zealand's soils, environment and farm systems, while watching developments overseas for relevancy. Any new research claiming benefits is examined for context and scientific credibility. Are the results robust? What's the process or mechanism? Could it work in New Zealand? Are there any potential downsides? Scientists are innately sceptical. They ask questions to understand the drivers of change and avoid unintended consequences.

RECORD-HOLDING MID CANTERBURY FARMER ERIC WATSON PREPARES HIS FIELDS FOR CROPS

"The success in the food production sector has been built on science and technology, targeted at New Zealand's soils, environment and farm systems."

This explains the concern articulated by many New Zealand agricultural scientists about the current push towards organic regenerative farming systems. We've asked the questions, done the analysis and have concluded that the unintended outcome will be a reduction in food production resulting in escalating food prices.

Further, the belief that the environment will be better off is difficult to substantiate.

The fundamental problem is the growth in global population. To feed more mouths using organic regenerative practices means that we will need more land. And that means expansion into what is currently not used for agricultural production. Suggestions that precision fermentation will take the place of animals overlooks the requirement for energy for the fermentation – a supply of sugar from cane, corn or beet. The sugar crops require land and all the usual fossil fuel and agrichemicals, including fertilisers, for production.

In New Zealand, moving to organic regenerative systems would mean that seaweed-based nutrient supplies and animal litter and bedding would be in short supply, and that means price increases.

Sri Lanka's experiment in growing their major export crops like rice and tea organically shows the result – the country didn't have enough organic sources of nutrients to cope. Food supplies reduced, prices escalated, and the timing with Covid-19 and reduction in tourism was appalling. The economy crashed and the riots continue.

Less dramatic but also important are the calculations for the EU's Green Deal, which is putting land into organic production and reducing agrichemical inputs. The Green Deal has been accompanied with warnings from scientists on yield reduction, and economists have examined the consequences.

(1) see Source Code page 40

UNDER ORGANIC REGENERATIVE PRACTICES, MEETING FOOD DEMAND GLOBALLY WILL REQUIRE MORE LAND

The United States Department of Agriculture Economic Research Services' analysis suggests that higher food prices would increase the number of food-insecure people in the world's most vulnerable regions by 22 million (EU-only adoption) to 185 million (global adoption).

With all the evidence it is difficult to understand the push behind organic regenerative agriculture. New Zealand pastoral farmers have not degenerated their soils – they maintain high organic matter in their soil profiles. They are also at the forefront of fewest greenhouse gas emissions per kg of meat or milk – we have the data. And, contrary to general perception, per kg of production, the environmental impact of organically produced food is higher than that of conventional.

"New Zealand pastoral farmers have not degenerated their soils – they maintain high organic matter in their soil profiles."

What New Zealand farmers have created is sustainable food production – maintaining soil quality under pasture and ensuring high welfare for their animals (the Animal Protection International Index assesses New Zealand as high or higher in farm animal welfare than our trading partners). It is the feed quality and high welfare that enable low GHG emissions.

To do better, we need to use all the tools we can, while developing more.

The future thinker Bjorn Lomberg[1], visiting fellow at Stanford University, agrees.

He is urging influencers, including governments and non-profit organisations, to focus on efficient agricultural production to prevent expansion into the conservation estate. Genetic engineering, improved pest control and irrigation and fertiliser are on his list as part of the solution to feeding people.

Science and technology have made, and will make, the difference in feeding people sustainably. Working together, New Zealand farmers, rural professionals and scientists will show the way.

Dr Jacqueline Rowarth is an adjunct professor with Lincoln University and a farmer-elected director on the Boards of DairyNZ and Ravensdown. The analysis and conclusions above are her own.
jsrowarth@gmail.com

Adoption and progression at Haldon Station: the heart of the Mackenzie

The ability to grow grass under pivot irrigation has been a game changer for Haldon Station in South Canterbury's Mackenzie Country. Lynda Gray reports.

Feeding, breeding and irrigation have combined in the building of a successful deer finishing system in the extreme climate at Haldon Station. But after 40 years of farming them, deer are still a work in progress for long-time manager and Ravensdown shareholder Paddy Boyd.

The move to weaner finishing was enforced after a brush with Tuberculosis (Tb) back in the mid-1980s. Up until then, progeny from the 2,000 breeding hinds were either sold on for finishing or finished on farm over two years. It was a simple no-fuss system that suited the extensive briar and hill and semi-developed lower-lying hill country typical of the Mackenzie Basin.

But that went by the wayside when Tb testing turned up 15 reactors.

"It was a low percentage of the herd, but Tb was confirmed," Paddy says.

"It was never proven, but it probably came from the live recovered deer, so there was always the likelihood it would happen."

The news brought with it an immediate red light to the movement of deer from Haldon and the end of the store stock system.

"We went to a closed herd situation. It was hard because you couldn't trade, and it became widely known. It made you feel like a lepper… it was pretty tough at times."

Haldon tested out of Tb over five years during which the basics of a finishing system were set in place, but it was a rocky start.

"We were forced into holding on to our young deer, and we simply didn't have the feed over the first few years and had to carry them through two winters," Paddy says.

It's hard to believe now, given that all young deer are sent for slaughter at 12–16 months of age. This year the yearling stags averaged a 60kgCW at 14 months, and the yearling hinds 57–58kgCW at 13 to 15 months.

Pivot irrigation offers control and precision

Breeding and feeding were integral in the development of the finishing system but Paddy says the addition of reliable and efficient pivot irrigation over the last decade has been the big game changer.

"We're competitive now in the finishing game because we have reliable water and can grow grass consistently."

Before the pivots, young deer were fattened on dryland lucerne and a border-dyke ryegrass area. The hinds grazed most of the year on the lower and mid-altitude hill country. Both areas got spring fertiliser; the productive downlands 200–250kg/ha of superphosphate and the hind hill-grazing country about 100kg/ha of 30% sulphur super. However, Paddy says fertiliser on the hill was potentially wasted. If application was followed by a prolonged dry spell the fertiliser wasn't taken into the soil; on the other hand, if there was a deluge of rain, it could be washed off the hill.

"We never had control, whereas under the pivots we can control that nutrient uptake by applying water."

The pivots have greatly increased the area of reliable quality feed so that hinds and young deer can graze it for extended periods, leaving the hill country time to recover. It's taken the grazing pressure off the hill areas and fertiliser application has been reduced from a three-year rotation to an as-needed basis.

Fertiliser is now targeted on the 1,770ha of pivot, productive dryland lucerne and pasture blocks, which collectively receive about 650 tonnes of fertiliser annually.

About 840ha is watered by nine centre pivots installed over what was blow-away silty soil and native country. Work with soil and irrigation experts throughout development was crucial for defining the optimal daily water application rate of 4.5mls.

> **"We're competitive now in the finishing game because we have reliable water and can grow grass consistently."**
>
> **Paddy Boyd, Haldon Station**

The irrigation season is from October to May during which incoming and outgoing water is regularly tested as part of Environment Canterbury's irrigation consent conditions.

"We test at a number of other sights outside of the pivot area as well and it's pleasing to see the reduction over time in nitrogen and phosphorous levels in the water that leaves Haldon," Paddy says.

The reliable water, supplied through the Mackenzie Irrigation Company scheme, has removed the risk and angst caused by hot, dry summers.

"We can grow grass over summer and have surplus that takes us up until June. It's effectively reduced our winter from 120 days to 90 days."

But learning how to grow and manage the predominantly Italian ryegrass and red and white clover mixes took Paddy a while to sort out.

MIXED-AGE VELVET STAGS

HALDON STATION MANAGER PADDY BOYD

"I've learnt a lot about managing pastures, especially over January and February. It has to be actively managed through grazing or cut for balage, because if it goes rank you don't get the root reserves of nutrients."

Astute grazing is one part of the management equation, as is targeted nutrient application. Paddy works with Ravensdown Senior Agri Manager Dan Laming to identify the right nutrients for the job.

A base maintenance dressing of 300kg/ha of Sulphur Super 15 and 0.5kg/ha of slow-release selenium Selprill Double is applied by a bulk spreader in October. As Sulphur (S) is the most limiting nutrient on this country, 50kg/ha of S is added to the lower altitude deer blocks on a three-year rotation. Haldon has naturally high pH levels due to wind-deposited glacial silt and lower aluminium levels than many other parts of the Mackenzie, which means lucerne is a viable forage option.

On some of the pivot blocks Flexi-N is applied to kick-start early growth for velvet stags. Potassium chloride on other blocks is used to maintain potassium levels that deplete over time due to the harvest of pasture for balage. Molybdenum levels are maintained with low rates of sodium molybdate applied on a three- to four-year rotation.

In late April, pivot pastures get a 100kg/ha boost of Ammo 31 which, in Paddy's layman terms, puts the pastures to sleep for winter and sets them up for spring.

"We get extra dry matter, and the grass puts reserves into the roots so once soil temperatures reach 8 to 10 degrees it's away again and growing in September, which is when we need it for the young deer."

The water-fed changes have created a diverse and flexible finishing system in which venison production generates about 40–45% of gross farm income.

The balancing act

Paddy's pleased with the overall balance of stock and the development of a sustainable production system, thanks to spray irrigation. But he's mindful of balancing production and profit with environmental sustainability. His success at combining all was formally acknowledged back in 2005 when Haldon Station won both the Supreme and Water Efficiency categories at the Ballance Farm Environment Awards. Since then, he's continued to enact and demonstrate responsible land and water stewardship through testing and nutrient budgeting. He says meeting the environmental expectations of New Zealand's red meat customers is the new challenge for farmers and one they need to walk towards rather than away from. His advice, based on his experience with irrigation development and associated water quality, is to document everything for regulators and stakeholders.

PADDY AND RAVENSDOWN SENIOR AGRI MANAGER DAN LAMING

"We can grow grass over summer and have surplus that takes us up until June."

"We're not allowed to grow pines due to the wilding pine issue in the Mackenzie area. That leaves mostly natives to choose from, which is very restrictive, but we are working hard to come up with a planting plan."

"You have to prove you're doing the right thing with the weight of evidence, such as science-backed data and photos. It's so important to keep a trail of evidence."

At present, plans are in progress for shade and shelter plantings around the pivots.

"That's been one of the biggest challenges because we're not allowed to grow pines or similar species due to the wilding pine issue in the Mackenzie area. That leaves mostly natives to choose from, which is very restrictive, but we are working hard to come up with a planting plan."

Deer comprise one-third (10,370) of Haldon's 28,000 stock units. There's been ongoing investment and development in feeding and genetically upgrading the Red deer herd. That's led to the establishment of an on-farm breeding programme where the top performing animals are selected for an elite herd to breed on-farm sires.

Merino and halfbred sheep account for 43% (12,000) and the Angus and Hereford cattle the remainder. Paddy's satisfied with the overall mix of stock classes and how the deer finishing system has bedded in. But he's always looking for ways to do things better and reckons there is scope to improve growth rates over autumn.

DEER FARMING AT HALDON STARTED BACK IN THE LATE 1970s, THE PROOF BEING A MURAL OF PHOTOS ON THE WALL OF THE COOKSHOP ILLUSTRATING THE ADRENALINE-CHARGED HELICOPTER RECOVERY DAYS

"I'd like the weaners to be 10kg heavier going into winter. We wean in March, and in April their growth ramps back."

He's unsure whether the growth check is related to the inherent physiology of deer, but to help plug the growth gap he plans to follow up by investigating some new forage and pasture options such as Raphno, plantain, red and white clover mixes.

That will mean more practical experimentation involving both trial and error. But Paddy isn't complaining because he reckons if you're not learning and trying new ways, you might as well give up.

Here's looking to the next 40 years and another chapter of deer farming at Haldon Station. ■

Single super is clever choice for future carbon target

By Tony Leggett

Single superphosphate (SSP) is a proven, low-emission choice of fertiliser that could help get more farms closer to New Zealand's carbon neutral target by 2050.

SSP's relatively low carbon footprint was identified in 2011 and confirmed in late 2019 by AgResearch's world-class Life Cycle Assessment (LCA) team. It reviewed the earlier estimates of greenhouse gas (GHG) emissions for a range of imported fertilisers and SSP, based on local production and importation data for 2018-19.

The study evaluated SSP and a range of other fertilisers including triple superphosphate (TSP), diammonium phosphate (DAP), ammonium sulphate (AS), calcium ammonium nitrate (CAN), and muriate of potash (KCl).

Prices might have changed considerably since the 2019 study was completed, but the relative differences in emissions produced by each fertiliser were similar for both studies, says one of its co-authors, AgResearch's principal scientist Dr Stewart Ledgard.

He's an internationally recognised expert in LCA, which analyses resource use and environmental emissions associated with a product or system.

In the more recent study, LCA methodology was used to account for all the sources of GHG emissions to calculate the carbon footprint of each fertiliser from the raw material source to the New Zealand port for the imported fertilisers, or source to New Zealand manufacturing-plant door for SSP. Extraction of the raw material, transportation to a New Zealand port, production of the inputs, and manufacturing emissions are included for both cases.

The study found the fertiliser manufacturing process was the primary contributor to total emissions for most fertilisers except SSP, but values for each fertiliser were lower than the earlier study, due to improved efficiency of production and transportation, and changes in the sources of raw materials.

The total carbon footprint of SSP in the 2018-19 study was lower than the earlier study (0.156kg CO_2 equivalents/kg of SSP vs 0.216kg CO_2 eq/kg in 2011), mainly due to the impact of differences in phosphate rock source and shipping efficiencies.

TABLE 1: TOTAL GREENHOUSE GAS EMISSIONS IN KG CO_2-EQUIVALENTS/KG SUPERPHOSPHATE COVERING THE CRADLE-TO-MANUFACTURING-PLANT-GATE IN NEW ZEALAND. IT REPRESENTS A WEIGHTED AVERAGE FOR SUPERPHOSPHATE PRODUCED ACROSS THE MANUFACTURING PLANTS OF BALLANCE AGRI-NUTRIENTS AND RAVENSDOWN.

	2018-19 estimate	2008-09 estimate
PR mining and beneficiation (including transport to port)	0.039	0.048
Train transport of S in Canada	0.003	0.002
Shipping of raw materials (PR, S and sulphuric acid) to NZ port	0.096	0.148
Truck transport of raw materials to plant	0.001	0.001
Net electricity use and fuel at plant	0.003	0.003
CO_2 from CO_3 in PR	0.014	0.014
Total	**0.156**	**0.216**

Emissions from shipping of the phosphate rock (PR) and sulphur (S) to New Zealand were the largest contributor to the carbon footprint of SSP, at 62% of the total. Mining of PR rock at the site accounted for a further 25% of the total, internal transport 2%, energy for production of SSP 2%, and CO_2 release from carbonate in the phosphate rock, 9%.

Another benefit from applying SSP is its sulphur content, which is about 10 times higher per kg P applied for SSP than for TSP, indicating greater GHG efficiency for the New Zealand average SSP.

The study shows the highest GHG emissions per kg of product were from the nitrogen (N)-based fertilisers – not surprising given the high energy requirements for ammonia production. TSP produced the lowest emissions of the imported fertilisers at 1.85kg CO_2 eq/kg P compared with 1.72kg CO_2 eq/kg P for SSP.

TABLE 2: CARBON FOOTPRINT OF IMPORTED FERTILISERS (KG CO_2EQ/KG), SHOWING RELATIVE CONTRIBUTION FROM PRODUCTION, LOCAL TRANSPORT (WITHIN COUNTRY OF PRODUCTION TO THEIR PORT) AND SHIPPING TO NZ PORT. DATA FOR UREA IS WEIGHTED FOR IMPORTED UREA AND UREA PRODUCED AT KAPUNI IN NZ.

	Urea	DAP	TSP	AS	CAN
2018 - 19					
Production	0.88	1.13	0.27	0.69	0.95
Local Transport	0.00	0.05	0.01	<0.01	<0.01
Shipping	0.09	0.10	0.10	0.07	0.19
Total	**0.97**	**1.28**	**0.38**	**0.77**	**1.14**
2008 - 09					
Production	0.94	0.91	0.35	0.47	1.66
Local Transport	0.00	0.01	0.00	0.01	0.00
Shipping	0.12	0.20	0.25	0.12	0.27
Total	**1.06**	**1.12**	**0.60**	**0.61**	**1.93**

Stewart and a colleague, modeler Shelly Falconer, also used the LCA data to calculate the carbon footprint of milk produced from the milking platform of the average dairy farm, using DairyNZ data from the 2016-17 year. The average rate of N, P and K applied in fertilisers was 140, 27 and 28kg/ha/year respectively.

This showed N fertiliser use contributed 7.4% of the total carbon footprint of milk from the milking platform compared with just 0.6% for the non-N fertilisers (P, K and S).

TABLE 3: SUMMARY OF THE CARBON FOOTPRINT OF NZ-AVERAGE MILK FOR 2016/17 SHOWING THE MAIN CONTRIBUTING FACTORS. THE FERTILISER CONTRIBUTIONS ARE BASED ON USE OF THE 2019 FERTILISER LCA DATA PRESENTED IN THIS REPORT, WITH PREVIOUS FERTILISER LCA DATA IN BRACKETS.

	kg CO_2-equivalents/kg milksolids
Animal methane (enteric fermentation)	6.79
Animal methane (manure management)	0.11
Animal excreta/effluent N_2O	1.20
Production & transport of brought-in feeds	0.49
Electricity	0.14
Fuel use on farm	0.05
Lime	0.06
N_2O from soil from N fertiliser after application	0.33
N fertiliser production (including CO_2 from soil after application)	0.39 (0.42)
Non-N fertiliser production	0.06 (0.08)
Other (e.g. crop residues, off-farm replacements inputs, transport including fertilisers to farm)	0.14
Total	**9.76 (9.81)**

"Electricity is not a large part of the production process of fertilisers here in New Zealand, but for TSP for instance, a lot of that is made in United States where they use less renewable energy compared to New Zealand."

The estimates for N emissions included nitrous oxide emissions, both direct and indirect, from fertiliser N after its application, CO_2 released from urea after application, and its manufacture. Not included were emissions from fertilisers used on the area for grazing replacements, wintering cows off and where crops were grown for production of brought-in feeds.

For the average North Island hill country sheep and beef farm (based on Class 4 land for the 2015-16 year), the contribution from N fertiliser to total farm GHG emissions was 2.8% compared with 1% for non-N fertilisers.

Stewart says he was not surprised the carbon footprint relativities between the fertilisers were similar between the two studies, and values for each fertiliser option were lower in the more recent one.

"The basic production methods [for each fertiliser option] are unchanged between the reports. Electricity is not a large part of the production process of fertilisers here in New Zealand, but TSP for instance, a lot of that is made in United States where they use less renewable energy compared to New Zealand.

"The average shipping distance for phosphate rock was less in 2019 than the earlier study, and there have been gains in the efficiency of shipping since the earlier study," Stewart says.

The LCA approach is helping to guide new thinking in environmental management because it accounts for all the emissions from all inputs through the life-cycle of the product.

LCA ACCOUNTS FOR ALL INPUT EMISSIONS THROUGHOUT THE LIFE-CYCLE OF THE PRODUCT, GIVING THE 'BIG PICTURE'

"We use the LCA approach when we want to look at future farm systems."

"It's why we use the LCA approach when we want to look at future farm systems because it provides a more complete picture rather than just focusing on the system itself in isolation," Stewart says.

"It includes all the emissions for each of the inputs. So, a mitigation might work well at farm level, but its total picture may not be so appealing."

He says the LCA approach also recognises there are additional costs to produce inputs that are not included in a one-dimensional system analysis.

"It is starting to become more valuable as we look to use LCA to evaluate new mitigations or new future farm systems," he says.

A next step could be to include the financials for a farm system evaluation so its profitability could be compared alongside environmental emissions.

Work is now underway with many other countries to agree a set of global LCA weightings for outputs, so claims can be compared internationally and prevent companies using LCA to manipulate weightings of outputs to produce a more desired carbon footprint result. ■

Evidence delivered by team to back product claims

AgResearch's world-class Life Cycle Assessment (LCA) team is providing an evidence base to help maintain New Zealand's export market edge.

AgResearch's principal scientist and LCA expert Dr Stewart Ledgard says LCA usually covers the full life-cycle of a product, including processing, transport, retail, consumer and waste stages.

Results are expressed per kilogram of a product and so it is often used to help make decisions in choices of food, goods or systems to minimise our impacts on the environment.

AGRESEARCH'S PRINCIPAL SCIENTIST AND LCA EXPERT DR STEWART LEDGARD

In 2020, the team measured the carbon footprint of products such as Simply Milk and a range of Anchor Milk brands, as well as the carbon neutral beef product marketed by Silver Fern Farms.

This LCA work enabled the companies to take actions to offset product emissions, such as purchasing carbon credits from third parties, so they could be certified as carbon zero or carbon neutral.

In January 2021, DairyNZ released research it commissioned from the AgResearch LCA team that showed New Zealand to be a world leader in the carbon footprint for milk production – with the most efficient production among comparable countries using a measure of kilogram of carbon dioxide equivalent (CO_2e) per kilogram of fat and protein corrected milk.

DairyNZ chief executive Dr Tim Mackle described the dairy research as playing a key part in understanding how New Zealand dairy farms stack up and informing how Kiwi farmers can be even more efficient.

"LCA work enabled the companies to take actions to offset product emissions, such as purchasing carbon credits."

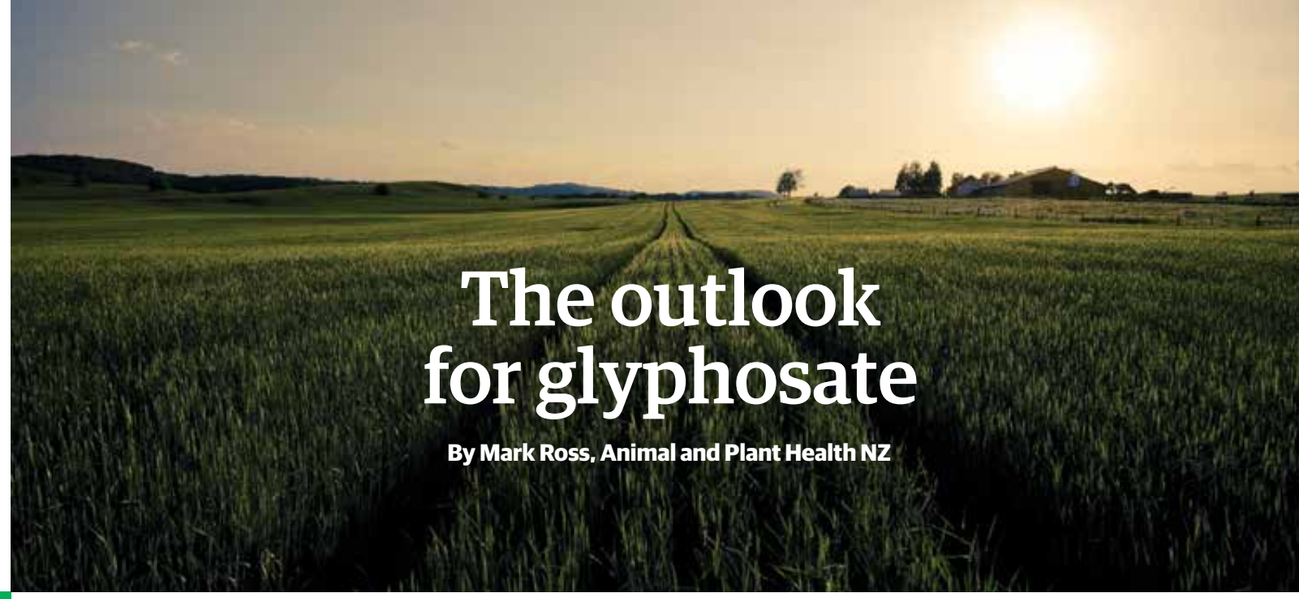
The AgResearch team has also worked with Beef + Lamb New Zealand on similar research measuring the carbon footprint of the country's sheep and beef sectors. Previous research has also demonstrated that New Zealand has a lower carbon footprint per kilogram of carbon dioxide equivalent (CO_2e) for sheep meat than other comparable producing nations.

Another advantage of LCA research is providing accurate measurements to debunk myths or challenge assumptions about exported products, including 'food miles'. After accounting for freight to overseas markets, New Zealand products often stack up favourably for environmental impact, given the way they are produced.

The team expects demand for LCA research to only grow with public concern about climate change, water scarcity and other environmental issues. The research is also likely to expand into areas such as social and cultural impacts.

"In future, it will go beyond just getting results for current systems and products to using LCA in designing new future systems and products with greater resource-use efficiency and lower environmental impacts," Stewart says.

"Additionally, it will go beyond a focus on only climate change to multiple impacts, including human health, ecosystem quality and waste reduction." ■



The outlook for glyphosate

By Mark Ross, Animal and Plant Health NZ

MARK ROSS, CHIEF EXECUTIVE OF ANIMAL AND PLANT HEALTH NEW ZEALAND

Farmers will no doubt have been reeling from the price of glyphosate recently, which was caused by multiple but interrelating factors. On top of this, the world's most widely used herbicide is under intense scrutiny here and overseas.

The raw materials needed to produce glyphosate have exacerbated its price, which more than doubled in the past year. In China, the manufacturing base for glyphosate, the price rose from under $4,000 a tonne in late 2019, to over $12,000 a tonne at the end of last year. Prices had started dropping over the first quarter of this year, but this is being countered by increasing fuel prices due to the Russian invasion of Ukraine.

Continued pandemic production disruptions, labour shortages, shipping costs and delays are also behind the inflating costs. Shipping backlogs, labour disruptions as well as China's continued zero-Covid-19 policy are all taking their toll.

More locally, capacity constraints due to a lack of available staff are creating issues with the supply chain including at ports, with trucking operations and couriers.

There should be no need to stockpile products though, as manufacturers are securing supply ahead of usual times. Those wishing to purchase glyphosate are urged to secure their supply six months ahead of usual times but should not order more than normal quantities – as this could further disrupt the supply chain.

Political environment protection

The Environmental Protection Authority (EPA) has recently published a summary report of the information provided in response to a call for information on glyphosate in October last year. The report, which includes responses both from experts and the general public, is expected to form part of the information that the EPA will use to assess whether there are grounds to reassess the use of glyphosate in New Zealand. It is also likely that the regulator will base its decision on those made in the EU.

In the EU, a three-year reassessment process for the herbicide was recently delayed. The European Food Safety Authority (EFSA) announced in May that it would postpone its final scientific opinion on the re-evaluation of glyphosate until July 2023. This decision was initially expected at the end of this year.

The postponement by the EFSA – which issues advice on existing and emerging food risks, to inform European laws, rules and policymaking – was due to the abundance of information to assess following a consultation process which ended late last year. Other concerns, including food security, may also have been a factor in the delay.

At the centre of the decision is whether the weedkiller is carcinogenic. The European Chemicals Agency (ECHA) Risk Assessment Committee concluded, in May 2022, that classifying glyphosate as a carcinogen was not justified. Further, the committee found that the available scientific evidence did not meet the criteria to classify glyphosate for specific target organ toxicity, or as a mutagenic or reprotoxic substance.

This assessment will feed into a risk assessment by the EFSA. In collaboration with the Member States, the EFSA will complete its peer review and publish its conclusions – which will assess all possible risks that exposure to glyphosate might pose to humans, animals and the environment.

The European Commission will then analyse EFSA's conclusions, before putting forward a renewal report and a draft regulation on whether glyphosate can be approved for use. Further discussions will take place ahead of a vote by the Member States on the Commission's proposal.

While there will be a scientific discussion, the ultimate decision on whether to re-authorise glyphosate, and for how long, is likely to be a political one.

Mark Ross is chief executive of Animal and Plant Health New Zealand, the industry association for companies that manufacture and distribute crop protection and animal health products. The association was previously called Agcarm. ■

Little and often hits the spot

By Victoria Rutherford

North Canterbury dairy farmers Kevin and Sara O'Neill have improved pasture quality by extending round lengths and applying different fertiliser mixes in a little-and-often approach.

Underpinning all their fertiliser decisions are Whole Farm Soil Tests (WFST) and the assistance of their Agri Manager, Eilish Burrows. If testing shows any paddocks are below optimum range for phosphate (P) and pH, they receive a capital application of superphosphate and lime to rectify them.

"WFST is a big driver for us when we catch up in the spring. Levels in some areas of the farm may have dropped or be trending down, so they might get a capital dressing. We are starting to build up a bank of trends now which is the key to making these decisions," Kevin says.

"It's a good way to give you a bigger picture and monitor what's going on," says Eilish.

The couple own two dairy farms at Culverden with contract milkers on both. Red Hills is 312ha, milking 920 cows at peak, and Pahau Reserve is 158ha with 510 cows at peak.

At Red Hills, 75% of the herd is wintered on (all mixed-age cows) while at Pahau Reserve 25% are wintered on and the remainder grazed out. Both farms are irrigated, currently with pivots and lateral shift gear, but they are moving to fixed-grid irrigators next spring.

The O'Neills operate with a stocking rate of 3.2 cows/ha on the pasture platform of both farms, excluding the wintering area. The pasture sward is a mix of ryegrass, clover and plantain.

They have five years of WFST data and have built a detailed view of each farm's nutrient status and trends. Eilish also carries out herbage testing to monitor micro-nutrient levels, particularly molybdenum.

They had previously focussed on short round lengths to help maintain pasture quality, but have since increased from 18 days to 24 days after struggling to maintain sufficient clover population in the sward and ensure its establishment at higher rates of N.

"Six days in a cycle is quite a long time, a quarter of the growing length," says Kevin. "We have found the grass is yielding better too."

Targeting clover persistence in their pastures led the couple to investigate the use and timing of other nutrients, particularly sulphur (S).

When Kevin was sharemilking, he found that single annual applications of fertiliser were okay, but often created a feed pinch later in the season.

KEVIN O'NEILL WITH RAVENSDOWN AGRI MANAGER EILISH BURROWS

MAINTAINING PASTURE QUALITY THROUGH SUMMER HAS BEEN A MAJOR FOCUS FOR CULVERDEN FARMER KEVIN O'NEILL

S also had the potential to leach out of the soil, especially in a wet winter. So he worked with Eilish to come up with a cost-effective mix that would ensure pasture growth and quality was maintained alongside the increased round lengths.

Single round applications range between 40–70kg/ha of urea, trending towards the lower end of input last season. "We have always been reasonably low, so the N-cap didn't mean drastic changes," Kevin says. After the first round in spring, both farms typically receive Ammo 36 (a blend of ammonium sulphate and urea at a ratio of 40:60). For subsequent rounds, a blend dubbed 'Red Hill' mix is spread to meet N, P, K and S requirements and keep pastures humming. "We apply the Red Hill mix to both farms, and review again in the autumn," says Eilish.

"Sometimes it's been a DAP mix with potassium chloride and a bit of granular ammonium sulphate (GAS). But this year with prices rising, we changed it to Sulphur Super 15 and Flexi-N with potassium chloride.

"So it's a little and often approach - the pastures are getting N, P, K, and S every round," Eilish says.

More S was applied in their Red Hill blend last season because it was wetter than normal. Testing showed soil S was lower, so sulphur super was added to the Ammo 36 to ensure elemental S (which is not water soluble and therefore not subject to a winter drainage effect) would be there in the spring before soil microbial mineralisation converts it to plant available sulphate S.

"With nutrients being expensive, it's good to think outside the square about how things can be changed to achieve outcomes."

"We went with more S than N because there'd been a lot of rain, and that definitely boosted things along," Kevin says.

He is aware the science suggests that as long as applications of each nutrient are adequate, there is little difference in total pasture growth between his preferred little-and-often approach versus spring/autumn applications, except under very high rainfall.

However, he feels this approach better suits them.

"One of the big drivers for me was the comfort of having S going on right through the season to try to help that clover. We were concerned that when you're putting P and S on at more leachable times of the year like the end of April, then you still have that whole winter to lose it."

While the soil tests and the trends dictate the capital application, the maintenance applications following the cows are standard. When following the cows, it's a set rate in the plan, allowing the contract milkers to adjust it to suit requirements.

"Anything that's little and often has to be good in my mind, rather than having infrequent larger applications of P. It's just about being more consistent," Kevin says.

Eilish says looking at things from a different perspective, such as round length rather than focussing on the nutrient application rates, can be beneficial.

"With nutrients being expensive, it's good to think outside the square about how things can be changed to achieve outcomes," she says.

Kevin agrees. "Just because it was appropriate once, doesn't mean it's necessarily appropriate now. We like to fine tune. We are very cost-focused on both farms so any way we can find the savings is enough of a reason to investigate further and look at how we do things."

Thought leaders: Mike Manning, Dr Jacqueline Rowarth & Dr Ants Roberts

Alternative Proteins as part of future farming: claim vs reality

Provocative headlines are part of modern-day living, but what's the truth when it comes to alternative proteins? In a recent paper, Dr Jacqueline Rowarth, Dr Ants Roberts and Mike Manning explored claims that dietary shifts will reduce climate change, finding that if veganism is the new future, not even the vegans would be better off.

We've seen a lot of headlines and hype regarding the environmental damage that animals are thought to do to the planet and, as a consequence, increasing suggestions that veganism will save the planet. So, it isn't surprising that farmers feel confused about what to do, while national and local government have been pushing for change.

In the Waikato, for instance, the regional council (via a report from AgFirst 2016)[1] has suggested that dairy, sheep and beef land uses could be more profitable (and with lower environmental externalities) under dairy goats, dairy sheep, gold or green kiwifruit, apples or chestnuts. Furthermore, the plant-based alternatives being suggested require suitable cropping land and environments, which cover fewer than 200,000ha of New Zealand.

Importance of protein and dietary choices

Most people recognise that animal-based food is part of a human diet. Research has shown that animal food allowed evolution of our large and complex brain, enabling us to become large, active and highly social primates[2].

However, ongoing statements that plant protein is just as good[3] is eroding that understanding. In addition, statements from high profile activists that we must become vegan to stop climate change and save the planet is having an effect. People are changing their diets – but the climate change effect is not as big as they think.

Research around diet is self-reporting and although vegan groups suggest that "As many as 6% of US consumers say they are vegan", the range of estimates in the same article is 2–6%. Later the article states the number of vegans in the US has increased by 600% since 2014[4]. Exaggeration leads to confusion; journalists can pick on whichever figure they like, point to the source and be right.

New Zealand is not immune. In 2019 headlines, including "Why 33% of New Zealanders are ditching meat" was based on a report for Food Frontier[5], an independent thinktank on alternative proteins. Just over 1,000 people were surveyed, and the report indicates 31% of people were flexitarian (eating what they want when they want) or "Meat Reducers". A further 3% were vegetarian or vegan.

Research in 2018 surveyed more than 47,000 New Zealanders, finding approximately 94% still ate meat and fewer than 6% were vegetarian or vegan. Longitudinal analyses further revealed that the probability of shifting from an omnivore diet to a vegetarian or vegan diet over a one-year period was low (fewer than 0.6% changed to vegan and just under 1% became vegetarian). In contrast, almost 30% of vegans changed diet between 2017 and 2018, with slightly more becoming omnivores than vegetarians[6].

Plant-based and cultured protein

Vat fermentation for culturing protein has been proposed as the biggest threat to ruminant farmers, with its claims of vastly reduced environmental impact. However, like "plant-based proteins" most of the claims are hype. Analysis by non-profit investor network Ceres[8] has shown the claims made, whether by plant-based or fermentation companies, are based on the environmental impact of the company alone, not a complete life-cycle analysis which would include the supply chain and waste. All the alternative protein companies rely on crops, either for the substrate of their processing (e.g. potatoes, rice, pumpkin, pea isolate) or the energy to drive the fermentation (usually corn syrup or sugar cane). Consequently, all plant-based "alternative proteins" require land to grow the component crops, and crops require agrichemicals and fossil fuel to drive tractors, harvesters and for basic processing.

Meat

Beyond Meat, which describes its products as "plant-based, vegan meat that's tasty and better for you and our planet", discloses nothing. Impossible Foods claims that eating the Impossible Burger will reduce your environmental footprint through reduced water (87%), land (96%) and lower greenhouse gas (GHG) emissions (89%) in comparison with a bovine burger. The figures are not supported with data. The Ceres 2018 report 'Measure the Chain: Tools for Assessing GHG Emissions in Agricultural Supply Chains'[9] estimated that more than 80% of the emissions generated by food systems stem directly from agricultural production and its associated land-use change. Most food and agricultural companies consider these emissions to be "scope 3". They are upstream or downstream emissions not under direct control of the company (indirect emissions) and are not included in their impact and 'savings' statements.

Cultured meat presents itself similarly. Memphis Meats[10] states that it is making meat in a new way: "One that satisfies our cravings, our conscience, and our heart." Memphis Meats is still at the pilot stage but claims (through investor Richard Branson) that cultured meat will use much less water, land and produce up to 90% less GHG than conventionally produced meat. No data are available to indicate how, and questions are being asked[11].

The problems of scaling up cultured meat have been examined by the Good Food Institute. Meeting 10% of the world's meat demand, estimated at 40m metric tonnes by 2030, would require 4,000 factories each costing around €382 million and housing 130 x 10,000L stirred tank bioreactors, each of which would be associated with 4 x 2,000L perfusion tanks. Each factory would need to be able to host 2,300,000L cell culture. The current largest facility hosts 250,000–350,000L cell culture[12].

The energy costs of maintaining a controlled environment and creating vats for fermentation are significant, and the energy for fermentation must be provided by something – sugar is the cheapest option, and sugar, whether from maize, cane or beet, requires agrichemicals and fuel. The impact of the overlooked factors could last much longer in the atmosphere than the methane from ruminants, the effect of which has gone in a few decades.

"All plant-based 'alternative proteins' require land to grow the component crops, and crops require agrichemicals and fossil fuel to drive tractors, harvesters and for basic processing."

University of Oxford physicists have suggested that "under continuous high global consumption, cultured meat results in less warming than cattle initially, but this gap narrows in the long term and in some cases cattle production causes far less warming, as methane emissions do not accumulate, unlike carbon dioxide"[13]. The authors identified a need for detailed and transparent life-cycle analysis (LCA) of cultured meat production systems and concluded that the relative impact of cultured meat will depend on the availability of decarbonised energy generation and the specific production systems that are developed.

Milk

Milk from dairy animals contains nutrients and processing is required to ensure human safety and product stability. Most of the plant-based alternatives contain additives to boost their nutrient content and stabilisers to prevent the additives from settling out.

Perfect Day has given up on creating milk through vat fermentation and is now trying to perfect 'dairy' ingredients, with success achieved using genetically engineered fungi to produce milk protein for ice cream. Other companies (TurtleTree and Better Milk) are in the initial stages of engineering mammary cells from humans and cows. This approach has similarities to cell-based meat and is likely to meet the same acceptance challenges identified by Pakseresht et al.[14].

Bio-availability and anti-nutritional factors

In plant-based proteins, essential amino acids (particularly lysine, leucine and choline) or EAA for human nutrition are in poor supply. Milk has a Protein-Digestibility-Corrected-Amino-Acid-Score (PDCAAS) value of 1, which indicates that all the protein (3.7g in 100g) is nutritionally available. Beef has a PDCAAS of approximately 0.92 whereby 100g raw steak contains 18.4g usable protein. In contrast, quinoa and rolled oats contain 11.9 and 9.6g of usable protein per 100g dry. A bowlful of either, once cooked, is not as protein-rich as first glance might suggest.

Further, plants have evolved anti-nutritional factors to protect their proteins from animal predation. To overcome these, humans apply external treatments such as fractionation, soaking, heating, acidification, fermentation and pulverisation. Treatment takes time and energy, and causes losses, which increases the greenhouse gas emissions associated with the food. Soybeans, for instance, which are considered the best large-scale plant-protein source, have high concentrations of dietary trypsin inhibitors, oestrogen mimics and tannins. The result is that only about 73% of the soybean protein is digestible compared with 80–100% from animal protein.

Although plants-only agriculture has been modelled for the US to produce 23% more food, it met fewer of the US population's requirements for essential nutrients. When nutritional adequacy was evaluated by using least-cost diets produced from foods available, more nutrient deficiencies, a greater excess of energy, and a need to consume a greater amount of food solids to meet nutritional requirements (calories) were encountered in plant-only diets[15].

Animal-derived foods meet essential amino acid needs up to 240% more effectively than plant-derived foods[16]. This means that vegans excrete far more excess N (as much as 140%) than carnivores, all of which is at some point oxidised to nitrous oxide, a GHG, in the atmosphere. Vegans also require more land and calories to meet their EAA needs, and supplements (which are not included in environmental impact of diet calculations). A modelling study on 'people fed' from the Canterbury Plains[17] concluded that mixed dairy/cropping systems provided the greatest quantity of high-quality protein per unit price to the consumer, had the highest food energy production and supported the dietary requirements of the highest number of people, when assessed as all-year-round production systems.

"Animal-derived foods meet essential amino acid needs up to 240% more effectively than plant-derived foods[16]. This means that vegans excrete far more excess N than carnivores."

Miscalculation, misrepresentation and misunderstanding

The claims that plant-based diets are environmentally better than omnivorous diets have been challenged and some have been discredited.

The FAO 2006 document 'Livestock's Long Shadow'[18] has had global impact. The document stated that livestock agriculture produced 18% of global emissions, and that "Livestock was doing more to harm the climate than all modes of transportation combined". The analysis used a complete life-cycle for meat (emissions from fertiliser production, converting land from forests to pastures, growing feed, and direct emissions from animals [eructation and manure] from birth to death) and compared the result with an incomplete assessment of transport – the emissions were calculated on exhaust from vehicles only.

More recent research from the FAO[19] showed that grazing livestock contribute directly to global food security by producing a greater amount of highly valuable nutrients for humans, such as high-quality proteins, than they consume. Research[20] indicates that somewhere between 7 and 13% of beef production comes from feed lot systems, yet most of the concerns about GHG are based on this small percentage.

"The claims that plant-based diets are environmentally better than omnivorous diets have been challenged and some have been discredited."

Of further interest, the authors state that "out of the 2.5 billion ha needed for animal production, 77% are grasslands, with a large share of pastures that could not be converted to croplands and could therefore be used only for grazing animals". Note that these grasslands in New Zealand support considerable soil carbon stocks and biodiversity – not as much of the latter as native forests, but certainly more of both than arable areas where soil disturbance is part of production.

Greenpeace International suggested in 2018 that diets should be reconsidered for both human health and the environment. Reductions in meat and dairy consumption were recommended, not a complete removal of animal products from the diet. The take-home message was that land that could be used for growing food for direct human consumption should be, with animal products coming from land that was not suitable for anything but pasture[21].

Furthermore, the 2019 IPCC 24[22] reports did not advocate becoming vegan. It stated that "balanced diets, featuring plant-based foods, such as those based on coarse grains, sustainable legumes, fruits and vegetables, nuts and seeds, and animal-sourced food in resilient, sustainable and low GHG emission systems, present major opportunities for adaptation and mitigation while generating significant co-benefits in terms of human health".

(1-27) see Source Code page 40

NEW ZEALAND PASTORAL FARMING PRODUCES ANIMAL PROTEIN (MEAT AND MILK) FOR FEWER GHG EMISSIONS PER UNIT OF PROTEIN THAN OTHER COUNTRIES CURRENTLY MANAGE [26, 27]

Despite the available research, position papers such as the 'Save the Planet' diet proposed by the EAT-Lancet Commission[23] have continued to be promoted. They fail to recognise population health realities. Plant-based diets require consumers to eat a significantly greater amount of dietary energy than is good for health[15] to obtain enough of all other nutrients. Only an animal-based diet can solve this problem.

The future

Nutrition company Cargill's March 2019 survey 'Feed4Thought'[24] found that more than two thirds of people surveyed in four countries intended to maintain or increase their consumption of animal protein this year.

Although 80% were interested in exploring plant-based or alternative sources of protein, they were not intending to drop the animal component of their diets. In addition, 93% of them considered animal protein was an important part of a healthy (and delicious) diet, and 80% of them believed that animal protein could be part of an environmentally friendly diet. The facts allow them to do so with a clear conscience and the dietary data[6] indicate that omnivores are prevalent. Further, recent reports suggesting that the "appetite for plant-based meat has already peaked"[25] indicate that consumers have been seeking variety by incorporating new products into their diets, rather than as a lifestyle switch.

New Zealand pastoral farming produces animal protein (meat and milk) for fewer GHG emissions per unit of protein than other countries currently manage[26, 27]. The Paris Climate Agreement emphasised decreasing GHG without compromising food production. Poorer performance in other countries affects us through, for instance, temperature and sea level rises. New Zealand is part of the physical, chemical and biological globe and cannot isolate itself through policy.

Calculating land use and environmental impacts based on essential amino acids would create a different picture for New Zealand[17]. A full life-cycle analysis of proposed alternative food production systems would create a different outcome from that espoused. Adaptive strategies are in good farmers' DNA. So is identifying bullshit – sorting the claims from the reality.

Thought leader: Dr David Burger

Tackling nutrient loss to waterways one farm at a time

By Tony Leggett

Significant and immediate reductions in nitrogen and phosphorus loss to waterways are possible if dairy farmers put good management practices into action.

DairyNZ's General Manager Sustainable Dairy Dr David Burger is leading the organisation's efforts to help dairy farmers meet the new freshwater quality standards set by government.

He says Farm Environment Plans (FEP), developed by farmers with the help of their dairy company or trusted rural advisor, are a great first step to identify local risks and mitigation tactics.

One of the best examples of the power of FEPs is the Waikato Upper Karapiro catchment. Between 2013 and 2015, about 640 farm owners in the catchment voluntarily developed their own FEPs with the support of DairyNZ and rural professionals.

When qualified by modelling, an analysis of all the actions identified in these farm plans suggested, on average, reductions of 8% in nitrogen loss and 17% in phosphorus loss to waterways.

"These plans were voluntary not mandatory, and each farmer implemented the good management practices they agreed to in their plans," David says.

"A lot of the actions undertaken by farmers in that catchment were about targeting the overland flow pathways, through critical source management and stock exclusion to manage run-off.

"Many actions also focused on effluent management. These included extending effluent block size and better managing nitrogen fertiliser.

"We know that farm plans are a fantastic tool for farmers because it helps them deal with local risks at an individual farm level," he says.

"We know that farm plans are a fantastic tool for farmers because it helps them deal with local risks at an individual farm level."

APARIMA CATCHMENT LANDSCAPE, SOUTHLAND

DR DAVID BURGER, DAIRYNZ

By the end of March this year, more than 5,200 dairy farms had a FEP and momentum is building toward the goal of every dairy farm in New Zealand having a plan by the end of 2025.

"FEPs will certainly help but good management practices alone may not be enough to achieve the reductions required to meet regulatory water quality targets for every catchment in the country.

"For some farmers a system change may be required over the long term, but it's not just about the number of cows. It's much more than that."

That's where DairyNZ's Step Change project comes in. Launched in 2019, it aims to improve profitability while helping farmers make progress towards their environmental goals and meet changing regulations.

"Step Change is all about understanding your farming system, your key numbers and looking at your best options to reduce contaminants, while remaining profitable. We think there is a significant opportunity to create financial head room for our farmers to try and manage these bigger environmental challenges that are coming our way over the next generation."

David says there are many catchments across the country that are not meeting the freshwater quality standards required in both rural and urban areas over the long term, so there is plenty of work to be done.

"For a lot of farms, an FEP may be all they need to make sure they can farm within the limits.

"For other locations, the farmers there will need more time to adjust and consider mitigation tactics such as introducing forages like plantain to reduce nitrogen (N) loss, or wintering systems that capture nutrients and reduce runoff to waterways. That is where our research comes in, to try and develop efficient ways to reduce our environmental footprint within the farm gate."

Based on the success of plantain trial work in the Tararua region, four other catchments are testing it now.

"We've been working on barriers to adoption, but we believe we can get as much as a 30% reduction in N loss from plantain."

Another good example of FEPs in action is the Aparima Community Environment Project in Southland where nearly 600 dairy and sheep-beef farmers are making huge strides to improve freshwater quality and reduce their environmental footprint in their region.

A 2020 survey of project farms showed they achieve better environmental results when they have FEPs. The survey also highlighted that farmers with environment plans are more likely to implement a range of good farming practices.

Plans must include actions to reduce farm sediment and nutrient loss, outline how wintering rules will be implemented, and where to riparian plant and fence. The plans are reviewed annually.

Will power leads to dairy success

New Zealand Dairy Industry Awards 2022 share farmer of the year Will Green is forging a path to farm ownership in the dairy industry. Rob Smith finds out what makes him tick.

NZDIA SHARE FARMER OF THE YEAR 2022 WILL GREEN

Will Green can't recollect when he first decided he was going to be a farmer: it's been inevitable as long as he can remember. His parents are tenant farmers on a large estate in Shropshire in the west of England, milking 100 cows and grazing a few sheep and beef cattle. As a teenager, Will's teachers helped forge his career path, perhaps unintentionally.

"When I was about 15, we had two weeks' work experience. Because I was okay at maths and numbers, careers guidance sent me to a local accounting firm. By lunchtime on the first day I knew an office job wasn't for me. I needed to be outdoors. This was not energetic enough. I always wanted to go farming anyway, and a couple of hours with the accountant totally confirmed it."

Farming appeals for multiple reasons.

"I really appreciate the variety. I love going through the seasons; I enjoy livestock, and meeting and working with so many awesome farming people is a constant pleasure," Will says.

After leaving school he studied agriculture at nearby Harper Adams University. Then he came halfway around the world.

"I was 20 when I first came to New Zealand in 2010. I quickly saw the opportunity to achieve farm ownership: to become 'self-made'. While it's still not easy to do that here, it's much easier than in England, where purchasing your own farm is almost impossible. Here, if you set farm ownership as an objective and work hard, you can achieve it."

Will's goal meant leaving family behind – a difficult step.

"I'm close to my parents and my siblings. With Covid-19, I've not seen them for four years. They are very supportive though, and fully understand why I want this."

Will returned to New Zealand in 2014, working near Fairlie in South Canterbury for Kieran and Leonie Guiney, who had financed their dairy farm via sharemilking. Then in 2020 Will became a lower-order sharemilker on a 270ha, 1,060-cow Dairy Holdings farm at Hinds, Mid Canterbury. He lives on farm with partner Sally Eames who works in Ashburton and whose parents are Manawatu sheep and beef farmers. Will was a 34% sharemilker owning 400 cows, graduating to a 47% sharemilker owning 990 cows from the start of the 2022-23 season. His goal is to step up from sharemilking to farm ownership, with his own 600-cow farm in the next five to 10 years.

On the way through, recognition has come Will's way, including winning the 2022 national Share Farmer of the Year at the New Zealand Dairy Industry Awards, after he was national runner-up in the Manager of the Year category in 2018. Will impressed the judges with his contagious energy, accuracy and commitment to looking for opportunities to learn. They also praised the strong team culture he fosters with his staff.

Will puts success down to determination: willpower, maybe.

Expertise appreciated

Both Will Green's previous and present employers, the Guineys and Dairy Holdings, are Ravensdown shareholders. Will worked previously with Agri Manager Hannah Wallace and now works with Alex Ferguson.

He says you need strong relationships with your professional advisors, drawing on their expertise. "Hannah and Alex understand what the soil needs to cost-effectively grow feed with minimum environmental impact and maximum efficiency.

"HawkEye mapping is great technology that Ravensdown continues to develop. Features like the nitrogen heat map and monitoring how close you are to the 190 N-cap make farming much easier."


WILL IS FORGING A PATH TO FARM OWNERSHIP THROUGH SHAREMILKING

"I always have a clear goal. It's easy for me to jump out of bed knowing what I want to achieve. When you have that, it's not difficult to enjoy your day," he says.

Setting goals points the way forward for the whole country, Will reckons.

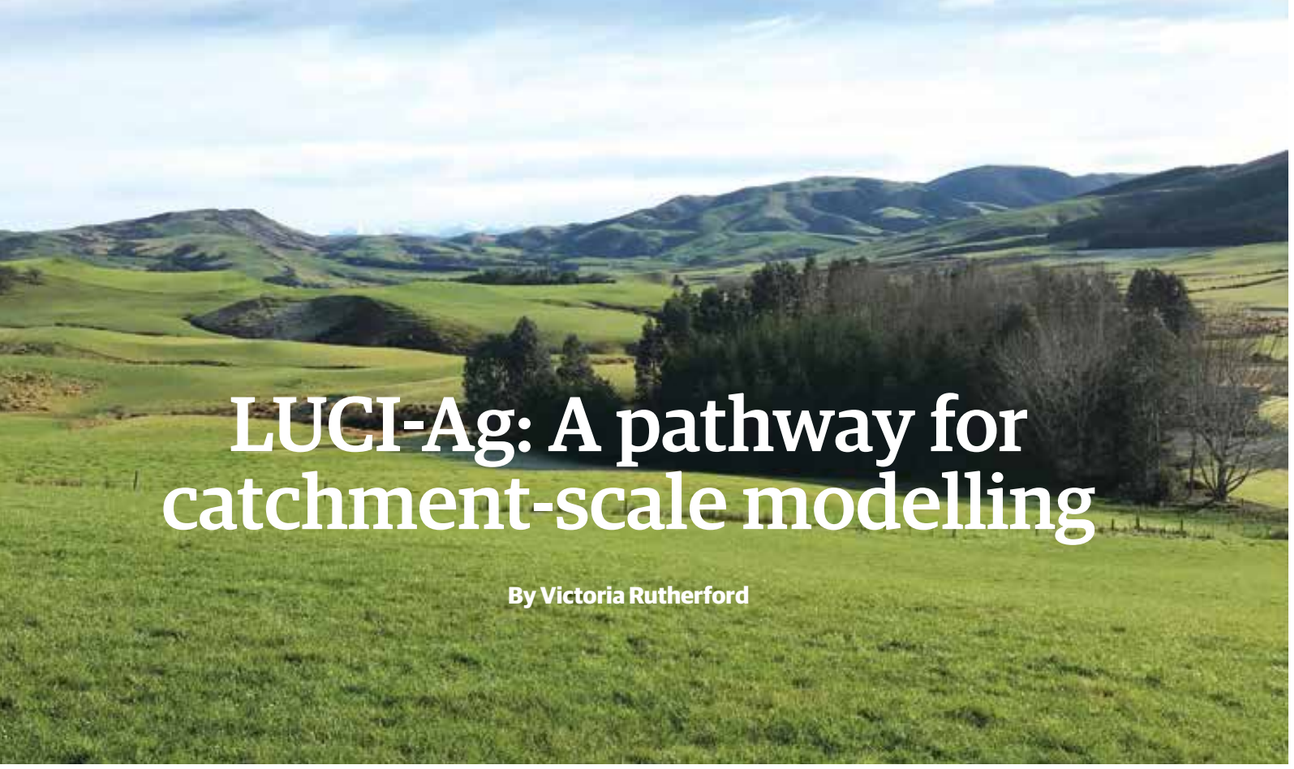
"This country's unfair advantage is our fantastic grass growing climate. Following the low-cost mindset of working New Zealand's grass growth, we can bring plenty of wealth into the sector. By smart marketing, we have a real opportunity to add further value to pasture-fed meat and dairy protein. We also benefit from the important role of strong, farmer-owned co-operatives in our sector: something I strongly believe in.

"Plenty of people are climbing the ladder to farm ownership by working hard, whether through sharemilking or equity partnerships. Although it requires skill and discipline, pastoral farming is simple, profitable and enjoyable."

Will says New Zealand agriculture is in the middle of so much change. Staying one step ahead of the game is always challenging, whether around the environment, freshwater, employment, or animal welfare. "Having the science, the knowledge, and the skillsets will take us where we need to be. Whenever we say or do something, we always need the proof to back it up."

Attracting more keen, competent recruits is the key, he says.

"Ensuring opportunities continue for young people with the right skills and energy to progress and make their careers in agriculture is essential for the future. We need to be able to show what a great life you can make out of farming." ■



LUCI-Ag: A pathway for catchment-scale modelling

By Victoria Rutherford

Ongoing work with LUCI-Ag to identify nutrient loss hotspots and mitigation solutions at a catchment scale is providing valuable learning opportunities for both Ravensdown and the Makarewa Headwaters Catchment Group in Southland.

Ravensdown's LUCI-Ag is a decision support tool that investigates current on-farm phosphorus (P) and nitrogen (N) losses. Developed for Ravensdown by researchers at Victoria University of Wellington, LUCI-Ag identifies nutrient hotspots and pathways on spatially detailed maps, allowing for targeted mitigation investigation to determine the best approach for achieving advantageous instream water quality outcomes. This enables mitigations specific to the biophysical environment and catchment management to be explored and ranked according to effectiveness.

Thriving Southland: The Makarewa Headwaters Catchment Group LUCI-Ag project

The Makarewa Headwaters Catchment covers 412km^2 and includes the Otapiri, Lora and Makarewa streams. The catchment outlet is located where the Makarewa River crosses SH96 between Invercargill and Gore, eventually feeding into the Oreti River.

The catchment area is predominantly sheep and beef, rounded out with dairy, cropping, deer and horticulture operations. The core catchment group is made up of 10–12 people, with a wider group of 40 who join in with events and projects.

Group chairperson and Otapiri Gorge farmer Alexis Wadworth says the strength of the community has been instrumental in the group's ability to gain traction.

"One of our objectives was to be proud of what goes into the Makarewa, but more than that, we wanted to build real community around the objectives and projects. That's helped define some of the direction and outcomes we wanted to achieve.

"We're fortunate that within our catchment we've got quite a few people who are heavily involved in the industry, including council and other related professions. They bring with them knowledge but also personal interest, helping build the direction of where we want to go."

So far, they have looked at what the environmental standards for freshwater will mean from a practical and on-farm solution aspect as well as investigated the water quality in their catchment with help from water quality specialists.

"The key thing for us is sharing of knowledge. We've got lots of expertise within our group, but also its about helping 'nudge thy neighbour' in a positive way ... providing the information that can help guide decisions," Alexis says.

ALEXIS WADWORTH

Bringing in LUCI-Ag to inform decision making

Thriving Southland first approached the group with the LUCI-Ag project concept and Alexis says it presented as a good fit with the catchment group's objectives.

"We thought LUCI-Ag was a good way to identify how our nutrient usage and farming practices are impacting our catchment water quality, and also to identify any changes or mitigations we could use to help improve that."

In March 2021, work started with Ravensdown to create a LUCI-Ag project to identify N, P and sediment loss hotspots and pathways in their catchment and explore possible mitigations at a catchment-wide level. This was approved by the Thriving Southland funding panel in April and commenced July 2021. Six farms from across the catchment, including the Wadworth's property Bare Hill, were recruited and team members from Ravensdown Environmental collected data on-farm to inform the study.

Alexis says the project gave them the chance to look at improving water quality from a different angle, such as good management practices and mitigations.

"We felt the modelling was a good way to identify opportunities and mitigations and whether they were worthwhile investing in – whether that's fencing or sediment traps, or the impact of breaking in new ground."

The LUCI-Ag reports were first generated for the the six individual farms in the area, before being combined into a catchment wide report.

Alexis says the feedback from the six farmers was that the individual reports were both valuable and relevant for long-term planning.

On their own property, they looked at the development of some of their gorse and broom blocks.

"We got them to model [potential] development to see the impact that would have on our N and P loads from the property. It also allowed us to see how we could we mitigate that impact.

"For us, having that sort of information to hand is valuable. Should we ever start to proceed with this development, then we're armed with all the resources that we need to support consent, or for planning and budgeting at our end."

Catchment wide modelling outcomes

The N, P and soil loss tools were run for the catchment with the aim of identifying areas of high N and P load, pathways of high N and P accumulation and areas of high soil loss. The report also identified areas where mitigation could be undertaken, suggesting actions and their likely impact.

Results from LUCI-Ag catchment modelling for the Makarewa Headwaters Catchment under current management indicate:

- The intensity of the farm system impacted N losses, with the highest N load areas on the free-draining brown soils (compared with the poorly draining gley soils). The less intense farm systems generated lower N loads, while the lowest N loads were generated under native/exotic forestry.
- The highest P load areas were on farmed sloped land underlain by pallic or other slower draining soils.
- Areas of highest soil loss are associated with harvested forest on steeper topography.
- It has been shown through individual farm reports (LUCI-Ag modelling) that fencing off waterways has resulted in significant reductions in N and P losses of 5-28% and 4-70% respectively. Further fencing work will improve individual stream N & P concentrations within the catchment.
- In a catchment scenario, 990ha of flat scrub land was intensified, and 990ha of steeper farmed land was retired. This reduced catchment P losses by 9%. Individual farm reports have shown that retiring land around streams can offset N and P losses of intensification of better land.

Follow the Makarewa Headwaters Catchment Group's journey here: https://www.thrivingsouthland.co.nz/makarewa-headwaters/

HEREFORD CATTLE ON BARE HILL FARM IN THE MAKAREWA HEADWATERS CATCHMENT, SOUTHLAND

Measuring the size of the PGP prize

What does hyperspectral scanning of chicken meat for possible contamination have in common with assessing soil fertility of hill country farms? At first glance, it wouldn't appear to be much. However, the concept of applying this technology in a different way – to take rapid, detailed measurements in a farming environment to scan pastures and determine the soil nutrient status – formed the basis of Ravensdown's Primary Growth Partnership (PGP) programme.

In 2013 Ravensdown and the Ministry for Primary Industries embarked on a PGP programme known as Pioneering to Precision. The project was undertaken with a view to improving the way fertiliser is used on hill country farms; firstly through remote sensing of the nutrient status of the farms via hyperspectral scanning or more informed soil testing, and secondly through precision application of fertiliser (IntelliSpread®). As the project draws to a close, we look at the ways the science and technology has impacted farmer shareholders, Ravensdown and the larger primary sector.

The four Rs

A view to applying the right nutrients in the right place, at the right time and at the right rate was the programme philosophy. Achieving this meant that fertiliser could be targeted to areas that gave the best returns productively and economically for the farmer. In addition, there was an environmental win. Areas where nutrients were not needed, such as waterways and bush, could be actively avoided.

How has Ravensdown achieved this?

1. Through remote sensing (AirScan) and soil testing (SoilScan)

AirScan is the service that will deliver precision variable rate nutrient plans through robust data-dense Olsen P maps of hill country farms. AirScan also uses remotely sensed hyperspectral data and imagery to categorise and quantify the farm landscape in greater detail, including accurately defining effective pasture areas, slope, aspect and soil characteristics to develop precise variable rate fertiliser applications.

A second option of informed farm soil testing coupled with the decision support software developed in the PGP known as **SoilScan** has also been developed. SoilScan will deliver precision variable rate nutrient plans through employing traditional soil testing with the incorporation of the PGP's sophisticated decision-making software. While it does not provide the data rich Olsen P layer or the detailed farm landscape of AirScan, it does provide scalability as it is not restricted to a remote sensing window (hyperspectral scanning works best when pasture is actively growing), and provides options for farmers wishing to carry out precision variable rate nutrient plans at a lower investment. This service also quantifies the farm landscape in detail which is useful for increasingly precise variable rate fertiliser applications.

2. Through decision-making support software

'Optimal fertility levels' are achieved when the cost of fertiliser (product and application) equals the financial return from the additional pasture grown. For sheep and beef farms an econometric approach should be considered when deciding on fertiliser allocations between land management units due to differing margins.

Fertiliser is a large ticket item within farm working expenses, so it makes sense to optimise capital and maintenance fertiliser requirements further. To achieve this, Ravensdown developed a suite of analytical tools using Geographical Information Systems (GIS) to assess actual and potential pasture productivity arriving at a detailed spatial recommendation of optimal soil fertility targets tailored for each farm. The resulting fertiliser plan is then aggregated to sensible options regarding product and rates.

3. Through IntelliSpread variable rate technology

IntelliSpread was not directly funded by the Pioneering to Precision programme but is a key outcome developed by Ravensdown to enable the delivery of sophisticated AirScan or SoilScan variable rate nutrient plans through precise rate control. Precise rate control depends on factors including:

- the aircraft's response to boundary rate changes
- aircraft GPS accuracy
- rate controller speed.

VARIABLE RATE TECHNOLOGY DEVELOPED IN THE PGP ENHANCES PRECISION AERIAL SPREADING

Rapid responses to boundary rate changes improve fertiliser placement accuracy and avoids off-target application near environmentally sensitive areas.

The PGP focus farmers

The Ravensdown shareholders who gave their time as research and focus farmers have been integral to the PGP programme. Focus farms were set up at the programme's inception and farmer input has helped shape the final outcomes of the programme. For the shareholders, it was a chance to gain insights on their farming operations with the potential to increase the efficiency of their fertiliser spend with an actionable outcome.

These outcomes include:

- Accurate information on the true effective area of property, which can aid in management decisions such as stocking rate decisions.
- Identification of property areas that are unproductive or must be avoided (bush/waterways).
- Reduction in environmental impacts through the avoidance of sensitive areas.
- Productivity gains through better matching areas of farms to certain stock classes or grazing management.
- Economic optimisation – putting fertiliser where it is going to give the best return based on farm physical and economic data.
- Confidence to make decisions backed by data.

What has the PGP meant for Ravensdown?

Ravensdown has benefited from the PGP in many ways. From improvements in internal innovation and technology to offshoots for improved strategic nitrogen use, the PGP has had far-reaching positive impacts for Ravensdown and by proxy the co-operative's farmer shareholders. This includes enabled people within the innovation and strategy, field and operations teams; higher education (which in turn benefits New Zealand precision agriculture); demonstration of more efficient use of fertiliser to the wider industry; added revenue streams, and improved technology, particularly regarding aerial spreading, spatial mapping (including HawkEye farm mapping) and the decision-support software built in the PGP. Working with MPI and other primary industry stakeholders has built confidence, credibility and strengthened industry relationships with Ravensdown.

The future

The commercialisation process is ongoing with final checks for AirScan, while SoilScan is on target for commercialisation in 2022. The final component has been the development of the IntelliSpread variable rate application system for aerial fertiliser which has been fitted into five of Ravensdown's Aerowork Crescos. ■

Key Facts

Programme start	October 2013
Length	Eight years
PGP funding	$5.6 million
Industry funding	$5.9 million

Commercial partners:
Ravensdown, Massey University, AgResearch and Hyperceptions.

Estimated potential economic benefits to New Zealand:
The programme is expected to generate additional export earnings of $120 million per annum by 2032 and contribute a net economic benefit of $734 million to the New Zealand economy over the period 2022 to 2052.

Programme highlights

- Total area of fertiliser applied using IntelliSpread during this programme: 293,319ha.
- Ravensdown's variable rate application is the most sophisticated in New Zealand by some margin.
- Fertiliser is now targeted to areas where it will get the best returns.
- Environmental benefits: Increased precision for avoiding sensitive areas including waterways and bush and not unintentionally overapplying fertiliser.
- Vast improvements to variable rate spreading technology (IntelliSpread).
- Automated systems have improved the pilot experience.
- Increased farmer connection and knowledge for Ravensdown staff providing advice to farmers using aerial precision fertiliser application.
- Higher learning: Three students have completed PhDs as part of the PGP (two students) and IntelliSpread research (one student).

ClearTech and EcoPond technology show promise for tile drain situations

Studies have shown subsurface drainage in effluent areas is a significant issue when it comes to phosphorus (P) and *E. coli* loss. Anne Lee investigates new research showing how ClearTech and EcoPond technology can help mitigate these losses to the environment.

ClearTech- and EcoPond-treated effluent will be even better for the environment when used in situations where tile drains are present, new research has found.

Subsurface drains are known to make great highways for excess water, but nutrients such as P and bacteria can also make a quick exit from paddocks to waterways along the same channels (Figure 1).

Scientists at Lincoln University have already shown the ClearTech and EcoPond systems turn phosphate in the effluent into a form that's more tightly held by the soil making it less likely to leach.

They've also shown the treatment destroys *E. coli* bacteria.

But recent research[1] by Lincoln University PhD student Xueying Che, working with Professor Hong Di and Emeritus Professor Keith Cameron, has found the treatments also significantly cut P and *E. coli* loss even when subsurface drains have been installed.

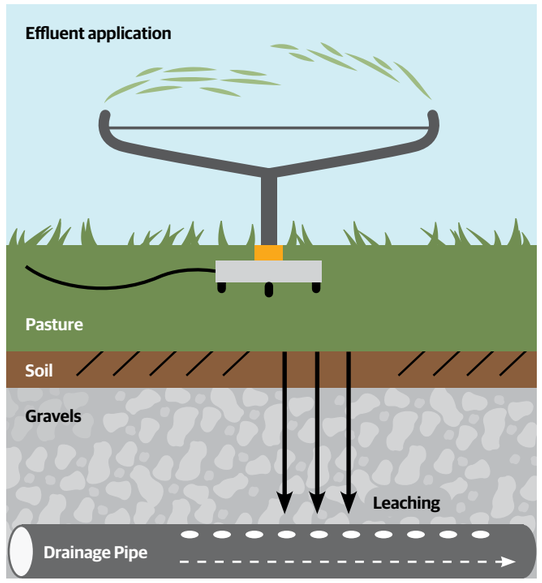


Figure 1. Diagram illustrating land application of farm dairy effluent over a subsurface tile-drain system. The depth of soil plus gravels over the drainage pipe varies between about 35 to 75 cm, depending on specific soil properties.

(1) see Source Code page 40

The findings are important, because up until Xueying's work, all the studies on the systems have been carried out using lysimeters with 70 cm deep soil. In those studies dissolved reactive phosphorous (DRP) losses in leachate were reduced by up to 99.5% when treated effluent was applied compared with untreated effluent.

In her work, the lysimeters had only 15 cm of soil with pasture growing in it, overlaying 55 cm of gravel, simulating tile or subsurface drain installations (Figure 2).

Xueying treated effluent with polyferric sulphate, the same active ingredient used in the ClearTech and EcoPond systems and used the same methods for treatment.

She applied treated effluent to the lysimeters on the same day it was treated, as well as applied effluent that had been treated and stored for eight weeks.

She applied untreated effluent as a comparison and plain water as a control.

She applied each in both May and September and collected drainage water from the bottom of the lysimeters analysing it for total P (TP) loss, dissolved reactive P (DRP) loss and total dissolved P (TDP) loss (Table 1).

TABLE 1: DRP, TDP, TP AND *E. COLI* LEACHING LOSSES OVER THE EXPERIMENTAL PERIOD.

Treatments	P losses (kg P ha^{-1})			*E. coli* (cfu 100mL^{-1})
	DRP	TDP	Total P	
Control	0.24 a	0.55 a	0.91 a	3.05E+05 a
Treated effluent	0.24 a	0.63 a	4.52 ab	6.29E+08 a
Treated stored effluent	0.27 a	0.89 a	6.31 b	3.51E+04 a
Untreated effluent	3.48 b	4.76 b	11.44 c	3.63E+10 b

Compared with untreated farm dairy effluent:

- DRP loss was reduced by 93% when effluent was treated and 92% when it was treated and stored
- TDP losses were 87% lower when effluent was treated and 83% lower when it was treated and stored
- TP losses were 60.5% lower when it was treated and 45% lower when treated and stored.

Importantly, pasture growth was no different between each lysimeter, showing the effluent treatment was able to limit leaching losses but maintain the availability of P to the plants.

Total *E. coli* losses were almost nil with a 98% reduction for treated effluent compared with untreated and a 99.9% reduction when it was treated and stored, also compared with untreated effluent.

Importantly, pasture growth was no different between each lysimeter, showing the effluent treatment was able to limit leaching losses but maintain the availability of P to the plants.

Studies have shown subsurface drainage in effluent areas is a significant issue when it comes to P and *E. coli* loss.

The findings of this latest research give hope to farmers in areas where tile and subsurface drainage is common. The ClearTech and EcoPond technology will provide a new and significant tool for reducing farming impacts on water by dramatically reducing the amount of both P and *E. coli* entering it. ■

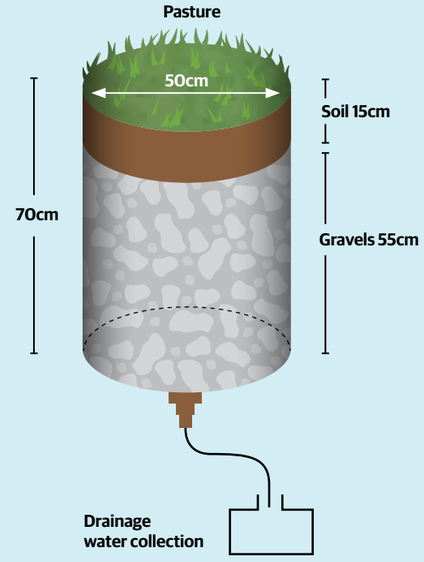


Figure 2. The design of the drainage model unit used for the study.

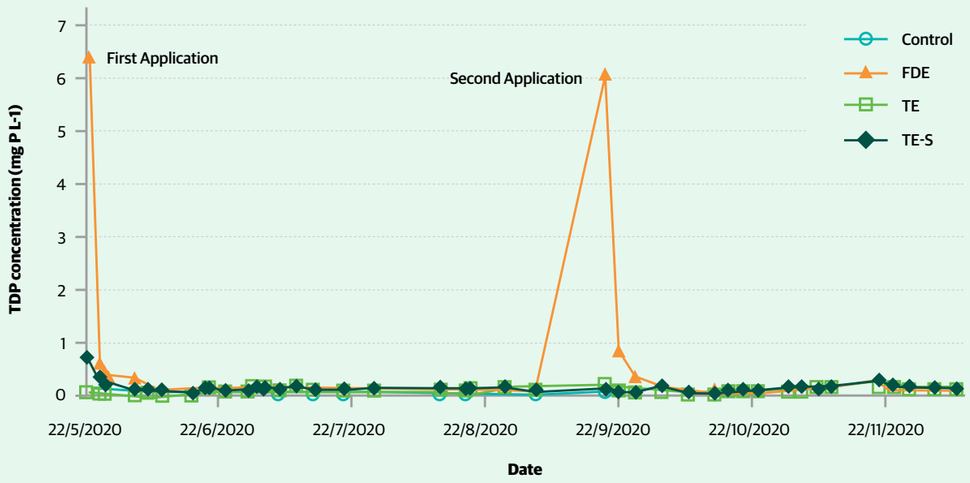
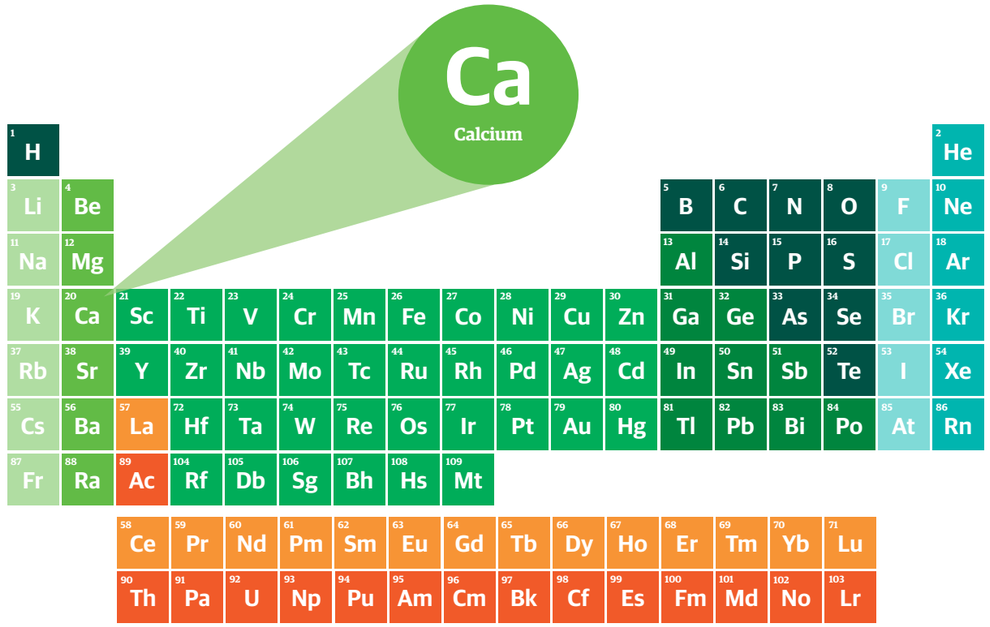


Figure 3. Average concentration of total dissolved phosphorus (TDP) in drainage water collected from the model drainage units. FDE, farm dairy effluent; TE, treated effluent; TE-S, treated effluent after 3 weeks storage. Error bars represent standard error of the mean.



Elementary essentials #6: Calcium (Ca)

By Dr Ants Roberts

DR ANTS ROBERTS, RAVENSDOWN CHIEF SCIENTIFIC OFFICER

The alkaline earth metal calcium (Ca) is the twentieth element in the periodic table and is one of the 19 elements essential for life in all higher plants and animals on planet Earth. Calcium is the fifth most abundant element in the Earth's crust at 3% and the third most abundant metal.

Discovery of Ca

Calcium compounds, such as calcium carbonate and gypsum (calcium sulphate) have been used by humans for millennia. Lime as a building material and plaster for statues has been used since 7000 BCE. Depending on your age, you may even remember using Plaster of Paris (aka gypsum) to make your own craft models. The first recorded lime kiln, discovered in Mesopotamia, dates to 2500 BC. Around the same time gypsum was being used in the Great Pyramid of Giza and in the tomb of Tutankhamun. The ancient Romans used calcium oxide as mortar, after heating limestone and driving off the carbon dioxide (although they did not realise that is what they were doing).

Pure Ca metal, as with magnesium (Mg), was first isolated in 1808 by Sir Humphry Davy in England. He used electrolysis on its oxide. Sir Humphry named the element after the Latin word calx, which means lime. Like Mg, Ca metal does not exist in nature as it reacts spontaneously with water and only occurs naturally as compounds in association with other elements.

Why is Ca essential?

Plants

Calcium is a secondary nutrient required in large quantities in plants for structural components of cell walls and membranes and as an important counter ion (to balance electric charge of anions inside cells). Calcium also acts as a messenger inside cells to promote enzyme activity and plant responses to biotic and abiotic stresses.

Animals

Calcium is highly important in animals because it builds the endoskeleton (bones) and teeth of vertebrate animals and the exoskeleton of invertebrates such as shellfish, crayfish and crabs. Calcium is also essential for muscle and nerve function.

The vital role of Ca in agriculture

Soils with adequate Ca levels generally have better structural qualities, are more friable and better aerated and drained. A principal reason for this is that Ca bound to soil colloids ensures that the colloids flocculate (bunch together) more easily, leading to greater soil porosity. As such, gypsum is known as a soil "conditioner" that can displace too much sodium (Na) in saline and sodic soils and assist flocculation in some heavy clay soils. Agricultural limestone would be a cheaper form of Ca to apply for this purpose but also raises soil pH, which may not be required. It should be noted that it is primarily the carbonate in agricultural lime that increases soil pH not the Ca ions, as some commentators insist. If Ca ions were responsible, then gypsum would also increase soil pH, which it does not.

While absolute Ca deficiency is relatively rare in nature (because of the relative abundance and availability of soil Ca), excessive Ca in calcareous soils restricts plant growth and development. New Zealand pastoral mineral topsoils generally contain between 1,000 and 5,000kg/ha of plant available Ca.

Plants, particularly horticultural crops, may show Ca deficiency symptoms even in soils with high Ca content. Symptoms of deficiency include death of growing points, premature shedding of blossoms and buds, tip burn, blossom-end rot and bitter pit. Calcium is supplied throughout the plant in the xylem and plant Ca cannot be remobilised and supplied to the growing points of developing plants.

In animals, without an adequate supply of calcium over the long term, teeth, vision and brains are damaged, and bones become brittle (osteoporosis). Given all these roles, it is no surprise that humans and other animals need a lot of Ca, as it forms about 6% of body weight, ignoring water content.

There have been no recorded Ca deficiencies affecting grazed legume/grass pastures in New Zealand and so calcium fertilisers per se are not usually recommended, although Ca is applied as a companion element in superphosphate (20% Ca), lime (39% Ca), dolomite (23% Ca), gypsum (23% Ca) and other derivative products, which helps replace Ca lost in product, transferred to non-productive areas of the farm, or leached as a counter ion.

Farm animals, particularly lactating females, can suffer acute Ca deficiency disease, i.e. hypocalcaemia. This may be despite adequate soil and hence pasture Ca content. This metabolic disorder can be precipitated post birth as lactation starts and the dietary requirement for Ca triples. The feed intake of Ca may not be adequate to meet this greater demand and the animals mobilise bone Ca. This mobilisation of bone Ca requires adequate Mg availability in the animal and a number of factors can act singly or collectively to prevent adequate remobilisation of bone Ca.

Environmental impacts

As a divalent cation, Ca^{2+} is relatively strongly bound to the negative charge on soil colloids and not very mobile. However, Ca does preferentially leach as a counterion to balance the electrical charges in soil as nitrate and sulphate anions leach in drainage water. While there are no known environmental issues with Ca, the principles of the 4Rs (right place, time, rate, and form) for fertilisers and lime containing Ca should still be followed. ■

NEW ZEALAND PASTORAL MINERAL TOPSOILS GENERALLY CONTAIN BETWEEN 1,000 AND 5,000KG/HA OF PLANT AVAILABLE CA

Source Code

In case you would like to learn more, we have collated this list of sources cited in our articles. Most of these are available online. If you'd like more information, or you'd like to discuss an article written in Ground Effect by any Ravensdown specialist, give the Customer Centre a call on 0800 100 123 to arrange a chat.

RUPERT, HENRY AND TOM THATCHER HELP THEIR DAD DAVE WITH TREE PLANTING NEAR PEEL FOREST, SOUTH CANTERBURY

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The Last Word

We hope you enjoyed the Spring edition of Ravensdown's Ground Effect®, which is all about smarter farming for a better New Zealand.

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On behalf of Ravensdown, we'd like to thank you, our shareholders, for your contribution to New Zealand and our food and fibre industry. We continue to invest in and develop our agri-science, technology and innovations for the good of your business and the country. Keep up the good work of Smarter Farming for a Better New Zealand.

Contributors

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Victoria Rutherford and Tony Leggett, Editors

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