Vol 26 | No 2 | JUNE 2022 | ISSN 2463-3011

THE JOURNAL

The Official Publication of the New Zealand Institute of Primary Industry Management Incorporated

INTERNATIONAL DAIRY SECTOR – INFORMED DECISION-MAKING FARMER RESILIENCE IN THE FACE OF ADVERSITY
AG COOPERATIVES AND UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS **ROLE OF RURAL SUPPORT TRUSTS**
CROSSBRED MERINOS AND PROFITABILITY ADOPTION OF COW COLLAR TECHNOLOGY

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Volume 26
Number 2
June 2022
ISSN 2463-3011

The Journal is published quarterly and provided free of charge to NZIPIM's members from across the rural profession including farm management advisors, rural bankers, farm accountants, fertiliser consultants, rural valuers, specialised service providers, farm managers, representatives from industry good organisations, CRIs and universities.

The Journal is a quality assured publication for rural professionals providing professional services within New Zealand's primary industries. The articles do not constitute advice. The Institute takes no responsibility for any decisions made based on the material in this publication. The opinions of the contributors are their own and not necessarily those of NZIPIM or the Editor.

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Annual Subscription Rates
$75+GST (NZ)
$100 (Australia)
$120 (other countries)

Cover photo: ¾ Merino ram at Melrose in Canterbury, courtesy of NZ Merino

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JO FINER CEO

Do the economic black clouds have silver linings?

Plenty of commentators are reporting black economic clouds on the horizon. Is the news all bad or do some of these clouds have silver linings that will help buffer the primary sector?

Inflation is rising. Interest rates are escalating. Producer and grower input costs are lifting. Black clouds are forming.

The indicative medium-term inflation figure for New Zealand is sitting at around 7%. The last time this country had significant inflation, from 1970 to 1987, the annual average was 12.6%. New Zealand certainly doesn't want this again and the Reserve Bank are making every move possible to avoid this. While inflation is well above the Government's target range, they have indicated it will trend towards the 2% mid-point over the coming years.

However, for now, inflationary pressure is causing on-farm costs to lift sharply, with farm operating costs forecast to continue to rise for the foreseeable future. Costs are rocketing, with labour, fuel and fertiliser leading the way. While there's improving primary sector resilience due to less debt, the lower debt is being offset by rising interest rates.

Over the last 10 years, the cost of living in New Zealand has increased by 19%, while wages have gone up 36%. The average wage cost increase over the last year alone was 4.2%.

Crude oil prices dipped in 2020 caused by a drop in demand due to COVID-19. With economic recovery underway and inflation fuelling the rise, oil prices have risen sharply from the COVID low. They continue to be affected by global uncertainties and the third quarter of 2021 saw massive hikes in prices. With around 30% of Europe's energy sourced from Russia, prices are being driven even higher.

Fertiliser prices were already escalating due to soaring wholesale gas prices. However, with Russia being the world's largest exporter of fertilisers, the war in Ukraine is starting to deliver a shock to global fertiliser supply and consequently cost.

So, what are the silver linings we can look for to support our primary industries?

Russia and Ukraine are among the biggest producers in agriculture and food globally, making up 26% of wheat, 30% of barley and 19% of corn crops. Russia also produces a large global share of fertilisers and components, including phosphate, potassium, urea and sulphur. The medium-term effect of the Ukraine situation may well be in food supply issues and increased food costs for many countries.

At the same time, the US is experiencing unprecedented drought conditions in California. Combined with the eastern European conflict, this will likely result in an imbalance in supply and demand. This means there could continue to be a sharp rise in global commodity prices, with a positive and direct flow into New Zealand's primary sector.

Dairy commodity prices continued to lift in the first quarter of 2022 as both dry weather in parts of New Zealand and the war reinforced the existing tightness in global dairy supply. However, a further COVID outbreak in China, with surging Omicron case numbers, has introduced uncertainty around global dairy demand and reiterates the risk associated with New Zealand's reliance on China.

Economists are predicting that falling levels of milk production here and overseas should see milk prices continue strongly into next season. They suggest that the Ukraine-Russia conflict and its impact on grain feed prices will continue to put the pressure on EU dairy production, which will keep prices high here.

Total combined red meat export revenue for the 2021-22 season is on track to lift 11% on the previous year. Economists report a positive outlook for the global red meat trade, supported by strong growth in key markets such as the US and China, and demand is projected to continue to exceed supply. A tightening of global beef supply, again impacted by high grain prices, is adding strength to the market. Even ongoing global supply chain disruption is not anticipated to significantly impact the outlook.

The New Zealand-UK free trade agreement provides an additional upside for the primary industries and is a positive for horticulture and wine. New Zealand's horticulture is set to benefit with the hort sector's trade profile growing, and with exports to the UK dominated by apples and onions. Concurrently, demand and prices for kiwifruit continues on a positive trajectory, with much of the value growth coming from Japan.

These positive market sentiments for producers and growers are supported by a further silver lining, the favourable New Zealand dollar forecast. This means a greater proportion of the strong prices in export markets are expected to flow directly into primary sector returns.

There are tough times ahead – but there may well be some silver linings to support us during these dark, uncertain times J

JOHN ALLEN & ERIK ELGERSMA

International dairy sector

NEED FOR INFORMED DECISION-MAKING

This article discusses the dangers of restricting dairy output in a world short of food when dairy can be considered a valuable source of nutrients if produced in a sustainable system. Policy-makers need more unbiased research into balancing the issues surrounding nutrients and sustainability.

Debstabilising the norm

Recent world events with COVID, inflation and the war in Europe illustrate that we live in an uncertain world and that 'Black Swan' events come along and de-stabilise the 'norm'. What appears right in policy terms can come back to haunt us in the future. Witness the policies surrounding de-carbonisation that have contributed to the inflation of energy and food prices. Therefore, policy-makers need to take information from a range of sources and balance their decisions based on wise 'counsel', rather than being led by pressure groups with their own agendas. This is important to avoid the law of unintended consequences.

We have prepared a number of reports in the UK looking at the growing demand for dairy and inflationary pressures creating a 're-set' for pricing as we came out of COVID. However, while all these reports were prepared at a time of great change, we could not have envisaged the sharp focus that the war in Ukraine has brought onto global food security. Once more, the dynamics of international commodity food markets have altered.

Against this rapidly evolving backdrop, the focus on climate change mitigation also remains at the fore. The most recent Intergovernmental Panel on Climate Change (IPCC) report, published in early April 2022, talks of the need to reach peak greenhouse gas emissions by 2025 at the latest if we are to limit global temperature rise to 1.5°C, and be reduced by 43% by 2030, with a methane reduction of one-third over the same timeframe. Agriculture is highlighted as being able to provide large-scale emissions reductions, while also removing and storing carbon in soil at scale. However, this will not be achieved without considerable change.

So, we have a strong 'now or never' message on climate change. We have global food supply challenges caused by the war in Ukraine and we have a backdrop of constricted dairy supply – part structural, part circumstantial – with growing dairy demand. But how do these factors interact and what does this mean for the UK dairy sector?

Analysing global dairy markets

For the purposes of this analysis on global dairy markets, countries are split into two distinct blocks:

- Net exporters (EU 27, UK, US, New Zealand, Australia, Uruguay, Argentina)
- Net importers (Brazil, Mexico, China, other nations).

Countries such as Canada, Norway, Switzerland, Turkey, Belarus, Russia, Ukraine, India and Pakistan are excluded from this analysis as they are rarely interacting with other countries in dairy.

The 'in scope' countries listed above produced a total of 558bn kg ECM* in 2021, of which international trade equated to around 74bn kg. Data have partly been supplied by the International Farm Comparison Network (IFCN). ECM is 'energy-corrected-milk', an approach to standardise milk from sources around the globe where protein and fat content of the milk might vary. **Figure 1** shows how the markets balance between exporters and importers.

When we project forward dairy market dynamics to 2030, there are many factors to consider. We must estimate the volume of future net exports, which is a combination of future raw milk supply minus future local consumption. We must take account of factors such as farm margins, dynamics around 'licence to operate' issues within markets and labour availability. We must also consider future dairy consumption, based on population growth and per capita consumption – the latter being particularly important given the rise in consumption of plant-based dairy alternatives.

For this analysis, we have assumed that drinking milk consumption will reduce by 30% by 2030 in developed markets as we see a rise in plant-based dairy alternatives. We already see around 10% replacement of dairy milk by alternatives in many net exporting markets, so we have assumed that per capita cow milk consumption will be 20kg/person lower liquid milk equivalent (LME) by 2030. We have assumed, however, that cheese or dairy ingredient consumption will remain stable, mainly because alternatives do not yet perform for taste, structure, functionality or affordability reasons.

We have based population growth figures on the available 2006-2021 compound annual growth rates to calculate the population changes from 2022 to 2030. International dairy markets are supplied from net exporting countries as shown in **Figure 2**.

Supply dynamics

Over the next eight years to 2030, the export volume from these net exporting countries is projected to decline, with a compound annual rate of –2.5% as shown in **Figure 3**. In absolute terms, this means that net dairy exporters are projected to reduce their dairy export volume in LME by around 15bn kg/year by 2030 vs 2020. This projection is based on a bottom-up assessment for all dairy exporting nations, taking into account environmental and other considerations, as well as the outlook for domestic consumption.

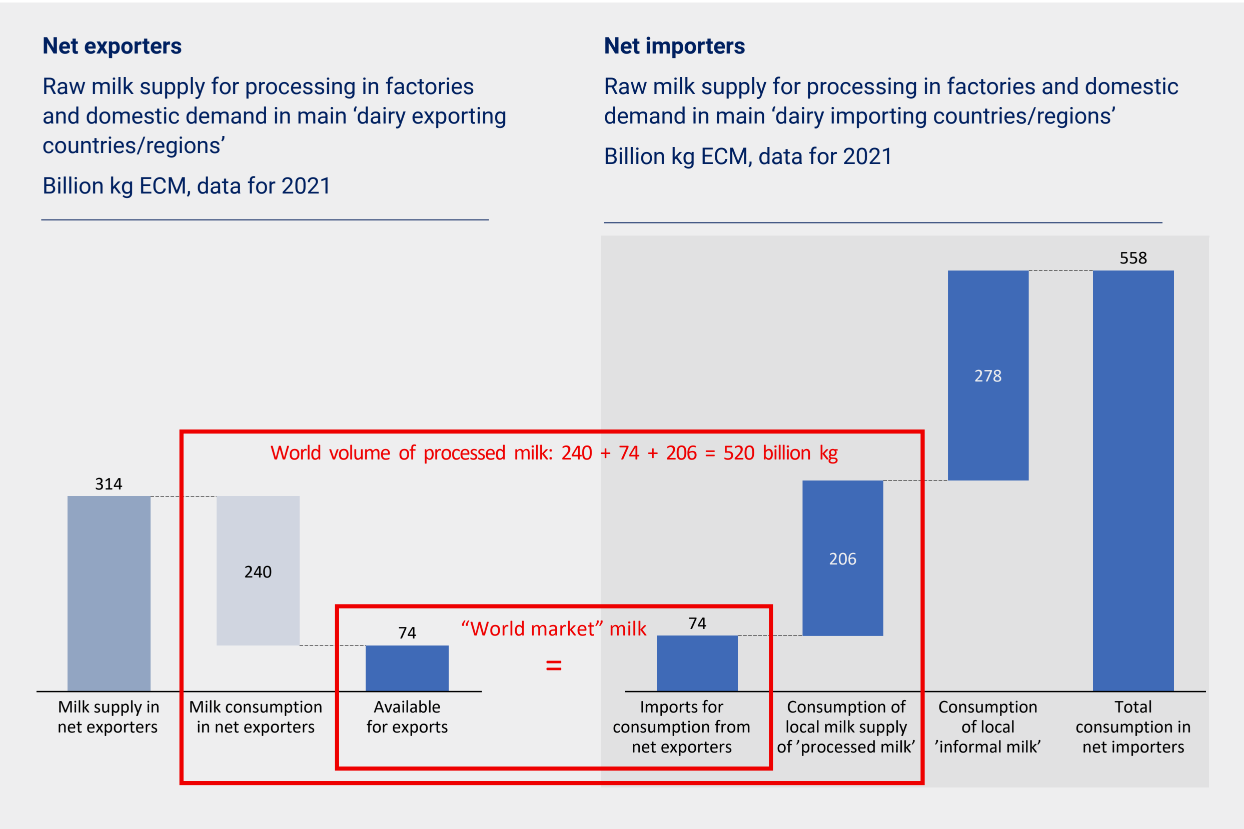

Figure 1: Dairy exporters and importers

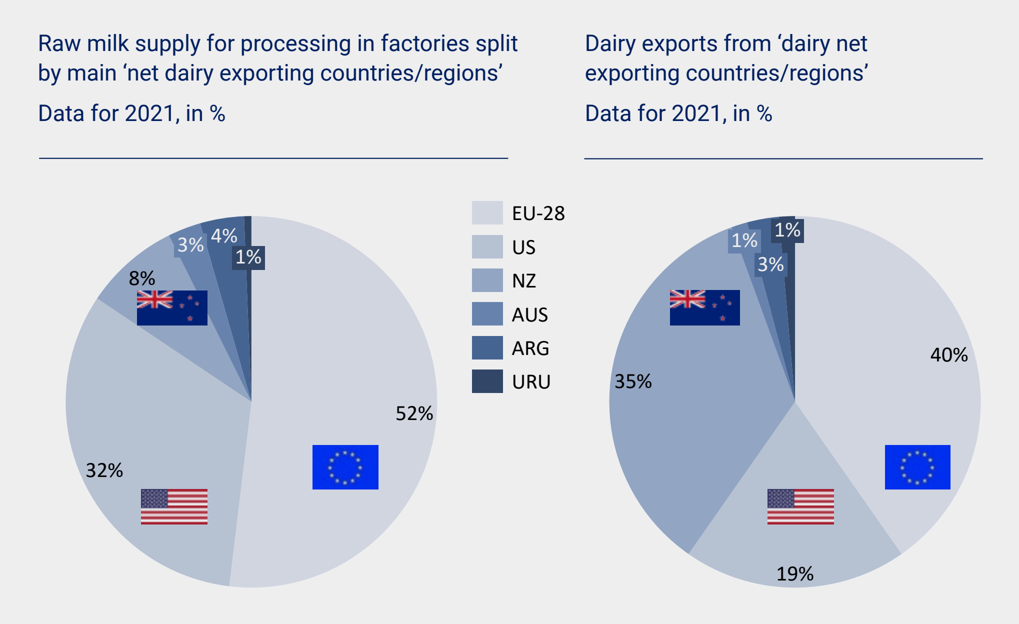

Figure 2: Net exporting countries 2021

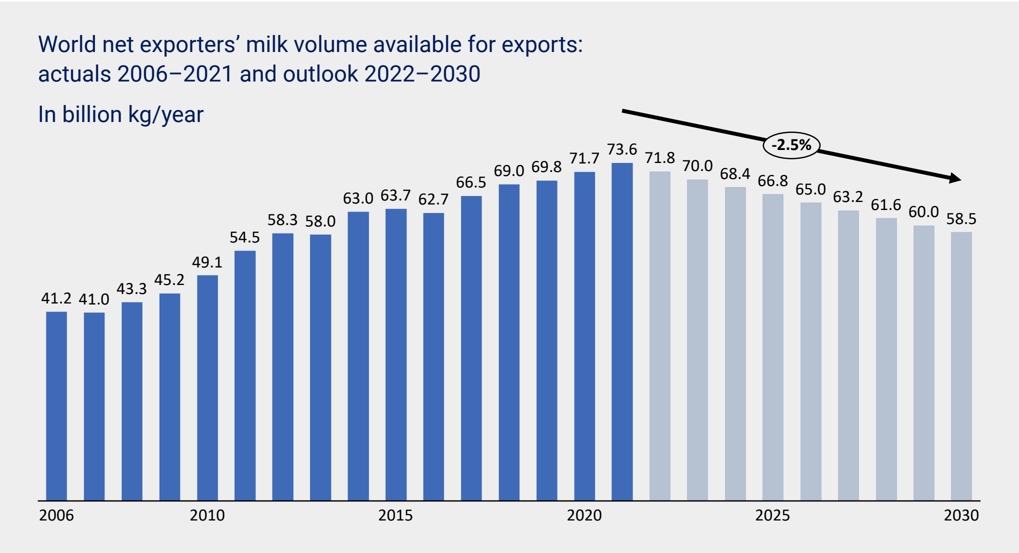

Figure 3: Projected development of available exports

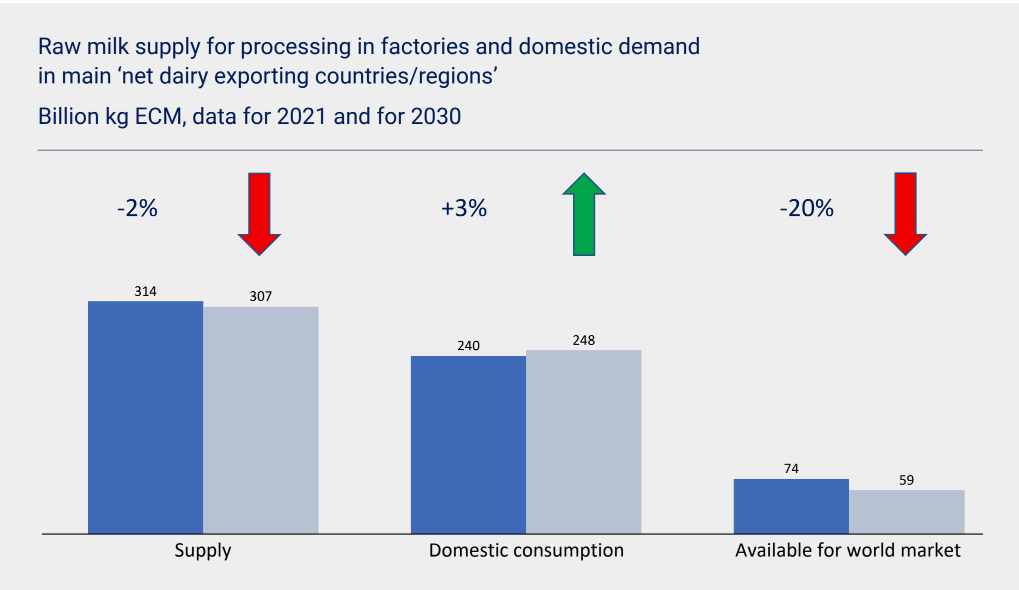

Figure 4: Raw milk supply for processing

What must be remembered is that small changes in domestic consumption or supply in net exporting nations can have a significant impact on the amount of milk traded internationally. Our analysis shown at **Figure 4** suggests that world dairy exporters will see production go down around 2% from 2021 to 2030, while domestic consumption will increase by around 3% because of population growth, meaning that global dairy export volumes will go down 20% by 2030.

We anticipate a shift between global net exporters, with the EU losing relevance as a dairy exporting block, New Zealand remaining relatively almost stable, and the US, Argentina and Uruguay increasing (see **Figure 5**).

Demand dynamics

Earlier research showed a net increase compound annual growth rate of 4.4% LME in world dairy markets. The two largest regions driving import growth from 2011 to 2019 were the People's Republic of China and Mexico, which together were responsible for 50% of all dairy import growth. Analysis suggests that Brazil also has potential to see demand growth.

Together, China, Mexico and Brazil are responsible for 20% of all world dairy market imports – an import compound annual growth rate (CAGR) of 1.4% from 2021 to 2030 has been calculated.

In recent years, due to insufficient availability and the resultant increase in dairy prices, LME export growth has only been 2.2% CAGR (2018-21). In the case of unrestricted supply, an import volume CAGR of 4.4% was, and remains, possible, but at recent higher prices 2.2% still proved possible. Our analysis assumes a possible volume growth of 2% CAGR for dairy imports shown in **Figure 6**, which is conservative.

Overall, this analysis shows that restricted dairy availability causes the world market for dairy to contract by 15bn kg/year, creating an additional unsatisfied demand for dairy of 30bn kg/year in net dairy importing countries by 2030 as shown in **Figure 7**, which is equivalent to twice the output of the UK.

This is mainly a result of environmental restrictions in net exporting nations, resulting in a more rapid reduction in supply than the expected reduction in consumption arising from the switch to plant-based alternatives. As noted earlier, we are not on track to limit global warming to below 1.5°C (see **Figure 8**) so action is only likely to increase in this area (particularly in the net exporting nations), limiting dairy supply further.

Our earlier research showed that the increase in dairy prices that results from production restrictions in today's exporting nations leads to a decline of dairy imports in the poorest countries. This decline is not compensated for by an increase of dairy output in these countries, largely because of climatological factors, the availability of capital and local capabilities. The result of this is that we already see 'unsatisfied demand', where consumers are open to buy (imported) dairy but cannot afford to do so.

Import statistics from 2010-2020 linked to economic development parameters by country show this to be ongoing. Our analysis shows that an additional 30bn kg/year of unsatisfied dairy demand is to be expected given the current outlook for dairy exporters and importers.

Given local constraints to dairy production growth in net importing countries, many of them depend on imports for consumption growth. Affordability issues, however, now look to result in an accelerated net consumption decline of dairy in these poorer importing countries. To consumers in

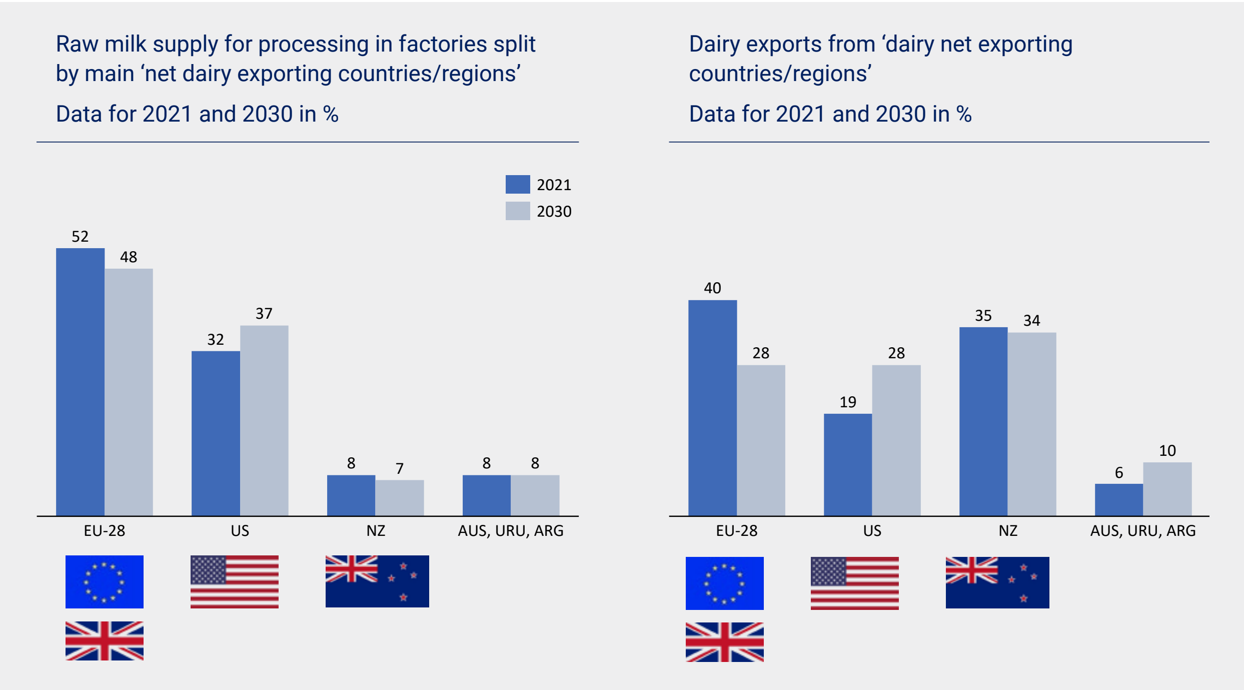

Figure 5: Projected evolution of exporters

We anticipate a shift between global net exporters, with the EU losing relevance as a dairy exporting block, New Zealand remaining relatively almost stable, and the US, Argentina and Uruguay increasing.

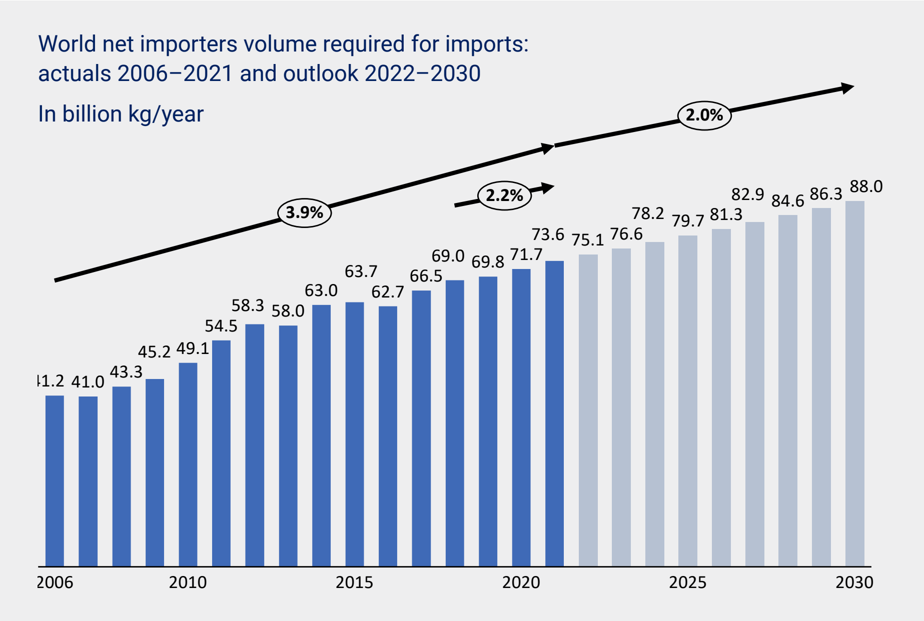

Figure 6: Outlook for demand growth

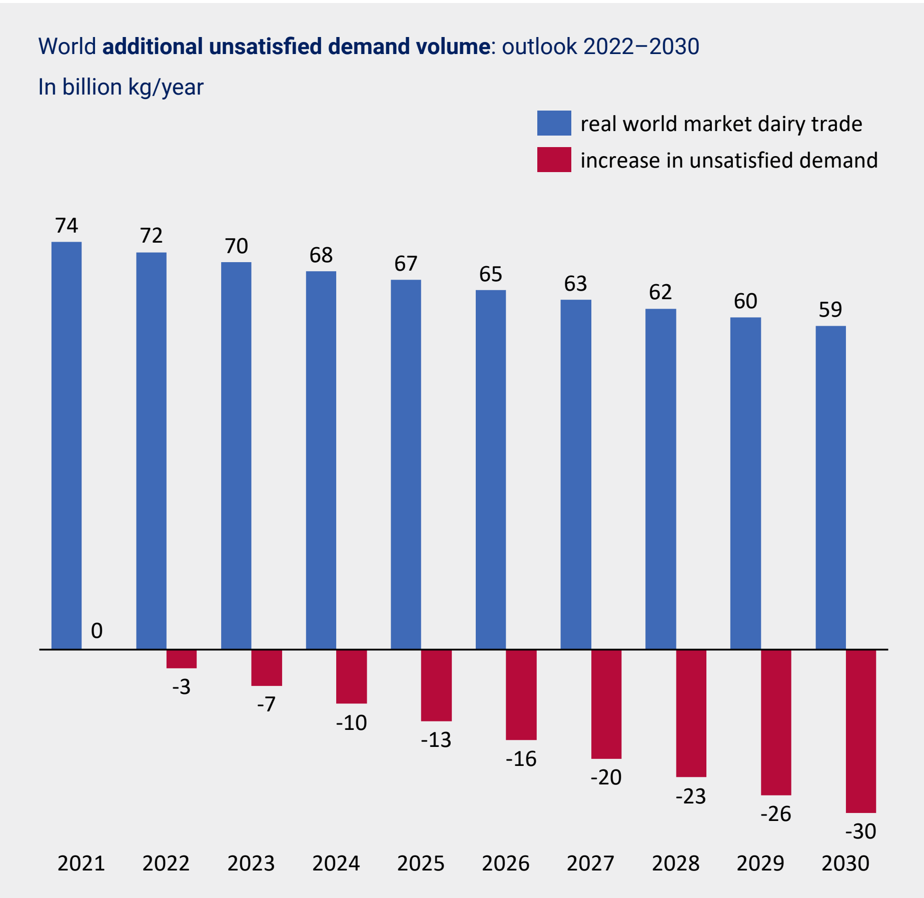

Figure 7: Unsatisfied demand volume

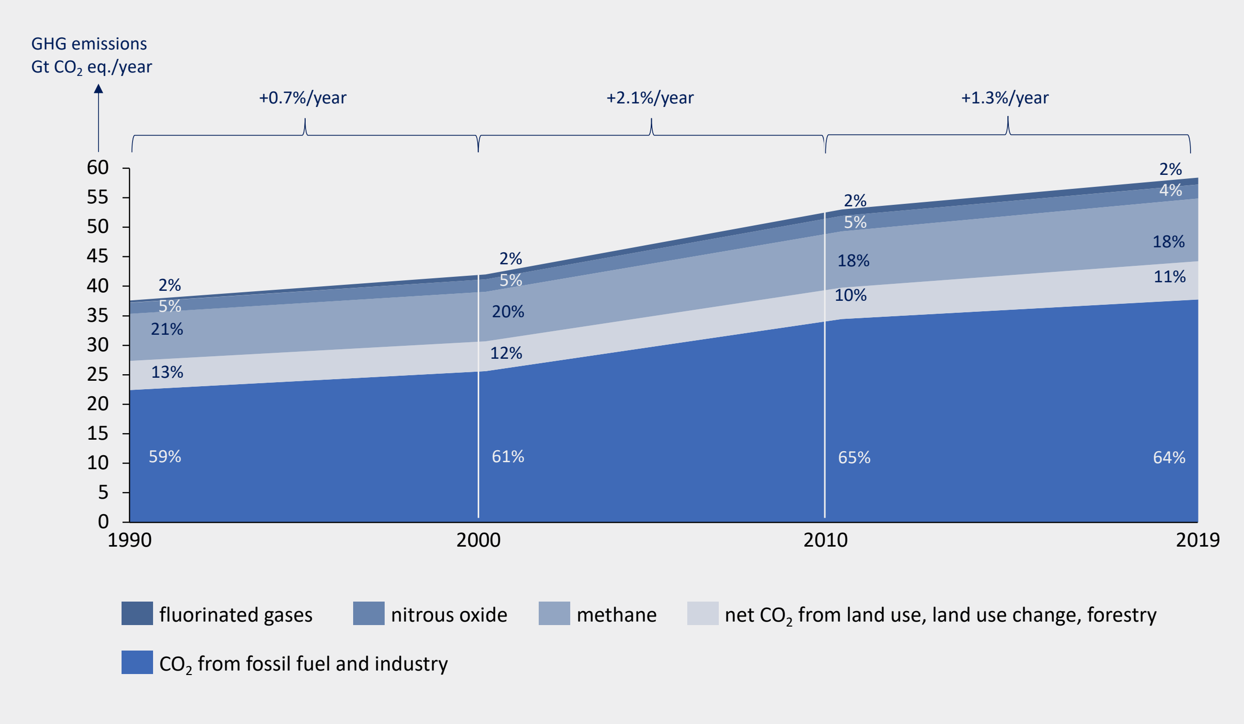

Figure 8: Increasing GHG emissions. Source: IPCC Sixth Assessment Report, April 2022

countries with a GDP/capita of <US$15,000, access to dairy may be almost denied by 2030. In 2021, these countries were home to over 2.6 billion consumers – about one-third of the world's population.

So, what does this mean?

The war in Ukraine has brought global food security into sharp relief. Ukraine is the breadbasket of Europe, with the International Food Policy Research Unit estimating that Ukrainian exports represent 12% of all the food calories in the world. Many vulnerable countries such as Ethiopia, Yemen, Lebanon and Palestine rely on Russia and Ukraine for food imports, particularly of wheat, corn and sunflower oil.

The UN World Food Programme has identified conflict as the main driver of food insecurity in the world, with the instability in exports pushing prices up and often making the countries most vulnerable to the situation in the worst position to secure alternative sources due to the cost.

When it comes to dairy, this presents a challenging situation. Of course, working on climate change is and should be a global policy priority. After all, climate change is a global issue and all countries need to act in unison – some earlier, some later depending on their state of economic development. But there is an urgent need for action and Western governments are pushing for progress which, as illustrated in the analysis above, is likely to have an impact on global dairy supply as many of these nations are net exporters of dairy.

Every country needs to act on climate change, but for any country to make progress its government must have legitimacy with its respective population. This requires a minimum level of social stability, which is jeopardised by issues with global food security. Yet without action, climate change will *also* cause issues resulting in social unrest.

Here lies the paradox – we risk commendable and much-needed initiatives to minimise climate change in Western economies, putting additional pressure on global food security. In combination with ongoing conflict, this is likely to result in high food inflation and poor availability. Any such increase in unsatisfied demand globally is an indicator for an increasing level of 'under-nourishing' the planet's population and thus a likely harbinger of future social unrest. In the most vulnerable countries, this will reduce the legitimacy of their governments and make addressing climate change harder.

Clearly, this situation must be avoided. Any initiative to combat climate change in the West that potentially reduces its food output may indirectly backfire through social unrest and a reduced propensity in the rest of the world to combat climate change. This may be because either: economic means are lacking due to high food prices in undersupplied markets; or the willingness of governments in developing economies (or their legitimacy with their population) will reduce in the face of more pressing concerns of food security. The net result would be a cleaner West but a worse outcome globally.

Of course, there are those who argue these circumstances will drive a reduction in food waste, which will benefit climate change while also helping to address food security. According to Friends of the Earth, around one-third of all food produced globally is wasted, so the potential to address food security by addressing this seems clear. Although one could expect higher food prices to bring this into sharp focus, this has proved to be a challenging area to address thus far.

The total amount of carbon emitted to meet your nutritional needs may be lower when consuming dairy vs alternatives (even though the carbon footprint per kilogram is higher) because you need less of it.

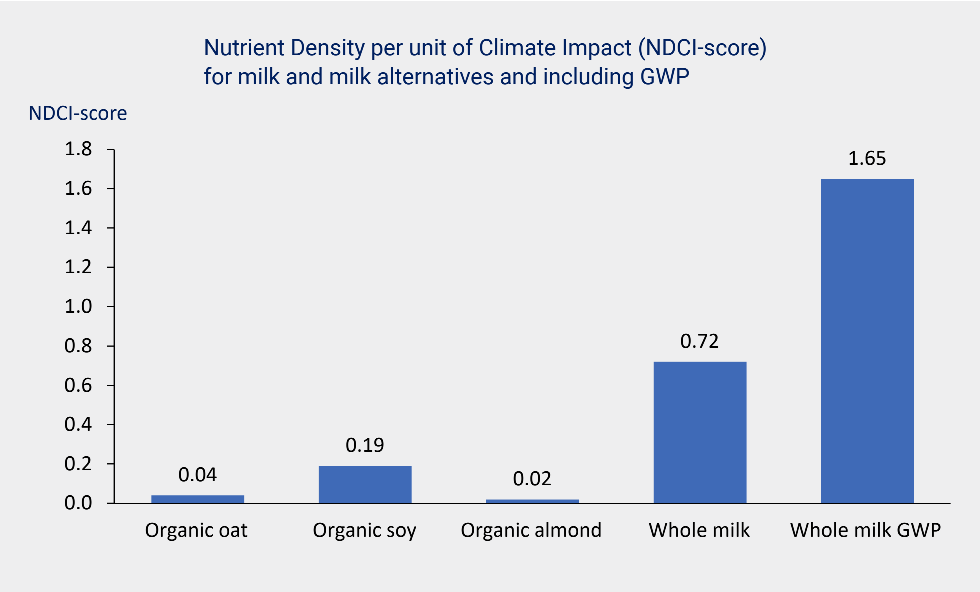

Figure 9: Nutrients per unit of carbon

Why is dairy significant in this context?

Dairy has a key role to play in nutrition, particularly in the face of food security challenges globally. At its most basic level, food is fuel and different foods have different nutrient profiles. While in developed economies we have the luxury of choosing food based on taste, texture, meal occasion and convenience, many do not have that choice. Dairy is nutrient dense and provides a cost-effective way to obtain the balance of nutrients needed to survive.

This seems straightforward in the context of a global food security challenge – dairy has a valuable role to play. But how is it relevant in the context of addressing climate change?

The accepted way of reporting a carbon footprint is to reference the amount of carbon dioxide equivalent (CO_2e) per unit of 'utility' – whether that be distance travelled in the case of a car, or amount purchased, in the case of food. But the reality is that, unlike some products, the utility value in food is not always transparent. As such, it is a crude and ineffective measure to simply look at carbon footprint per kilogram of food, as 1kg of one food is not the same as 1kg of another. What matters most then is the carbon footprint on a nutrient density basis – or what is the carbon footprint emitted by choosing that foodstuff to get the required daily intake of a broad spectrum of nutrients.

And that is where dairy becomes significant. Dairy has been widely publicised as having a high carbon footprint due to the methane burped by cows, the carbon footprint of the farm inputs and the energy required in processing and transporting the end products. And, on a carbon footprint/kilogram of food basis, that analysis is correct.

The real point that has been missed, however, is that the carbon impact of food is not taking account of nutrient value but is simply being based on quantity of product. Taking the example above, it has become widely accepted that dairy is bad for the environment. But dairy has a high nutrient density – so relatively small quantities of dairy will fulfil your nutritional needs. As such, the total amount of carbon emitted to meet your nutritional needs may be lower when consuming dairy vs alternatives (even though the carbon footprint per kilogram is higher) because you need less of it.

We looked at the nutrients that dairy provides for a kilogram of carbon compared to dairy alternatives. The comparison is based on 'pure' milk and dairy alternatives before any fortification or additives, as shown in **Figure 9**.

As we can see, the analysis highlights that dairy yields nearly four times as much nutrition as soya (even when measured using GWP100) and this increases to eight times as much if using GWP*. Other alternatives are even poorer in nutritional terms. Policy-makers need to recognise this issue when setting targets for changing consumption of dairy.

This is key. The UK dairy industry is leading on decarbonising, with ambitious net zero plans. Dairy is nutrient dense with a rapidly reducing carbon footprint,

which makes it a valuable part of the food chain on an ongoing basis when considered in the wider global context of food security challenges outlined in this report.

Summary

This analysis paints an interesting picture for dairy in the global context up to 2030. Despite the rise in plant-based dairy alternatives, our analysis suggests that dairy demand will continue to grow. Meanwhile, the world supply for dairy is expected to decline, particularly in the EU and New Zealand, which will create challenges for the dairy processing sector in those areas as well as adding to the challenges of global food security as prices increase.

This leaves the UK in an interesting position. As a country, we are well-placed to produce dairy due to our temperate climate and established, efficient dairy farm and processing base. All other things being equal, we could continue to produce the valuable and much-needed nutrients that dairy provides and supply the growing export opportunity.

We are also well-placed to adapt to the environmental challenges of climate change while continuing to maintain or increase production. Indeed, the UK dairy industry's carbon footprint is already well below that of the global average, with considerable activity being undertaken across the supply chain to drive this down further.

Yet UK policy-makers are taking the focus away from efficient food production, with a greater focus on nature conservation and the delivery of other public goods. The dairy industry is also in the spotlight from climate campaigners.

Of course, we must address the biodiversity crisis and decarbonise agriculture – that is not up for debate. But what seems clear is that UK policy-makers need to create a framework that achieves this while also encouraging and recognising the significant value that comes from producing sustainable, nutrient dense affordable food.

Seeing this analysis should also raise questions in New Zealand and other dairy-producing regions about whether the right policies to de-carbonise their agriculture are being pursued. We are in danger of sleepwalking into a global food security challenge which could, in turn, counter the efforts of Western economies to lead on climate change mitigation, undoing any good that has been achieved while creating a bigger problem. Global unrest from poor food security could be compounded by further global unrest from a failure to address climate change in a balanced way across the globe.

This cannot be allowed to happen. What's clear is that we need a robust policy framework that allows UK farmers to respond to supply chain challenges (such as cost inflation and the longer-term impacts of decarbonisation), while at least maintaining, and ideally increasing, dairy production to avoid food security issues across the globe. This requires a much more joined up approach to food security and agricultural policy than we have seen to date, ideally coordinated between nations.

The challenge is significant, but the opportunities for real progress are also considerable – both on climate change and economically. The question is whether policy-makers really understand these issues and if they will respond effectively in time.

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JACK COCKS & JOANNE R. STEVENSON

HOW RESILIENT FARMERS THRIVE IN THE FACE OF ADVERSITY

Farmers face adversity from multiple sources and additional challenges to other sectors of society. To date, there does not appear to be a simple high-level resilience-focused model for how farmers can be more resilient 'personally'. This article, which is the result of a Kellogg Rural Leadership Study on 'How Resilient Farmers Thrive in the Face of Adversity', is a first step towards developing that model. The study found there were three key strategies that facilitated farmer resilience – purpose, connection and well-being.

Adversity affects farmers from multiple sources

Like all members of society, farmers face adversity in a range of forms from health crises to financial volatility, family challenges and personal loss. Due to the nature of their business, however, farmers are more vulnerable than those in other industries to climate challenges and global market shifts. They are also often toiling at the coalface of legislative changes and can have less access to appropriate support services.

More than other industries farmers have strong identity ties to their land and business, meaning that disruptions to the farm are de facto disruptions to the farming family. They also typically live at their place of work. The current global environment (autumn 2022) – experiencing climate change, a global pandemic and a war in Eastern Europe – highlights the dynamism, volatility and interconnected global marketplace in which New Zealand farmers operate.

Developing strategies to recover quickly from adversity, or 'building resilience', is essential to achieving long-term success in farming. While there are a number of tools and resources available that address social-emotional resilience, there does not appear to be a simple, high-level resilience-focused model developed specifically for farmers. Such a model could be used by farmers when facing adversity to ask themselves, 'Are we implementing the key strategies and techniques (both as an individual and as a team of individuals) that we need to be resilient in the face of this adversity?'

More than other industries farmers have strong identity ties to their land and business, meaning that disruptions to the farm are de facto disruptions to the farming family.

Context

The lead author, Jack Cocks, an Otago high country farmer, experienced adversity from a life-threatening brain injury which saw him in a coma, suffer a cardiac arrest, a seizure and a pulmonary oedema. On day one in hospital Jack's family was given a prognosis that their husband, dad and son would likely be dead today. The best case scenario was that he would survive but spend the rest of his life in an institution. He obviously did survive, and the following six years saw him undergo 15 major surgeries and spend eight months in hospital re-learning to talk, and several times re-learning to walk.

Through this experience and recovery Jack has been told that he is a resilient character. He has been asked to give several talks to farmers on his experience and how he developed resilience through adversity. He found that giving these talks was a humbling and surprising experience for the feedback received. However, the presentations were based on just one farmer's thoughts and he had two questions he could not answer from them:

- The adversity he had faced, while bad, was it any worse than what many people face?
- Were his ideas on resilience applicable to all farmers, or were they just the ideas of one farmer who had faced some adversity?

Research project – five case studies

To answer these questions, Jack undertook a study on 'How Resilient Farmers Thrive in the Face of Adversity', as part of the 2021 Kellogg Rural Leadership Programme (K43). The first part of this study was a literature review, which uncovered that the resilience literature related to farming largely concentrates on climatic and financial resilience. The literature also suggests that some individuals are naturally more resilient than others, but resilience is a skill that can be learnt.

Due to the apparent lack of a theoretical model for personal (social-emotional) resilience for farmers within the literature, a grounded theory approach in the form of case studies was undertaken. Grounded theory is a research methodology where the focus is on theory development. The emphasis was on developing a theory for how farmers become 'resilient' and 'thrive' in the face of adversity.

Jack had the privilege of interviewing five resilient and remarkable New Zealand farming individuals and couples about the adversity they have faced and how they have become resilient. From these interviews there were strong commonalities across the five case study participants.

The participants were chosen as individual farmers who had faced significant adversity in one of five chosen areas and had in turn thrived through their exposure to it. Note that the term 'case study participants' is used to classify the five farmers. In some cases, the participants were individuals, but in others they were part of a couple (for some couples only one member of the couple was met). The case study participants were purposely selected and Jack had not met any of them before.

Five areas of adversity

The five areas of adversity and a brief synopsis of each case are given below:

- **Health**
  Doug, who farms on the East Coast, faced severe adversity in the form of depression. This was primarily brought about through farming in what became an eight-year drought.
- **Natural disasters, climate and weather**
  Andy, who farms in Canterbury, has farmed through a succession of major weather events, snowfalls and droughts. He has a great deal of knowledge about how to farm through adversity.
- **Financial**
  Kevin and Jody, who farm in Otago, have faced a very high amount of adversity in their lives starting from before they emigrated to New Zealand. Their major adversity in this country has been financial, in the form of a very low dairy payout in their first two seasons as 50:50 sharemilkers.
- **Family**
  Brent and Jo, who farm in Southland, experienced a number of challenges to farm succession early in their farming career. Communication and a desire to split assets evenly among all children, farming and non-farming, were the major challenges. They have since done everything right to complete succession with Brent's siblings and are an example for how farm succession can successfully be completed with their own children.
- **Personal loss**
  Melissa lost her husband to cancer and has since done tremendous good for her community.

It would be impossible and unfair to compare each of these stories. The level of adversity and the situations they have faced are so different that any of them would have responded differently, perhaps better, perhaps worse. The choice of case study participants provides representation of the common sources of adversity farmers in New Zealand face and a cross-section of the likelihood of adversity from the 'wow, that is incredible', to 'yes, our neighbours have been in that situation – I've seen it many times.'

The most remarkable story of resilience is notable for the breadth of the sources of adversity and the severity of the situation they faced. One of the case studies is therefore an important reminder of the possibility of compounding disruptions, where adverse events seem to stack up, showing the way that resilience can be repeatedly eroded and then built back up.

Jack was able to identify some of the case study participants because they have shared their stories publicly, mobilising the power of story-telling to process their own adverse event and improve the lives of others by sharing their message. Interviewing and examining their stories collectively revealed common themes that underpinned this diverse range of experiences.

Resilience strategies and the 'Resilience Triangle'

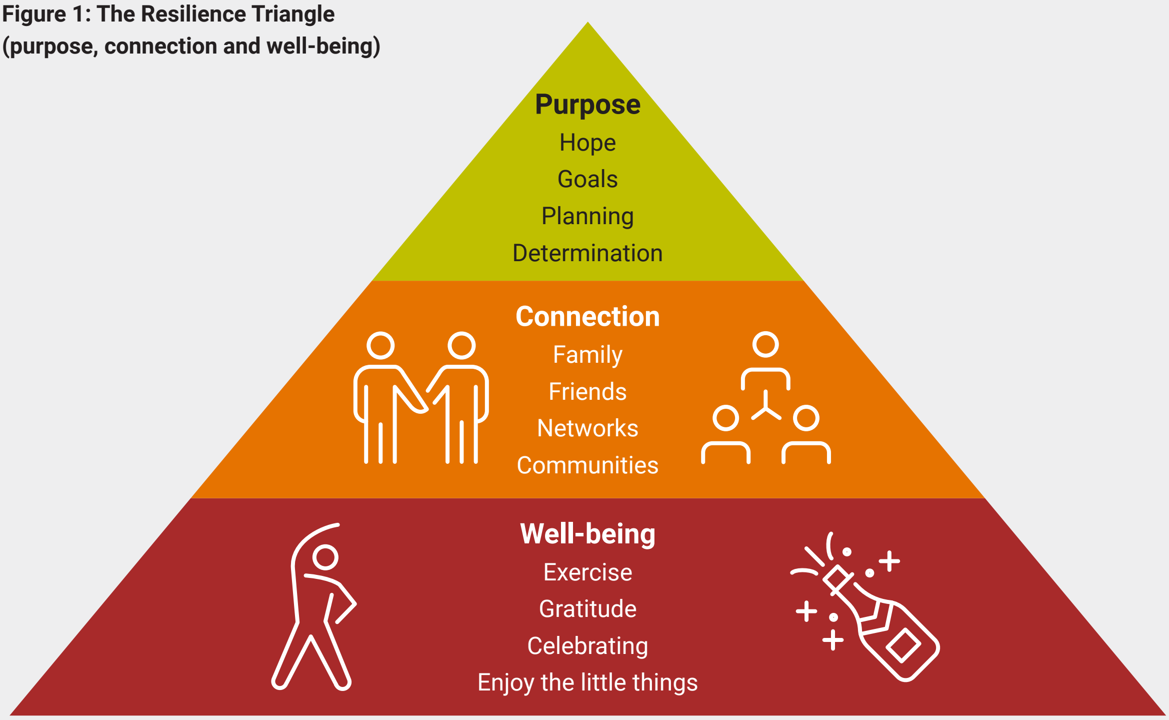
Analysing the interviews revealed the common resilience strategies that the five case study participants knowingly or unknowingly put in place in their lives. These strategies are captured in the form of a three-level triangle, the 'Resilience Triangle' (see **Figure 1**):

- **Purpose**
  This is the reason we are doing what we're doing; the 'direction' of the triangle, the 'why'.
- **Connection**
  This is the middle of the triangle; the 'glue' that holds it together, or the 'who'. This is keeping connected with other people – friends, family, farming networks and local communities. These connections are the people in our lives who buoy us up and encourage us to achieve, to rise above, and to have courage when going through adversity.
- **Well-being**
  This is the base of the triangle. It is, 'what do I need in my life to be well' or to be happy and content? It is the 'foundation' for resilience, the 'what'.

Participants in the study placed different weighting and had different consciousness of the use of these strategies, but they are common across all five cases. Key to the effectiveness of these resilience building strategies is the combinations of approaches across the three levels and how the participants have implemented the strategies in their lives.

For each of these strategies there were four 'enabling techniques' below each one that the farmers used to enable resilience at each level. There are different enablers that underpin their sense of purpose, connection and well-being. We could identify enablers that, when missing, eroded resilience at different levels of the triangle.

Figure 1: The Resilience Triangle (purpose, connection and well-being)



One of the case studies is an important reminder of the possibility of compounding disruptions, where adverse events seem to stack up, showing the way that resilience can be repeatedly eroded and then built back up.

Purpose

Purpose is the 'why' we are we doing what we are doing. Identifying purpose erases the mist so we can see the mountains and know where we're going. By having clear purpose, participants could quickly, consciously and clearly make decisions, compare alternatives, and ensure they were able to climb the obstacle in their immediate path.

For Doug, purpose was having a sense of belonging and value. For Brent and Jo, it was building a sustainable business and leaving it in better heart than when they took it over.

Kevin and Jody have a remarkable story of purpose enabled by hope (i.e. the sense of expectation and trust that a desire can be fulfilled). They emigrated from South Africa where they had faced adversity that most Kiwis could never imagine. Because of the severity, longevity and uncertainty this adversity had created for them, their purpose in New Zealand was 'creating a future with certainty'. Sharemilking was how they aimed to realise this purpose. Yet, during the low dairy payout years of 2015 and 2016 they were facing potential bankruptcy, while simultaneously dealing with the murder of family members back in their homeland.

Their resilience was being eroded, and they were losing their grasp on that sense of purpose, when an unknown sheep farmer from a neighbouring district stopped on the side of the road beside Kevin one day to talk to him. He said, 'I know you're doing it tough in the dairy industry at the moment. We did it tough in the sheep industry in the eighties and we got through. I wanted to tell you, don't give up, don't give up.' He shook Kevin's hand, then got in his car and drove away.

This random act of kindness from a complete stranger reinvigorated their hope, they managed to re-finance, and in their words 'by hook or by crook' they got through this adversity and have since done incredibly well. This random act gave them hope, it changed their lives, and it enabled their purpose.

Connection

The resilience literature emphasises the importance of both connecting with others for our long-term health and of the resources accessed through social networks for managing through adversity. Some authors argue that meaningful connection is as important to health as eating well or quitting smoking. For this study we defined keeping connected as, 'interacting with the people in our lives who make us feel better, stronger, and more able to cope with adversity'.

All case study participants discussed interpersonal connections that were critical to handling adversity, and some noted the way that a lack of connection had eroded their resilience. For example:

- Kevin and Jody very much missed the connections of their family and close friends when they went through their major period of financial adversity in New Zealand.
- Andy described the importance of 'drought shouts' as a place to connect with other farmers going through the same kind of adversity as they provided a space to share stories, experiences and learnings. This connection with other farmers was, in most cases, more valuable than the messages given by invited speakers at these events.
- Melissa, who was navigating the illness and death of her husband, cited the collective impact of the sporting, business and school communities to which she belonged. Not only did they provide moral support, but they reinforced her purpose by rallying behind fundraising efforts to support the building of the Southland Charity Hospital.

Enablers for keeping connected therefore were engaging with farming networks, allowing friends and family to support them in their time of need, and building connections in communities that can be drawn on in tough times. It can often be difficult for farmers to make time for connection, but it is one of the best investments they can make for the resilience of themselves, their families and their businesses.

Well-being

The well-being element of resilience in this study is defined as 'what we need in our lives to be happy and content'. It is seen as the foundation of the resilience triangle. When physical or mental well-being is compromised it can be difficult to deal with additional forms of adversity. Mental un-wellness, in particular, can undermine the other two parts of the triangle, making it difficult to connect with others and to find purpose.

Common enabling techniques of well-being included exercise, gratitude, celebrating and enjoying the little things. All participants cited exercise as vital to making them feel good – just the physical act of moving around activates chemicals that make us feel better. On gratitude, one participant had their own physical list of things they were grateful for in their lives – a list to be read and appreciated when experiencing adversity.

Rural professionals supporting our farmers need a clear understanding of not only the causes of adversity, but some of the strategies and techniques they can use to be resilient.

The lead author cites that after brain injury induced balance issues, having sufficient stability to be able to dress standing up was a cause for celebration after having to sit on the bed to do this for so long. Enjoying the little things such as seasonal foods, a sunrise, or the first birdsong in the early spring were all cited as enablers of well-being.

Conclusions

This study was concerned with developing a theory for how resilient farmers thrive in the face of adversity. It found that the case study participants employed three strategies in their lives to be resilient:

- they lived with 'purpose' in that they had a clear understanding of 'why' they were doing what they were doing
- they were very good at keeping 'connected' with those people around them who would and could help them through periods of adversity
- they also understood what they needed to do to keep 'well' – what they needed in their lives to be happy and content.

Also, for each of these three strategies there were four enabling techniques which these farmers employed to facilitate each strategy.

The future global environment in which New Zealand farmers operate will face significant volatility, turmoil and potentially subsequent adversity. Rural professionals supporting our farmers need a clear understanding of not only the causes of adversity, but some of the strategies and techniques they can use to be resilient. We believe this study is a first step in crystallising how resilient farmers thrive in the face of adversity.

Acknowledgements

Thanks are due to the Kellogg Rural Leadership Programme for developing and delivering such an excellent programme. Also, to the five case study participants who have openly shared their stories of adversity and resilience, as they are remarkable and inspirational farmers.

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KASANITA OFA & ELENA GARNEVSKA

The UN Sustainable Development Goals

HOW AGRICULTURAL COOPERATIVES IN NEW ZEALAND ARE RESPONDING

Cooperatives are playing an important role in achieving the 2030 UN Sustainable Development Goals (SDGs). New Zealand operates in one of the most cooperative-driven economies in the world. This article explores the sustainability practices of agricultural cooperatives in this country and how they engage with and achieve the SDGs.

SDG goals and cooperatives

New Zealand, as a member state of the United Nations, has agreed to negotiate a broad agenda aimed at enhancing global coordination on all aspects of human and ecological well-being in the post-2015 period. The 2012 UN Conference on Sustainable Development provides governments and businesses with practical measures to implement this area. In 2015, the General Assembly of the UN ratified the 2030 Agenda that sets 17 SDGs, with the aim to guide the world and business leaders on the path of sustainable development to achieve a more sustainable planet (see **Figure 1**).

The United Nations, as well as the International Cooperative Alliance (ICA), have identified that cooperatives are playing an important role in achieving the 2030 SDGs. Cooperatives are owned and controlled by their members, where profits generated are either reinvested in the company or shared by the members.

Figure 1: UN Sustainable Development Goals

The United Nations, as well as the International Cooperative Alliance, have identified that cooperatives are playing an important role in achieving the 2030 SDGs.

The ICA's 2014 publication *Blueprint for a Cooperative Decade* reports that sustainability is one of the five priorities to achieve the Alliance's vision, which is to strengthen the cooperative model and grow the global economy. In 2016, the ICA also launched an online platform, known as *Co-ops for 2030*. The purpose of the initiative was to encourage cooperatives to commit to study more about SDGs, to commit to pledges, and to report on their progress on achieving the 17 goals as set in the 2030 Agenda. Following the launch of this online platform, 80 cooperatives in 31 countries have pledged to support the SDGs.

Systems approach to sustainability

According to the ICA, sustainable development is comprised of environmental sustainability, social inclusion and economic development, and this links to the three pillars of sustainability (social, environmental and economic). The SDGs have been analysed using a systems approach to sustainability that addresses the three interlinked environmental, economic and social systems (see **Figure 2**).

Each goal is identified as primarily contributing in either an environmental, economic or social system, but the same goal may be considered to overlap more than one type of system. For instance, even though quality education has been identified primarily as a social system goal, it could also be considered as an economic system goal. This is due to the importance of schooling as it relates to the formation of human capital, and in the longer-term economic development and prosperity for society. The SDGs are now grouped into three interlinked systems that includes five environmental system goals, seven economic system goals and five social system goals (**Figure 2**).

An alternative sustainability model proposed in one 2010 study suggests a 3Ps framework – People, Profit and Planet – arguing that a positive impact on people and the planet can become 'the best source of profitable growth'.

In 2017, another study found that only a few companies are including SDGs in their reports due to challenges in linking any incentives in the business that might have an influence on the choice to invest in them. A further

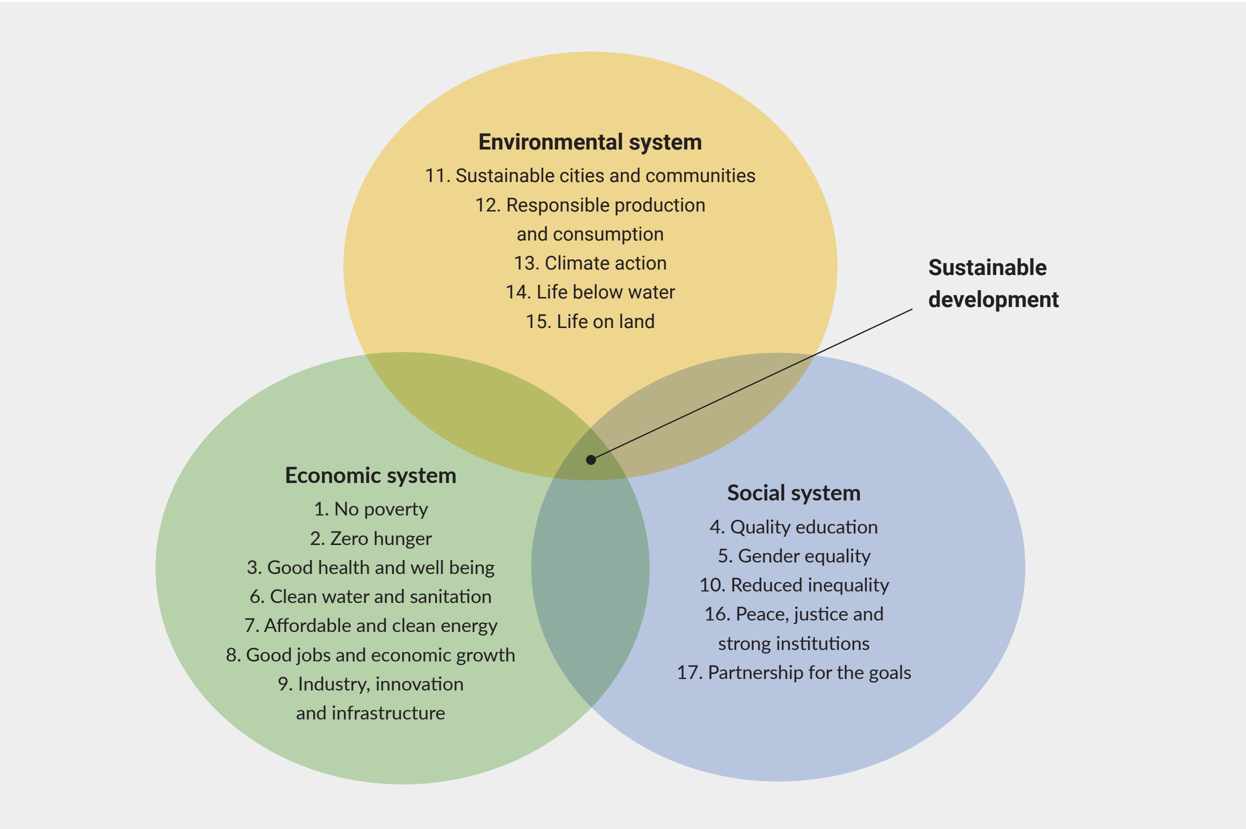

Figure 2: The systems approach to sustainability applied to the 17 SDGs. Source: Barbier, E.B. and Burgress, J.C. 2017. Economics: The Open-Access, Open-Assessment E-Journal, 11

New Zealand agricultural cooperatives generate revenue of more than $31 billion p.a., with profits distributed to around 200,000 members and involving the direct employment of more than 42,000 people.

study in 2019 highlighted that only 16% of the surveyed organisations considered SDGs in their sustainability reports because SDG reporting was related to a:

- larger size organisation
- higher level of an intangible asset
- higher commitment to sustainability frameworks and external assurance
- higher share of female directors and a younger board of directors.

NZ agricultural cooperatives

Craig Presland (former CEO of Cooperative Business NZ) has indicated that the ICA has recognised New Zealand as one of the countries in the world where cooperatives play an essential, far-reaching and significant role in the economy. New Zealand agricultural cooperatives generate revenue of more than $31 billion p.a., with profits distributed to around 200,000 members and involving the direct employment of more than 42,000 people.

However, even though New Zealand operates in one of the most cooperative-driven economies in the world, its contribution to the UN SDGs has yet to be studied. The overall aim of this study is to explore and understand the sustainability practices of agricultural cooperatives in this country and their contribution to engage with and achieve the UN SDGs.

Methodology

The data utilised in this study was provided by the cooperatives and included information from their 2019 annual reports and information from the relevant sustainability reports of the 14 largest agricultural cooperatives (by revenue) in New Zealand. There are only five cooperatives that have linked their sustainability measures to the 17 SDGs, but this study classified the rest of the cooperative's sustainability measures into the related SDGs. In some cases, the data was verified by cooperative representatives.

Findings

Sustainability reporting

This study classified New Zealand largest agricultural cooperatives into three groups based on how they have reported sustainability (**Table 1**). The results of this study revealed that:

- About 23% of the cooperatives published a sustainability report as a separate document (one of them published three reports and the other two have just published, or are in a process of publishing, another report)
- Another two cooperatives are in the early stages of producing their sustainability reports
- About two-thirds (62%) are integrating sustainability into their other published reports, such as their annual report, social responsibility snapshot, roadmap, integrated reports and their websites.

Since this study was completed, another few agricultural cooperatives have produced sustainability reports as a separate document.

Even though each of the agricultural cooperatives that took part in this study has applied sustainability principles to their business, each one is at a different stage of sustainability reporting. The results also suggest that the cooperatives (irrespective of size and sector) have played their part in ensuring that they produce and supply their goods and services in a more environmentally sustainable, as well as in a socially responsible, way. According to an Australian study, about 5% of the local government authorities there currently publish an annual sustainability report.

Response to SDGs

The results of this study showed that New Zealand's largest agricultural cooperatives are responding to all the SDGs except for goal 16, which is peace, justice and strong institutions (**Figure 3**). On the top two goals, the cooperatives prioritised climate action (SDG 13), as well as good health and well-being (SDG 3). The importance accorded to climate action is in line with the New Zealand Government's policy to reduce the impacts of climate change and transition to a low emissions economy.

This includes the Zero Carbon Bill, which aims to provide a framework to implement climate change policies. The Bill sets an ambitious target to reduce all greenhouse gases to net zero by 2050 and is consistent with the Paris Agreement's long-term goal of limiting global warming to 1.5°C above pre-industrial levels.

The recognition of good health and well-being in the New Zealand agricultural cooperatives may be driven by the effectiveness of the Health and Safety at Work Act (HSWA) in 2016. The HSWA sets out the principles, duties and rights for health and safety in the workplace. Most of the cooperatives (85%) reported on decent work and economic growth (SDG 8)

Even though each of the agricultural cooperatives that took part in this study has applied sustainability principles to their business, each one is at a different stage of sustainability reporting.

Table 1: Sustainability reporting of the 14 largest NZ agricultural cooperatives (by revenue) in 2019

Cooperatives	Status of sustainability reporting	Rank in NZ – top 30 by revenue in 2018
Fonterra Cooperative Group	✓✓✓	1
Silver Fern Farms	✓✓✓	5
Dairy Goat Cooperative	✓✓✓	20
Farmlands Trading Society	✓✓	4
Market Gardeners	✓✓	9
Foodstuffs – North Islands	✓	2
Foodstuffs – South Islands	✓	3
Zespri	✓	6
Alliance Group	✓	7
Ballance Agri-Nutrients	✓	10
Ravensdown Fertiliser Cooperative	✓	13
Tatua Cooperative Dairy Company	✓	16
Livestock Improvement Corporation	✓	18
Eastpack	✓	23

Key

✓✓✓ Published sustainability report

✓✓ Early stage of sustainability reports

✓ Integrating sustainability into annual and other published reports

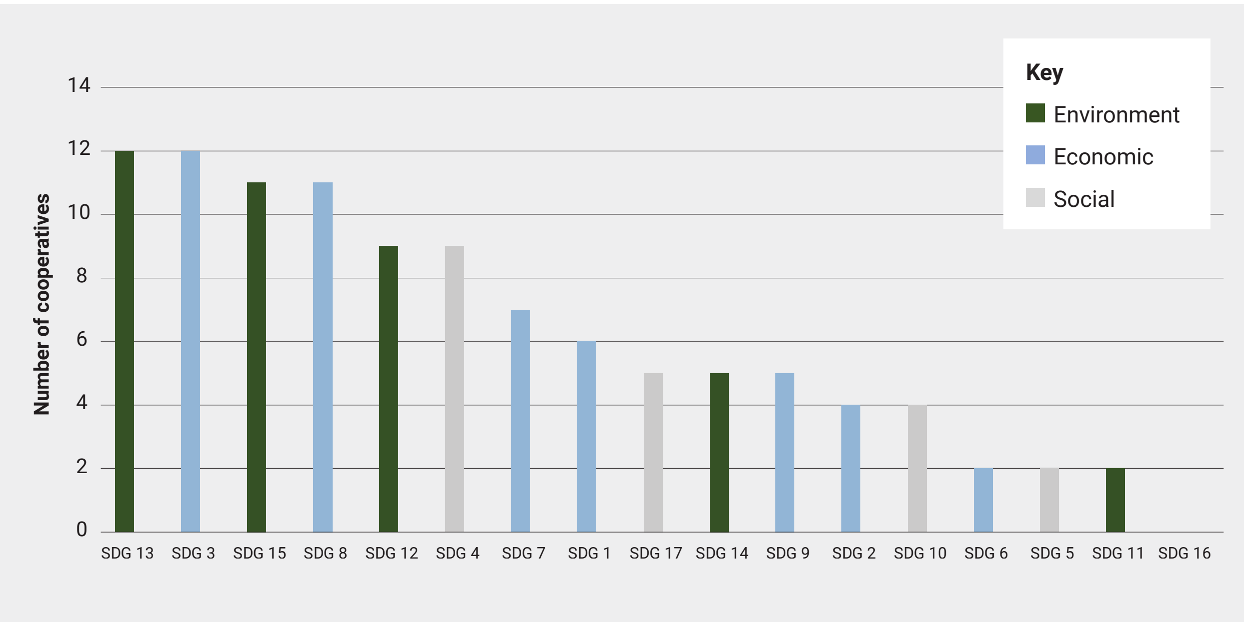

Figure 3: Contribution of the largest NZ agricultural cooperatives to SDGs

and to the goals of life on land (SDG 15). This indicated that the agricultural cooperatives have made a substantial impact on New Zealand's work and economic growth. They provide employment and training opportunities for their members and employees, which enables them to make investments and expand their sources of income. The New Zealand agricultural cooperatives have also invested in and give back to their communities via various community grants.

Also, 69% of the cooperatives that participated in the study responded positively to responsible consumption and production (SDG 12) and quality education (SDG 4). The three goals at the bottom of the list were gender equality (Goal 5), clean water and sanitation (Goal 6), and sustainable cities and community (Goal 11).

Quantifiable measures and reporting

For the three interlinked systems outlined above, cooperatives are committed to looking after the integrated environmental and economic system as their priority (e.g. achieving economic expansion and growth without a decline in environmental and social goals).

The findings of this study also demonstrated that many agricultural cooperatives had quantifiable measures (key performance indicators or KPIs), where they set a target to measure their sustainable development performance, such as global reporting initiative (GRI) and integrated reporting (IR) frameworks.

One 2017 study suggested that GRI was the most widely used of the guidelines for sustainability reporting, and that new sustainability reporting had evolved into IR. Cooperatives also set a timeframe to ensure targets were met at a particular time. The largest agricultural cooperatives in New Zealand also worked together with related stakeholders (e.g. schools and communities in different areas around the country) to help establish and implement some of their sustainability initiatives.

Economic, environmental and social sustainability is at the heart of agricultural cooperatives in New Zealand.

Conclusion

Economic, environmental and social sustainability is at the heart of agricultural cooperatives in New Zealand. This is reflected in their strategies, policies and decision-making, including their actions and practices. They have embraced the SDGs and sustainability and are committed to publishing a stand-alone sustainability report or sustainability sections in their annual report or other reports they produce.

Regarding contributing to SDGs, agricultural cooperatives are responding to 16 of the 17 SDGs, focusing on climate action, good health and well-being, and life on land as key priorities, which is in line with government policy. Further research could be conducted on a greater number of cooperatives in New Zealand, as well as cooperatives from different sectors.

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PHIL JOURNEAUX

RURAL SUPPORT TRUSTS WHAT DO THEY DO?

Rural Support Trusts are now a common feature in the rural landscape, assisting farmers going through tough times. This article outlines the work they do and provides some guidance for rural professionals.

Background

The genesis of Rural Support Trusts (RSTs) was the economic restructuring through the mid-late 1980s, where they were set up in a number of regions to help farmers cope with the stresses of the time. Following the 2007-2008 drought, the Government embarked on an exercise to support the existing RSTs and help set up one in regions where they didn't exist, so that there was a national network across the country.

The key *raison d'être* for the RSTs is to provide support to rural people going through tough times. This is mainly through having someone to talk to who can point the person towards professional advice if needed. This is an important aspect of the RSTs – they are not there to provide advice, but to facilitate the situation and draw in professional advice if required.

The RSTs also play a key role in natural disasters that affect the rural sector, where they are usually the body that oversees government support and work in closely with the Ministry for Primary Industries (MPI) and Civil Defence. For some RSTs this is their main area of operation, while others also operate during 'peacetime' by providing support to rural people.

There are 14 RSTs across the country, with a National Council which acts as a coordinating body. Details on the regional RSTs can be found at www.rural-support.org.nz/ along with information on what they do.

Main areas of focus

Key areas the RSTs operate in are:

Health and well-being

This is possibly the main issue where farmers are under stress for a variety of reasons, including mental health issues. The primary goal is to support people to work through these issues and return to 'normality' as soon as possible.

Financial pressure

Many farmers are working with their advisors, accountants and banks on financial issues, but RSTs are an independent

Many farmers are working with their advisors, accountants and banks on financial issues, but RSTs are an independent entity to discuss these issues with.

entity to discuss these issues with. As part of this, the RSTs are an integral component of the Farm Business Advice Support Fund in conjunction with the trading banks.

Animal welfare

RST facilitators are available to work with and support farmers who may be involved in animal welfare cases.

Employment issues

In the event of a dispute, RST facilitators are trained to provide a supportive environment so both parties can work through the issue.

Adverse events

As noted, this is a key role, where RSTs are involved in providing information to the Government and other agencies on the impact of the event and issues farmers are facing, and directly controlling or coordinating assistance measures provided by the Government (such as Enhanced Taskforce Green, Rural Assistance Payments and community events). This can also extend to biosecurity issues, and many RSTs have been involved in supporting farmers who have been affected by *Mycoplasma bovis*.

Community events

The RSTs also run, or assist in running, various community orientated events such as Good Yarn sessions, Surfing for Farmers, Community BBQs, Go Karting, Quiz Night, Ladies Lunch, plus local meetings on issues (e.g. well-being). A mix of events are run to appeal to different farmers and growers, and are aimed at men, women and families, with the events linked back to the five ways of well-being: Be active, Learn, Take notice, Give, Connect. During the pandemic, a number of online events were also run. Over the last year the Waikato-Hauraki-Coromandel RST engaged with 5,000 people via various events.

Make-up of RSTs

The RSTs are typically made up of a board of trustees, with a number of facilitators who go out to meet with the farmers requesting assistance. For the Waikato-Hauraki-Coromandel RST, of which I am a trustee, we have a board of seven trustees, two women who share the 0800 phone, an administrator and a coordinator, all part-time, and 35 facilitators who are based geographically around the region.

The facilitators are mostly people with a good understanding of farming and rural issues and are trained by the RSTs to handle the myriad of issues they encounter. Their role is not to tell a farmer what to do, but to listen, navigate and, if necessary, advocate and wrap specialist support around the person. In the last year the Waikato-Hauraki-Coromandel RST dealt with 161 active cases.

How it works

The usual approach is for the farmer, or a close family member, to contact the RST via the 0800 phone. The operator takes details of the case and then passes this onto the relevant facilitator, who then in turn contacts the farmer and arranges a visit. Rural professionals can also assist in this area, by contacting the RST if you're aware of a situation that may require its input. Just a note – if you've got a potential case of suicide or self-harm, ring the Police, asap.

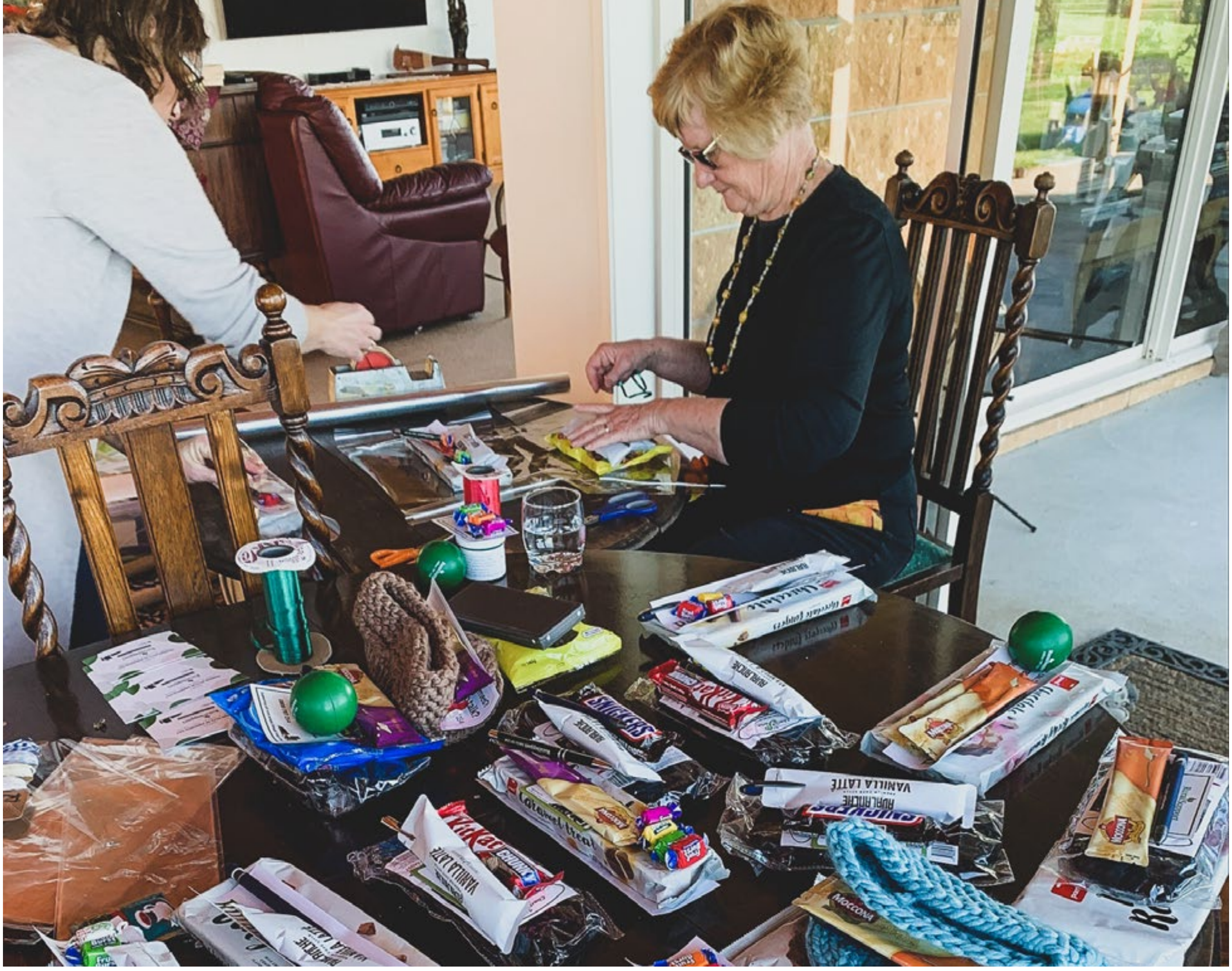
Funding for the various RSTs can vary. The Government via MPI provides a core level of funding to help cover basic overhead and operating costs. For the Waikato-Hauraki-Coromandel RST, this makes up around 17% of our total annual costs. The Government can also provide funding for specific programmes (e.g Wellness) and any input into adverse events is fully funded. For most of the operating costs, however, RSTs rely on donations or fundraising events. For the Waikato-Hauraki-Coromandel RST, around 40-50% of our funding comes via this route, and it must be said that many rural people and firms are very generous in their donations.

Guidance for rural professionals

The RSTs have published a report for rural professionals called *Supporting Farmers in Tough Times*, which is available at https://bit.ly/3KDfq7V

An excerpt from this on helping to identify whether someone is struggling and may require help suggests looking out for signs such as:

- Changes in the farm context (e.g. shed normally clean but cleanliness now an issue, animals now late to shed for AB, paperwork not done to usual standard)
- The farmer is more disconnected or withdrawn, a lack of enjoyment of usual interests
- They reveal a personal life event, such as relationship break-up
- Death of family member or someone in the community either by suicide, accident or natural causes
- Taking more risks (e.g. careless driving, gambling, substance abuse)
- Expressing a sense of sadness, despair, emptiness or hopelessness
- Increased fear, anxiety, anger or irritability, or startling easily



Sorting Random Act of Kindness packages – these are small packages of goodies the RST randomly distributes to farmers to boost morale

If you think someone is having a tough time, don't be afraid to ask if they are, and then ask how they're coping.

- Difficulty remembering, concentrating or following instructions
- Changes in communication ability including, for example, hesitation, silence and broken sentences
- Being unavailable, denying and avoiding.

If you think someone is having a tough time, don't be afraid to ask if they are, and then ask how they're coping. Talking to them about your concerns doesn't mean you need to solve their problems. There is no guarantee someone will open up to you, but letting them know you are there and happy to talk can really help.

Phil Journeaux is the Deputy Chairman of the Waikato-Hauraki-Coromandel RST. Email: phil.journeaux@agfirst.co.nz J

Rural Support

Phone contact

Rural Support Trust – 0800 787 254 (0800 RuralHelp)

Online support and information

- www.rural-support.org.nz – Rural Support Trust
- www.farmstrong.co.nz – Live Well Farm Well – Farmstrong is a nationwide well-being programme for the rural community
- www.depression.org.nz – includes *The Journal*, a free online self-help tool (all services are free and available 24 hours a day, seven days a week, unless otherwise stated)
- www.thelowdown.co.nz – visit the website or free text 5626 (for support for young people experiencing depression or anxiety)
- www.leva.co.nz or www.facebook.com/LeVa Pasifika – information and support from Le Va for Pasifika families on mental health, addiction and suicide prevention
- www.afterasuicide.nz – practical information and guidance for people who have lost someone to suicide
- www.mentalhealth.org.nz – looking after your own mental health and working towards recovery.

LYDIA FARRELL, PETER TOZER & PAUL KENYON

TRANSITIONING TO CROSSBRED MERINO FOR INCREASED PROFITABILITY

In the face of falling prices for coarse wool and increasing shearing costs, producing medium wool (i.e. ≈ 24 µm) through crossbreeding Romney ewes with Merino sires to eventually farm a second-cross ¾Merino ¼Romney flock can improve farm profitability.

Rationale for producing finer wool

Prices for coarse wool (fibre diameter ≥ 30 µm) have decreased over recent decades (**Figure 1**) while shearing costs have recently increased. For many coarse wool farmers, shearing is now considered more important for animal welfare than income generation and they now focus on lamb production. At the same time, prices for medium (fibre diameter ≥ 24 and < 30 µm) and fine (fibre diameter < 24 µm) wool have risen, increasing income for farmers who can produce this type of wool.

Wool from New Zealand's national flock, in which Romney is the major breed, is mostly coarse wool. Only 15% and 8% of the wool produced is categorised as medium and fine, respectively. Merino-Romney crossbreeding studies indicate that within a few generations the average fibre diameter of an initially purebred Romney flock can be reduced through crossbreeding with Merino sires, potentially increasing wool income while retaining the higher lamb production of the established Romney flock.

A successful grading up to a second-cross three-quarter Merino one-quarter Romney (¾M¼R) flock could result in the sheep enterprise increasing wool and total income with minimal losses to lamb income, and thereby increasing farm profitability. Simulation modelling of an East Coast North Island hill country farm was used to estimate changes in sheep enterprise production and profit as the proportion of Merino genetics in the flock increased and wool fibre diameter decreased.

What we did

We modelled an 'average' East Coast hill country farm, based on Beef + Lamb New Zealand quintile data. Grading up to producing higher-value wool aimed to replace the current flock of 2,490 Romney ewes (1,866 breeding ewes and 624 bred hoggets) with an equivalent sized second-cross ¾M¼R flock. It was assumed that the Romney flock consumed 60% of pasture on the farm, with the remainder being consumed by beef cattle. During the grading up to Merino (while ewe numbers and breeds were changing year-to-year), flock annual feed demand was constrained to 55% to 65% of farm feed supply through varying ewe culling rates, so as not to significantly disrupt the beef herd size or operations.

The baseline for the change was the self-replacing Romney flock to establish the sheep numbers, flock feed demand, lamb and wool production, and profit. In year one of grading up, all Romney (36 µm) ewes were bred with Merino rams (21 µm) to produce ½M½R (28.5 µm) lambs (**Figure 2**). The first cross ½M½R ewe lambs retained for breeding were mated to Merino rams to first lamb at two years old, producing ¾M¼R (≈ 24.3 µm) lambs.

The ¾M¼R ewe lambs retained for breeding were mated to ¾M¼R or similar rams to maintain the 'medium' (24 µm) fibre diameter of the mature flock. When the ¾M¼R flock reached the same annual flock feed demand as the baseline Romney flock, the ¾M¼R flock was assumed to have reached a stable size.

Merino-Romney crossbred ewe lambs were selected at two time-points each year during grading up – weaning and post-wool testing (at around 10 months of age). Selection intensity was 65% of ewe lambs retained at each of the two time-points. This resulted in 43% of total weaned ewe lambs retained each year of grading up for subsequent breeding.

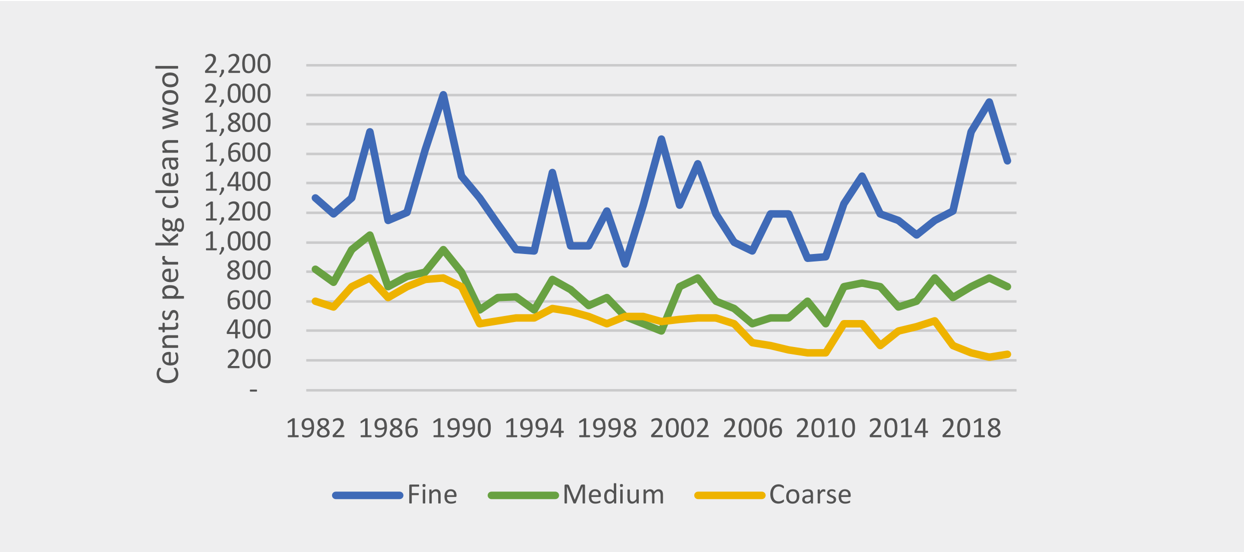


Figure 1: Wool prices over time. Adapted from Beef + Lamb New Zealand Economic Service

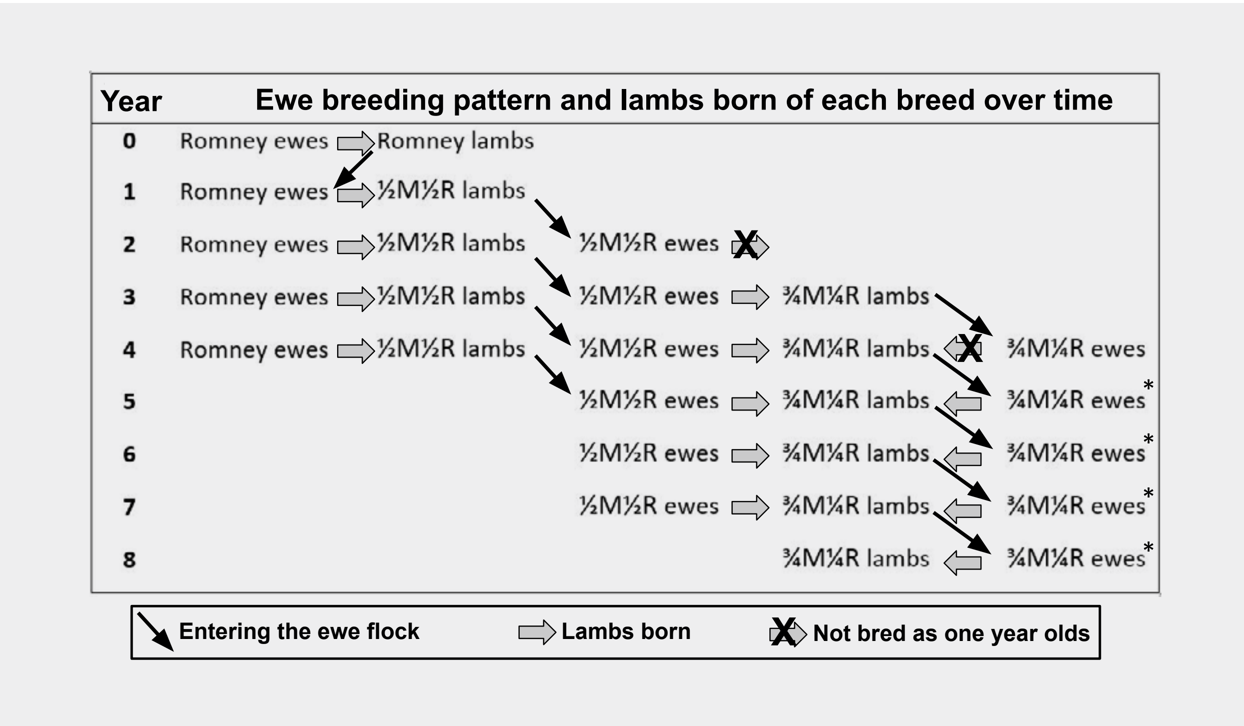


Figure 2: Changes in sheep breeds on-farm for grading up to Merino based on doi.org/10.1016/j.smallrumres.2020.106236
*** Indicates use of ¾M¼R rams, with all other rams used for breeding being purebred Merino**

For many coarse wool farmers, shearing is now considered more important for animal welfare than income generation and they now focus on lamb production.

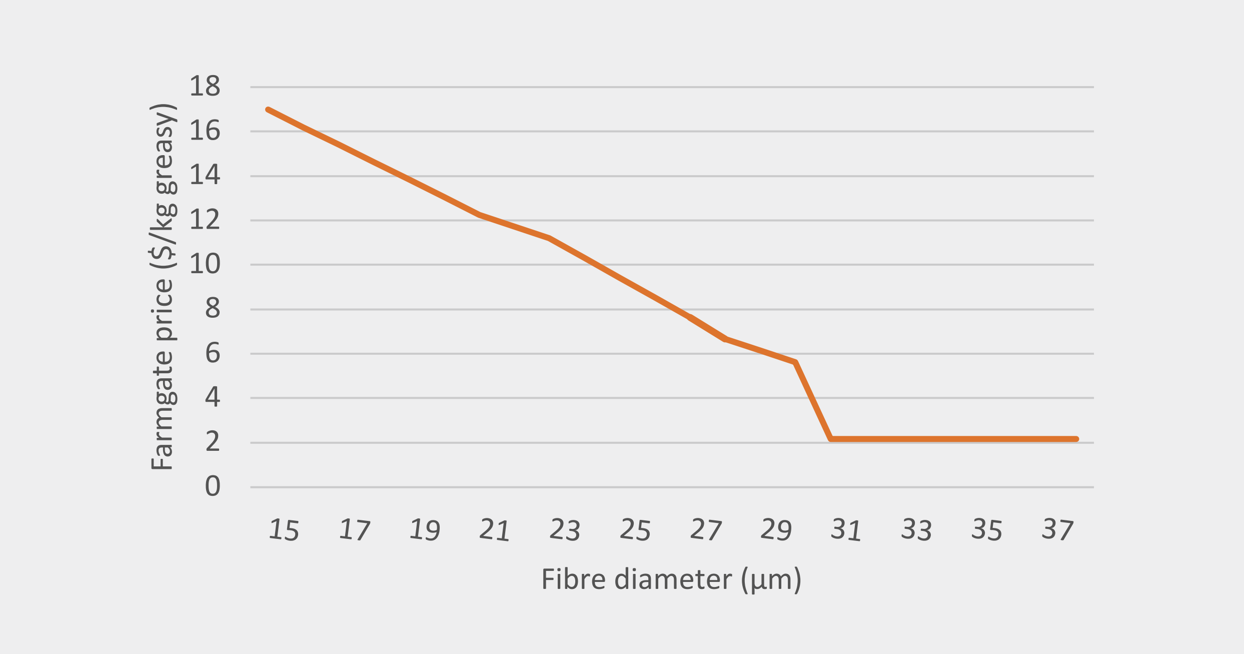


Figure 3: Farmgate prices from 2017/18 for greasy wool of varying fibre diameter. Adapted from doi.org/10.3390/agriculture11100920. Values obtained through collation of data from The New Zealand Merino Company and Carrfields Primary Wool

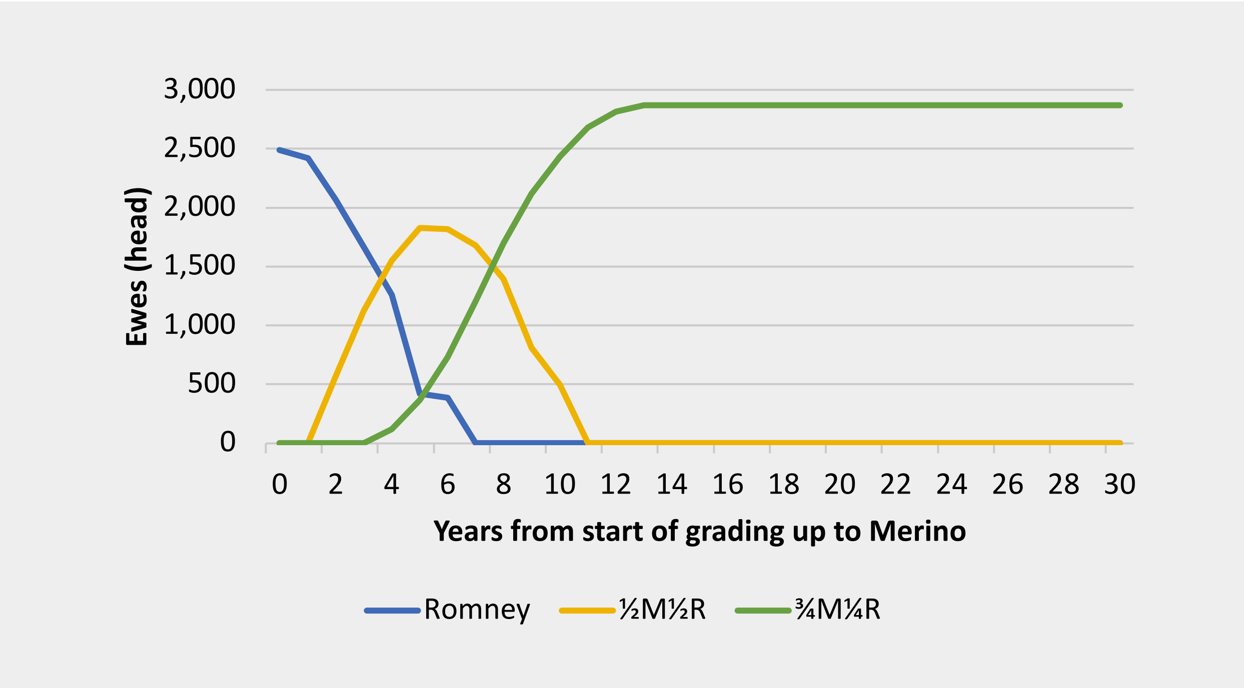


Figure 4: Ewe numbers for the baseline Romney flock in year zero, then ewe numbers for all breeds during grading up to Merino. The ¾M¼R flock had the same feed demand in year 13 as the baseline Romney flock and was henceforth modelled as a self-replacing flock. Adapted from doi.org/10.3390/agriculture11100920

It was assumed only the 65% of ewe lambs with the finest wool after wool testing would be retained, therefore reducing the average fibre diameter of ewe lambs post-selection. However, wool fibre diameter also increased as ewes aged in the flock, so flock average fibre diameter was determined by both ewe lamb selection intensity and flock age structure.

Lambing performance of Merino crossbred flocks farmed in the North Island is uncertain, but research has shown that it decreases with higher proportions of Merino genetics. The analysis was undertaken with weaning rates of 132%, 120% and 114% assumed for Romney, ½M½R, and ¾M¼R crossbred ewes, respectively. All production parameters were varied according to breed, including ewe liveweight, fleece weight and lamb weights. For example, weaning weights of single-born lambs were 28 kg, 25 kg and 24 kg for pure Romney, ½M½R and ¾M¼R lambs, respectively.

Market values from 2017/18 were used to estimate sheep enterprise cash operating surplus (COS), including lamb (carcass weight of 18 kg) and cull ewe prices, wool prices for varying fibre diameter (**Figure 3**), and costs (variable costs for the sheep enterprise and the allocatable fixed costs). Beef enterprise COS was assumed to be a fixed value per hectare, added to the sheep enterprise COS based on the proportion of the 530 ha farm matching the proportion of feed eaten (ranging from 55% to 65% of feed for sheep).

Net present values (NPVs) were also estimated, with discount rates of 6% or 10%. To explore the effects of varying lamb and wool prices, several scenarios were tested where lamb and wool prices were varied by plus or minus 10% of the 2017/18 base values.

Table 1: Sales, income and COS (cash operating surplus) values for the baseline Romney flock and the stable, post-grading up ¾Merino¼Romney flock

	Romney flock	Stable ¾M¼R flock
Wool sales (kg)	15,252	10,811
Wool price ($/kg greasy)	2.15	10.31
Wool income ($000)	33	111
Lamb sales (head)	2,316	1,779
Lamb price ($/head)	102	110
Lamb income ($000)	236	196
Cull ewe sales (head)	412	489
Cull ewe price ($/head)	114	98
Cull ewe income ($000)	38	57
Total income ($000)	308	364
Total expenses ($000)	184	200
COS ($/ha)	390	516

What we found

Once grading up to Merino was complete, there were 2,871 ¾M¼R sheep (including 2,189 breeding ewes and 682 unbred hoggets) in the flock with an average wool fibre diameter of 24 µm, which was 421 more ewes than in the base Romney flock (this included 1,866 breeding ewes and 624 bred hoggets). The Merino-cross replacements were not mated because they did not reach a suitable live weight by mating.

The difference in flock size is due to the Merino-cross ewes being slightly smaller, with lower lamb production than the pure Romney ewes, and because 75% of the Romney replacements produced a lamb whereas the Merino-cross replacements did not. The changes in flock structure are shown in **Figure 4**, and both the baseline Romney flock and the stable ¾M¼R flock had annual replacement rates of 25%.

The baseline Romney flock weaned 2,930 lambs from 1,866 breeding ewes and 624 bred hoggets with weaning rates of 132% and 75%, respectively. The baseline Romney flock sold 15,252 kg of greasy wool and 2,316 lambs annually, with an annual COS of $390/ha (**Table 1**). The stable ¾M¼R flock weaned 2,495 lambs (with a weaning rate of 114% from the 2,189 breeding ewes and without breeding hoggets due to their low weights) and sold 10,811 kg of greasy wool and 1,779 lambs annually with an annual COS of $516/ha, 32% higher than the COS of the Romney flock. Lambs of all breeds had target carcass weights of 18 kg and ¾M¼R lambs were sold later in the year for higher per head values due to their lower growth rate.

Lamb numbers were lower for the Merino-cross enterprise as the reproduction rate of the ¾M¼R ewes was 114% compared to 132% for the purebred Romney ewes, so lamb revenue was lower. However, even though wool production was 4,441 kg lower in the Merino-cross case, the wool price differential more than made up for the lower volume and wool revenue was significantly higher for the Merino-cross ewe flock.

With the variations in ewe numbers and breeds during grading up, there were fluctuations in COS (**Figure 5**). From the baseline Romney sheep enterprise COS of $390/ha in year zero, COS of less than $300/ha was predicted in years two and five of grading up when there were high proportions of young, unproductive stock on-farm, which may challenge farm debt servicing and may require deferred capital investment in those years.

However, during grading up, most years had predicted COS greater than the baseline Romney level. The age structure of the ewe flocks affected flock lamb and wool production, feed demand (informing stock units and expenses) and also wool fibre diameter. Therefore, COS continued to fluctuate until the ¾M¼R reached a stable age structure.

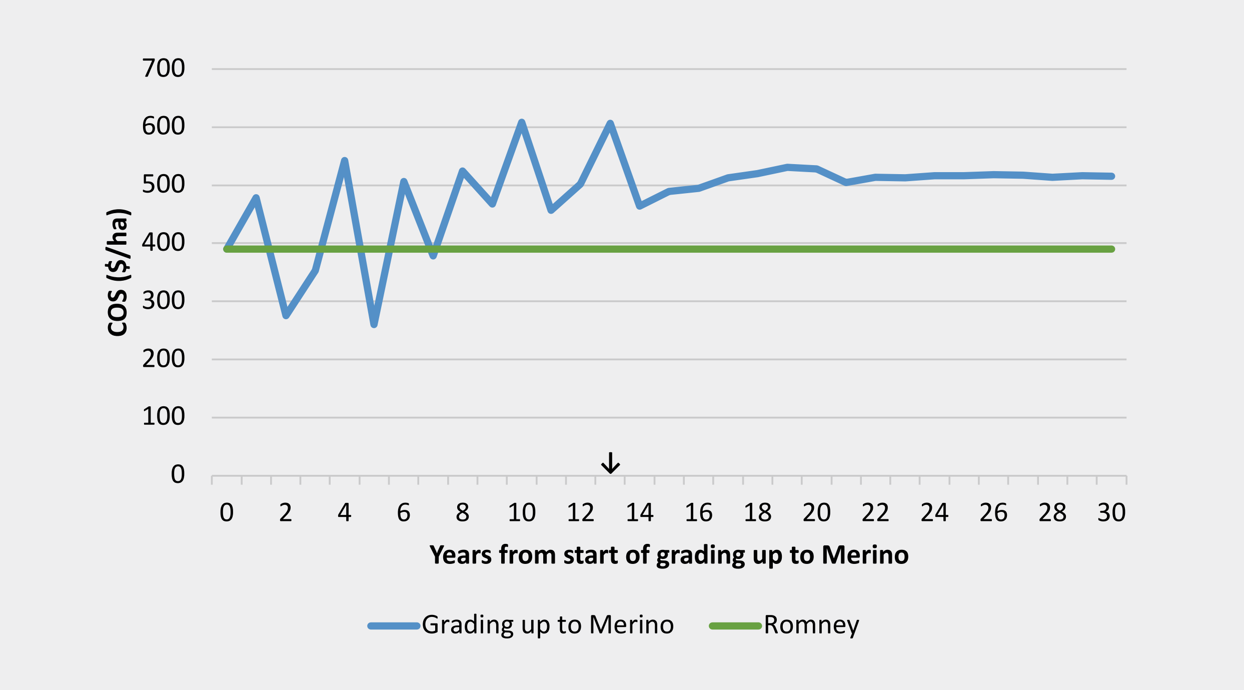


Figure 5: Sheep enterprise cash operating surplus (COS) during the grading up to Merino and after the ¾M¼R flock reached desired size in year 13. The COS of the baseline Romney flock is also shown. Adapted from doi.org/10.3390/agriculture11100920

NPV analyses

The NPVs for grading up were always higher than for maintaining the Romney flock, with the same sheep and wool prices, discount rates and analysis periods (**Table 2**), overall showing grading up to Merino to be a profitable option. With base prices for sheep and wool sales, the NPVs for grading up were 8.38% to 12.86% higher than for the Romney flock.

The biggest difference in NPV was observed with reduced sheep prices and increased wool prices, where the Merino-cross NPV was up to 17.97% higher than the NPV of maintaining the Romney flock. Conversely, with lower wool prices and higher sheep prices the Merino-cross NPV was only 3.18% higher than for the Romney flock. This demonstrates that grading up to Merino will be more profitable compared with maintaining the Romney flock when wool prices are higher due to the proportion of income accounted for by wool for the ¾M¼R flock. Conversely, with higher sheep prices, the Merino option is less advantageous due to the lower lamb production of Merino-Romney crossbred flocks.

Further considerations

Although there is increasing interest from North Island coarse wool producers to breed for wool with a lower fibre diameter, the specific management requirements of Merinos (such as grazing style, potential health issues like footrot and facial eczema, and retention of lambs over winter) likely needs further investigation. Potential production losses (specifically lambing rate, lamb growth rates and carcass conformation) also create uncertainty and producer concerns.

With higher sheep prices and lower wool prices, the small difference in NPV (**Table 2**) may make grading up to Merino-cross less appealing when the risk of greater health issues of Merino-Romney crossbred animals is considered.

For farmers looking to achieve higher-value wool than was modelled in this study, Merino rams with wool of fibre diameter < 21 µm could be used or the grading up period could be extended through applying higher selection pressure to Merino-Romney crossbred ewe lamb fibre diameter and taking longer to build up numbers of ¾M¼R ewes. Another option is to only breed part of the Romney flock with Merino sires, maintaining a flock of coarse wool-producing ewes with higher lamb production and likely easier management.

An alternative option for farmers looking to take advantage of medium wool prices is to use Merino rams as terminal sires across Romney or similar coarse wool producing flocks. The Merino-Romney crossbred offspring can remain on-farm over winter to shear before slaughter in spring with lamb carcass premiums. Alternatively, the terminal Merino-Romney crossbred offspring could be grazed off-farm or sold store for a premium after weaning to mitigate the effect of increased feed requirements incurred over winter.

Farmers looking for different options in the face of rising shearing costs could also consider grading up to a self-shedding flock using Wiltshire rams, with similar simulation analysis to that conducted for this study having previously been published and an experimental flock currently being trialled at Massey University.

With higher sheep prices, the Merino option is less advantageous due to the lower lamb production of Merino-Romney crossbred flocks.

Conclusions

Grading up from a Romney to ¾M¼R flock to produce higher-value wool was predicted to always have a higher NPV than maintaining the Romney flock. Although annual COS was lower than the baseline level during three years of the 13-year grading up period, COS was mostly higher than the baseline level and eventually was 32% higher for the stable ¾M¼R flock.

Farmers considering a similar grading up process need to focus on maintaining lambing performance in the Merino-Romney flocks, choice of Merino rams and selection intensity to apply to the fibre diameter of Merino-Romney ewe lambs. However, there remain uncertainties about the productivity, management and health issues of Merino-Romney flocks farmed in the North Island.

Acknowledgements

This analysis was part of the Wool Unleashed Primary Growth Partnership Programme, jointly funded by the Ministry for Primary Industries, the New Zealand Merino Company and Callaghan Innovation. This article is adapted from papers previously published in two peer-reviewed journals – *Small Ruminant Research*, 192 (doi.org/10.1016/j.smallrumres.2020.106236) and *Agriculture*, 11 (doi.org/10.3390/agriculture11100920) – where further details can be found.

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Table 2: NPV analyses ($) with base 2017/18 sheep and wool prices or varied by ± 10% for the self-replacing Romney flock or grading up to Merino, discount rate of 6% or 10%, and analysis of 30 years until the ¾M¼R flock reached a stable age structure (the ¾M¼R flock reached stable numbers after 13 years). Adapted from doi.org/10.3390/agriculture11100920

Sheep prices	Wool prices	Scenario	6% discount rate	10% discount rate
Base	Base	Romney Grading up to ¾M¼R	3,085,167 3,481,919	2,178,743 2,412,304
+ 10%	Base	Romney Grading up to ¾M¼R	3,486,771 3,872,059	2,462,355 2,690,615
- 10%	Base	Romney Grading up to ¾M¼R	2,683,564 3,091,734	1,895,131 2,134,107
Base	+ 10%	Romney Grading up to ¾M¼R	3,133,714 3,613,486	2,213,027 2,498,065
Base	- 10%	Romney Grading up to ¾M¼R	3,036,620 3,350,303	2,144,459 2,326,524
+ 10%	+ 10%	Romney Grading up to ¾M¼R	3,535,317 4,003,747	2,496,639 2,771,769
- 10%	- 10%	Romney Grading up to ¾M¼R	2,635,017 2,960,178	1,860,847 2,048,420
- 10%	+ 10%	Romney Grading up to ¾M¼R	2,732,111 3,223,071	1,929,415 2,219,792
+ 10%	- 10%	Romney Grading up to ¾M¼R	3,438,224 3,665,834	2,428,072 2,551,418

RYAN LUCKMAN

ADOPTION OF COW COLLAR TECHNOLOGY

This article by veterinarian Ryan Luckman examines the opportunities that cow collar technology offers, as well as providing a real-world example of how the data can be integrated into farming practice.

Evolution in technology

When I first graduated as a vet pregnancy testing was often done by hand, and even when scanners were used it was rare to age the foetus to estimate calving date. There was a slow evolution as we first identified late calvers, and then ultimately aged the whole herd. The adoption was a slow creep as people understood that the data could be used to better allocate winter feed, manage calving groups easier and analyse reproductive performance.

We are now verging on the edge of a similar evolution in the dairy industry with the adoption of cow collar technology. Much like the early adoption of pregnancy scanning, early users were sold on the easy wins. With pregnancy testing these were pregnant/empty. With collars these are typically heat detection and early detection of sick cows.

On some farms, especially where heat detection was a major limiting factor to the farm's reproductive performance, we have seen huge initial gains. However, many have bobbed up and down under the effects of seasonal weather conditions following these initial wins. As an industry, we now need to take the next step in harnessing the data from these systems to make better real-time and retrospective decisions.

Role of farm consultants

Most of these systems are set up to accommodate year-round calving in a barn with Total Mixed Rations (TMR) inputs. The barn life suits collar technology perfectly – triggers are generally set up to identify deviations from a normal activity or rumination behaviour. When your life consists of the exact same diet and walk every day there are very few deviations without a cow being on heat or sick.

They are then introduced to the New Zealand pastoral system where the distance walked can change on a twice daily basis. Feeding is anything but uniform, with seasonal changes in the amount of grass being fed, entry covers and quality. Cows calve down in a seasonal window and are then

expected to get pregnant again within a short time period, with no ability to allow stand down periods for late calvers.

Understanding what is normal within the regions, systems and farms that you advise is one of the first critical steps. One of the things we have noted in our interactions with farms around the country is that farm consultants typically feel most comfortable interacting from the space of being the 'expert' in the subject – and I include vets in this generalisation. They typically try to advise based on the best science, which is to be applauded. However, with collar data there is no validated blueprint for what we can get out of it, and we have noted a hesitancy by some to get involved because of this knowledge gap.

Taking the plunge and getting involved with farmers is the key first step. Farmers are usually dipping their toes in alongside you, so this can be a highly collaborative learning experience. The biggest asset farm consultants can bring to the table is that they are usually able to see data across multiple farms, so should be able to get a better handle on what 'normal' is.

Making a difference in real-time

One of the key opportunities posed by collar technology is the ability to monitor and intervene live and before it is too late. Instead of getting to the end of mating and finding out that things went poorly, the target should be building in effective monitoring and intervention steps throughout the season to prevent the ship from crashing in the first place.

However, to build real-time interventions we generally require retrospective data analysis first to identify what the key monitoring steps are. This analysis often requires two key skills/attributes:

- **Hypothesis generation**
  Hypotheses are often built from the scientific and anecdotal experiences we have had with our own clients. What parts of a system appear to be contributing to good performance? Conversely, what is contributing to farms that are struggling? A good thing about having collar data is that often, with the right data extraction, we can stress test these theories and explore whether they hold weight. While this will not be as good as true randomised controlled trials, it allows us to take a step above the anecdotal/experiential advice that we often give at a farm level. In general, this hypothesis generation step is a natural part of consultancy.

- **Data analysis skills**
  To be truly effective in testing these hypotheses a degree of knowledge and skill with data analysis will give a big advantage. What data is required to test the hypothesis? Is there a way to extract the data? Once extracted how can you display it to look for trends or patterns? Can we put some statistical significance around these outcomes to increase the validity? Do you know if you are unable to make a conclusion because of a wrong question, wrong data or an incorrect analysis? In my experience there appear to be fewer people equipped with these skills in the agricultural consultancy world, and it is likely that there will be a niche for those who put effort into upskilling and capturing this market.

Once a valid hypothesis is identified we need to work out:

- Can it can be monitored in real-time?
- Can you create or validate targets for the monitoring?
- What are the potential intervention steps for farms that fail to reach the target thresholds?

An example is set out below of an application of real-time on-farm monitoring around the post-calving period that our practice has developed using the above steps.

Transition cow monitoring post-calving

- **Hypothesis generation**
  Our practice has invited Sue Mackey (a veterinary nutritionist) to talk to our farmers for the last two years, and one of her areas of expertise is the post-calving period. Based on her experience and extensive nutritional knowledge she advocates the use of a once-a-day (OAD) milking regime in cows for up to 14 days post-calving. We have had several farms try this and anecdotally they have shown increased in-calf rates after adopting the practice.

  Our hypothesis, in a broad sense, was asking the question around whether milking cows OAD in the colostrum period made any measurable changes, and then if it did, whether this had any effect on in-calf rates.

- **Data analysis**
  Using the collars, the key piece of information we were able to see was the rumination recovery rate. For this analysis, we used Allflex Heatime 2 systems as they allowed bulk data exports for external analysis. When we looked at all our farms, we were able to find collar farms with extended OAD periods (14 days plus) vs short OAD periods (two to five days only) vs the traditional twice-a-day (TAD) systems. Across all farms it appeared that rumination rates held steady across all farms by the day 30-40 mark. **Figure 1** shows the time taken to get up to the stable day 30-40 rumination rate post-calving across the three different colostrum management systems.

What was clear was that cows on OAD milking had much higher rumination rates in the immediate post-calving period than those on TAD. **Figure 1** shows that the blue cows (milked TAD) took about a week longer than the grey cows (milked OAD) to reach 90% of the stabilised rumination rates.

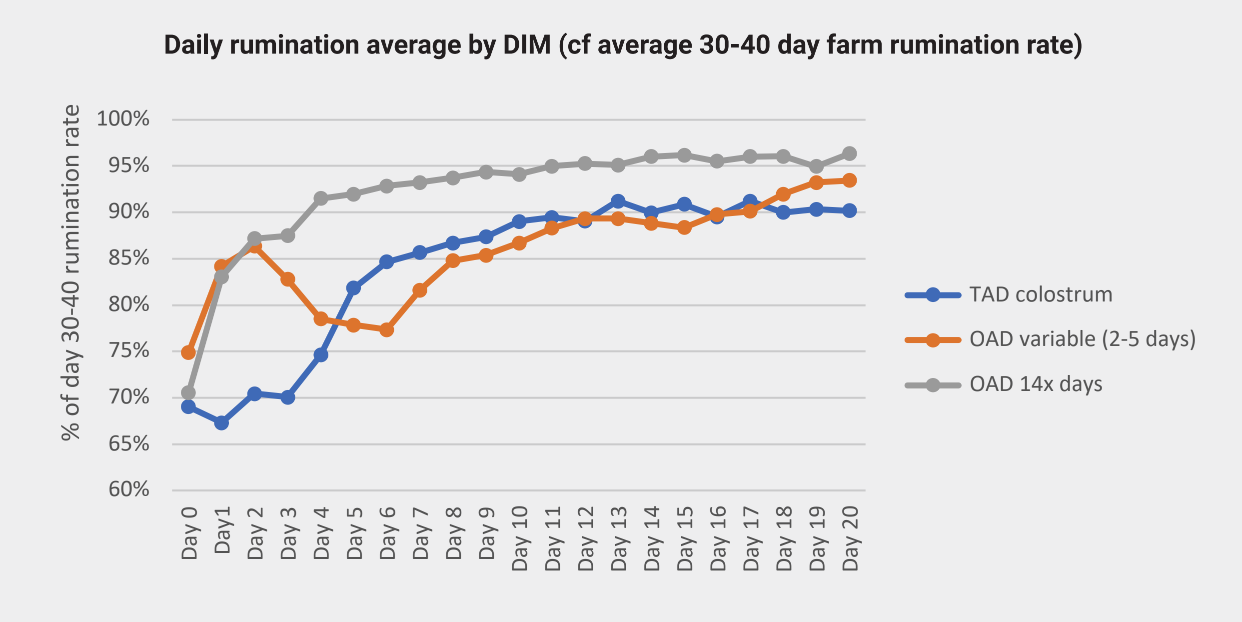

Figure 1: Daily rumination recovery rates in the post-calving period with three different management strategies

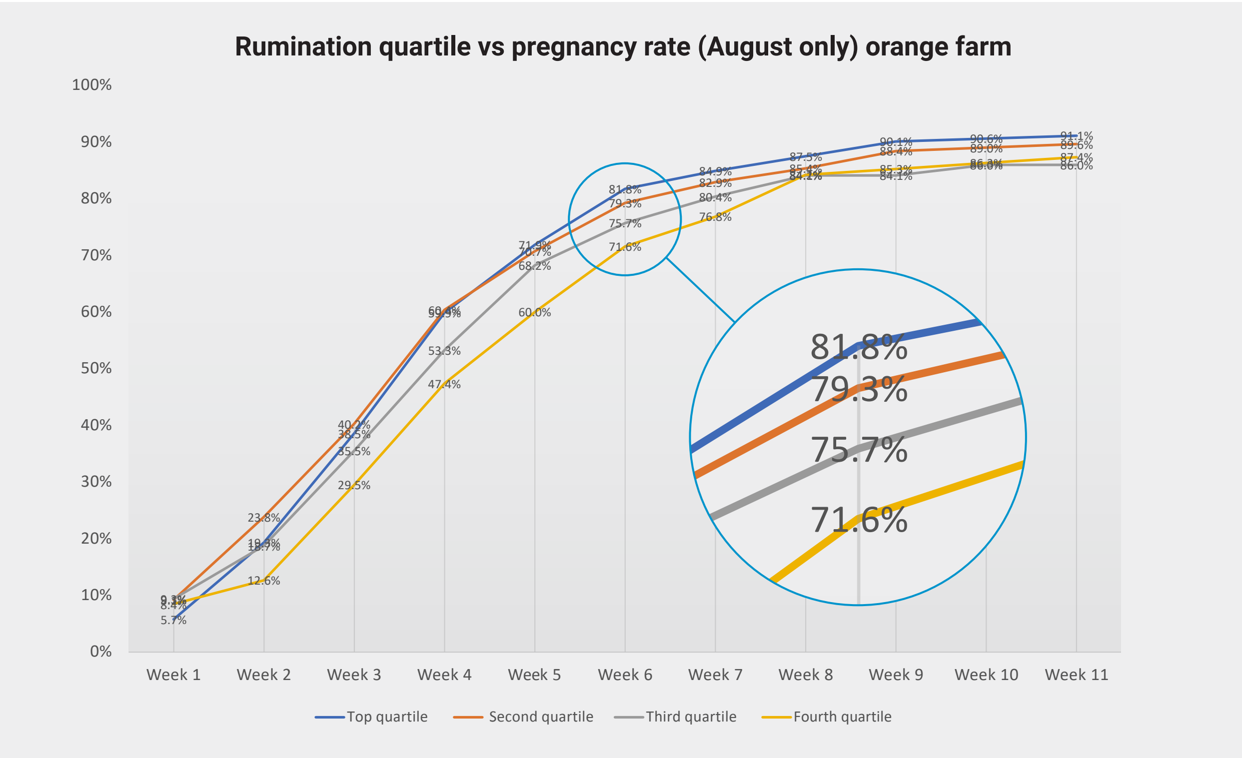

Figure 2: Pregnancy rate of OAD variable farm (August calvers only) broken down by rumination quartiles

On the orange farm we were further able to assess the effect of lower rumination rates on in-calf rates. This farm started milking cows on OAD, but then returned them to a TAD herd at variable times between two to five days post-calving. This created a high amount of variation with rumination recovery on the farm, which was system-based, rather than natural individual cow variation. When we ranked these cows on total minutes of rumination during transition (into quartiles), we found a 10% difference in the 6WICR between the highest 25% and lowest 25%.

Can the hypothesis be monitored in real-time?

In our hypothesis, we found a metric (the speed of transition recovery rate) that may positively influence the farm outcomes. We then met with the Allflex crew to design a live report to essentially recreate the retrospective data in **Figure 2** in real-time.

Figure 3 is a screenshot of the report we have set up for our collar farms this season. It breaks down the cows into groups based on days calved (from 0 to 20 days), giving the average daily rumination of that group, as well as the three-day change.

Days in Lactation ▲

Cow Number	Group	Lactation Number	Daily Rumination ▲ 1	Rumination Peak	3 Day Total Rumination...	Ac
⊕ Days in Lactation: 1						
16			293.56		-204.13	
⊕ Days in Lactation: 2						
22			424.18		-115.18	
⊕ Days in Lactation: 3						
22			445.86		25.05	
⊕ Days in Lactation: 4						
24			461.29		140.22	
⊕ Days in Lactation: 5						
13			473.77		182.67	
⊕ Days in Lactation: 6						
22			507.41		145.71	
⊕ Days in Lactation: 7						
12			494.25		98.50	
⊕ Days in Lactation: 8						
20			490.55		113.43	
⊕ Days in Lactation: [illegible]						
412			469.69		11.66	

Figure 3: Rumination transition (live) report built into the Allflex Heatime 2 system

Can you create or validate targets for the monitoring?

At the start of the season we estimated target recovery lines based on the OAD farm in **Figure 4**. We have now been able to benchmark data from across all our collar farms in the practice to validate what the top and bottom quartile of farmers are achieving in their transition recovery.

The second question in this target validation is whether this rumination recovery actually makes a difference. That is, did the findings from our original data (around improved reproductive performance) really play out with a larger data set?

To assess this, we benchmarked pre-mate cycling rates across our collar farms, especially comparing farms using OAD and TAD colostrum management. **Figure 5** compares the percentage of August calvers (early calvers in our practice) that had had a pre-mate heat two weeks out from mating. While the figure does not specifically link transition outcome with cycling rate (it just assumes that OAD herds likely had a better transition), overall it certainly appeared to be a valid assumption.

Potential intervention steps for farms that fail to reach the target thresholds

Using a real-time report to monitor the transition zone was useful as it is very responsive. Any changes that were made to the system would usually show up on the report the following day, which enabled both farmers (and our practice) to experiment with interventions. Also, for our non-collar farms the recommendations and findings were typically universally applicable.

Examples of some issues that were rectified on farms that failed to reach the target thresholds included:

- Keeping cows in the yard post-calving (rather than using a drop-in paddock)
- Leaving cows in the paddock with the calves on them for 24 hours (creating bonding)
- Inadequate lime-flour dusting
- Tight breaks overnight – there is no ability to make up for a tight break and whenever feeding is restricted it shows up with low rumination rates
- Targeting low residuals in the colostrum mob (driving inadequate DM intake)
- Very high entry covers, especially with poor quality grass (this was best diverted to other non-critical mobs)
- Inadequate feed offered, mainly due to not increasing feed as more cows are introduced.

Into the future

There are endless opportunities, as outlined above, to develop and investigate hypotheses to utilise collar data to improve our farming systems. A similar, but slightly wider opportunity, comes with combining data sources to increase the power of what can be questioned and examined. This year we developed a retrospective graph that combined rumination data, eating time, milk protein %, milk production and milk urea, alongside conception rates broken down by week of mating. The combination of these data sources gave a much clearer picture of what had been happening feeding-wise over the mating period than any individual piece of information could provide.

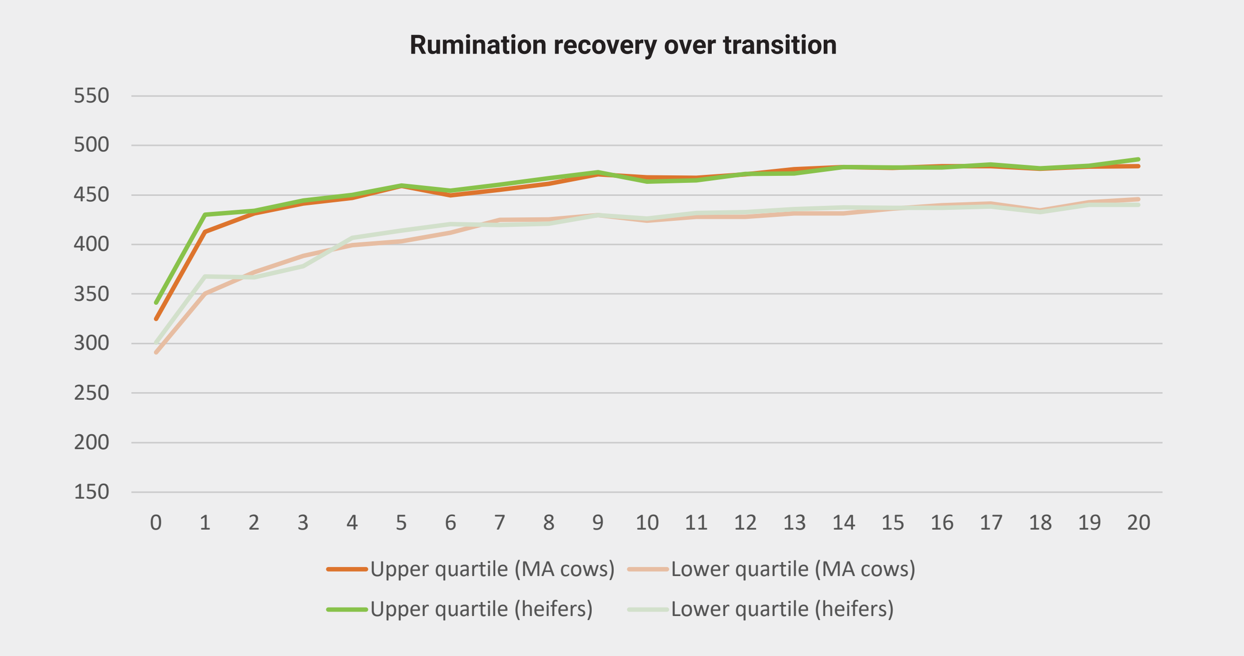

Figure 4: Benchmarked transition recovery data (practice-wide)

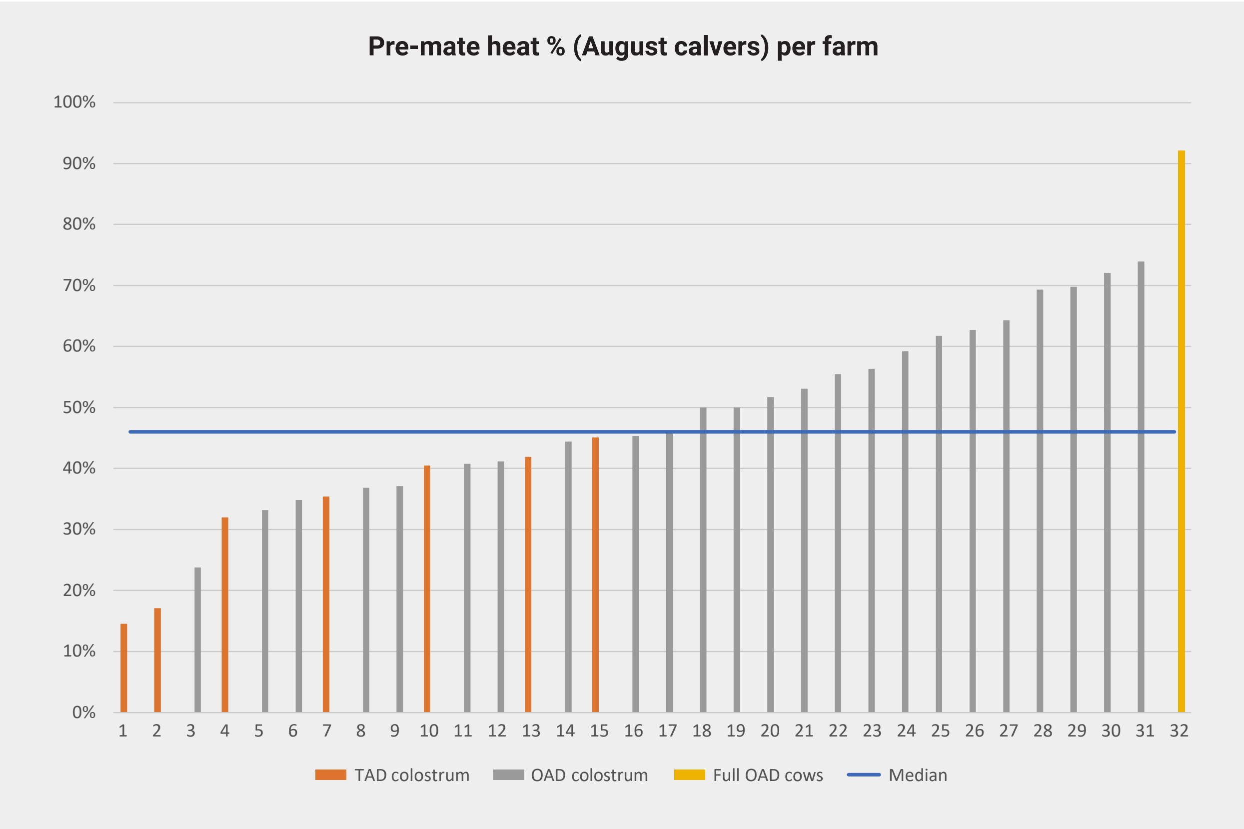

Figure 5: Benchmarked pre-mate heat data for August calvers (practice-wide)

As technologies develop we can combine things like SPACE farm walks with GPS precision feed allocation data, NIR instant feed analysis, production metrics and collar data to have knowledge of what we are feeding that more aligns with that of the TMR systems widely used in the northern hemisphere,

We are currently in the infancy stage of how we interact with collars and collar data. The time to jump in and get involved is now. In 10 years' time it is likely that you won't be asking if a farm has collars, but more enquiring as to which brand.

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DERRICK MOOT

BALANCING PASTURE PRODUCTION AND RESILIENCE REQUIRES AN UNDERSTANDING OF GRAZING PRINCIPLES

This article reviews the impacts of grazing management, water and nitrogen stress on plants as the basic understanding required for successful pasture management.

Basic principles of pasture management

Solar panels are a hot topic at the moment, with their ability to provide renewable energy at the forefront of modern thinking. For New Zealanders, renewable solar panels have been the mainstay of our economic prosperity, national identity and production systems for over 100 years. They are so ingrained in our farming practices that we seldom give them a second thought – until they stop working. I am, of course, referring to the green leaves that capture the sun's energy and conveniently, through photosynthesis, convert it into sugar (dry matter) on a daily basis for us to graze livestock on for milk and meat production systems.

Grazing management underpins our pastoral system, and we like to believe we are world-leading at doing it. However, disappointment about pasture persistence and productivity has become a familiar complaint from farmers in recent years. It is therefore timely to revisit some basic principles of grazing management. These issues were at the forefront of a special New Zealand Grasslands Association 'Resilient Pastures Symposium' held in 2021.

Plant response

Plants respond in predictable ways to the environment in which they grow. To summarise:

- If plants are short of carbon they grow leaves
- If plants are short of nitrogen (N) or water they grow roots.

Best management practices must take account of these facts if pastures are to be productive and persistent. In its simplest from dry matter (carbon) yield comes from the product of the amount of photosynthetically active solar radiation available (PARo), the fraction of that which is intercepted by the solar panel of green leaves (PARi) and the efficiency (RUE) with which it is converted to dry matter (**Equation 1**).

Equation 1:

$$\text{Yield} = PAR_o \times (PAR_i / PAR_o) \times RUE$$

In practice, PAR_o is set by location (day length and light intensity) and RUE is consistent amongst similar species. It is higher for plants that produce mainly sugars (e.g. fodder beet) compared with those that produce a higher proportion of more complex products like proteins (legumes) or oils (canola). Therefore, differences in the yield of a pasture or crop are mainly caused by how much light the canopy of leaves can intercept.

To fully capture all of the available radiation, a pasture canopy needs at least 3 m² of green leaf per m² of ground area (leaf area index (LAI) >3.0). On a daily basis, the total amount of assimilate supplied by the canopy is then allocated to leaves, stems and roots. Grazing management affects both the supply and allocation of assimilates, so it is the major determinant of pasture production and persistence.

Recovery of plants after grazing

For plants like perennial ryegrass, best grazing management practice has been well defined based on the recovery of plants after grazing. Specifically, when the canopy of green leaves is defoliated then the plant is short of carbon. Its solar panels have been removed and the priority is to restore the green leaf area to capture more carbon, which is done through the remobilisation of water soluble carbohydrates (sugars) from roots and leaf sheaths to regrow green leaves. To capture all of the radiation available and restore the reserves to the roots and shoots each tiller needs time to produce three green leaves.

If defoliation occurs before the reserves have been fully restored, then the plant will once again deplete root and sheath reserves to re-establish the canopy of green leaves (it is responding to being short of carbon). Continuous early defoliation of the canopy inevitably leads to a shallower root system. These plants are therefore exploring less and less of the soil so have reduced access to water and N.

The consequences of early defoliation are compounded during periods of water and/or nitrogen limitation. For example, when a period of dry weather occurs on a dairy farm the plant immediately reduces its leaf area and allocates a greater proportion of available assimilates to root growth. This reduced leaf area results in lower pasture growth rates and thus less feed is available to meet animal demand.

N fertiliser and the provision of supplementary feed can slow down the grazing rotation. The aim of using them is to increase post-grazing residual cover and ensure the ryegrass plants have fully recovered three green leaves before defoliation (**Figure 1**). In practice, grazing rotations are often shortened, residuals lowered and plants grazed early at the 2–2.5 leaf stage, particularly in regions where the availability of supplements is minimal.

Use of browntop and other species

The impact of continuous early grazing is most detrimental to perennial ryegrass, which has lower levels of carbon reserves than tall fescue. Cocksfoot is the most resilient of our commonly sown grass species, but the most adapted species to intensive defoliation is browntop. Therefore, it is not surprising that browntop and similar species (e.g. creeping bentgrass) are commonly used for urban lawns and on golf courses, where defoliation is both frequent and to low residuals (see first photo).

The ability of browntop to initiate minimal leaf, but produce a carpet of storage rhizomes and stolons, is advantageous for its survival and if you are developing a fairway or green (see second photo). However, it is less useful for providing feed to grow animals. Browntop is also highly competitive at accessing phosphorous (P) from the soil. Plants that are short of P also become carbon limited because P is used as an energy source in photosynthesis. Therefore, a direct consequence of lower levels of soil P and overstocked or set-stocked pastures is the dominance of browntop.

It begs the question as to whether we have forgotten these facts in our management of hill country pastures. Indeed, we commonly hear people suggest we can grow as much feed under set stocking as rotational grazing, but have we forgotten the research that indicated the pasture cover needed to be 1,500 kg DM/ha to achieve it? Only at this level of cover is the LAI high enough to capture most of the available light (see **Equation 1**).

For New Zealand's summer-moist regions, the implications for pasture management are clear:

- Minimise set stocking to avoid browntop
- Fertilise with P and S to ensure higher quality species can compete

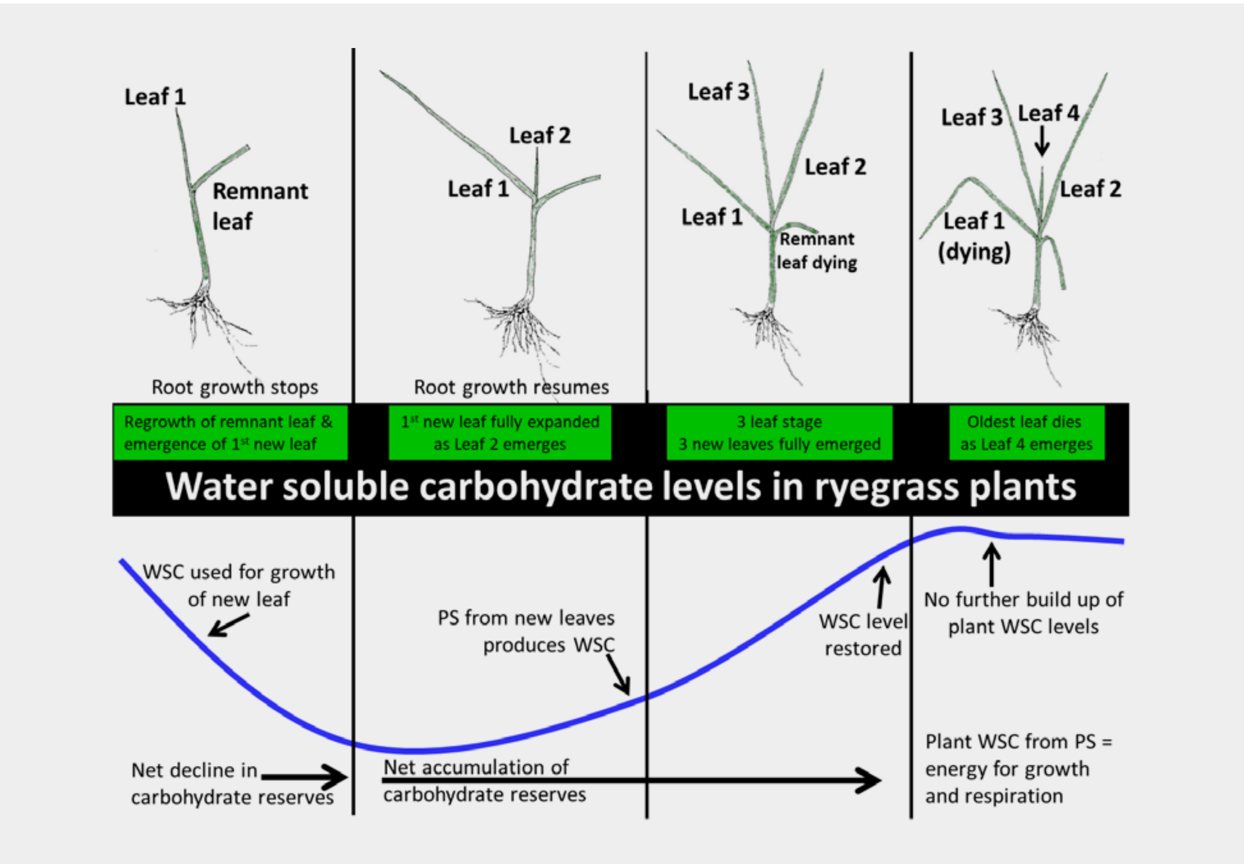

Figure 1: Relative change in water soluble carbohydrate levels (blue line) in ryegrass plants during a regrowth cycle. Modified from McCarthy et al. (n.d.), www.dairynz.co.nz/media/2634153/perennial-ryegrass-grazing-guide-web.pdf

Soil core showing rooting depth of creeping bentgrass (*Agrostis stolonifera*) taken from a golf course. Source: E. Lyons, University of Guelph, Ontario, Canada

Golf green consisting of 30-50% browntop, creeping red fescue and annual bluegrass (minor component) at St Andrew's golf course, Scotland. Source: E. Lyons, University of Guelph, Ontario, Canada

- Adjust rotation lengths to allow sown species to recover root reserves
- Graze ryegrass at the appropriate three green leaf stage
- Use N to increase pasture cover if deficits are developing
- Utilise supplements early in periods of water or N stress.

For our summer-dry regions similar strategies are required, but the emphasis has to be on managing the spring when moisture is usually available:

- Minimise set stocking – increased LAI also increases water use efficiency
- Use N in late winter to increase cover for lambing
- Maintain flexible stock policies so you can trade in periods of deficit
- Identify high-yielding paddocks and use them for improved species
- Identify your legume and manage it.

Managing nitrogen deficiency

The strategic use of N to increase pasture cover before times of deficit is advocated to overcome the fact that plants are N deficient most of the time. Intuitively we know this because we frequently see taller, darker green urine patches within pastures. Many of our grasses, including perennial ryegrass, adjust their leaf area to try to maintain an N content in the leaves of about 3%, which is why N deficient pasture is frequently short with small leaves.

In high fertility environments (e.g. dairy farms) the addition of N is estimated to produce 10 kg DM/kg N applied, which comes from a quicker recovery from grazing and higher photosynthetic rates at higher leaf N concentrations. In lower fertility environments (such as on hill country) the N deficiency can be much greater leading to responses of 20–40 kg DM/kg N applied. The greater response is because the leaf area of the plants increases to a greater extent to overcome the deficiency, which allows more light interception.

The alternative to applying N to pastures is to encourage an appropriate legume for N fixation. The N is then mainly transferred to the grass through the grazing animal. For dairy pastures this has traditionally been, and is returning to, encouraging white clover. Recent work from Lincoln has shown that a perennial ryegrass/white clover mix was as productive with and without 200 kg N/ha applied.

For hill country sheep and beef pastures, the limited land for cultivation reduces the opportunity for pasture renewal. However, the impact of legumes to provide N-rich herbage can be measured compared with resident pasture. In a summer-safe environment one study showed that clover-dominant pastures produced more than three times the feed of the resident browntop. Similarly, in a summer-dry environment lucerne has produced two to three times the feed of the resident pasture on hill country on Banks Peninsula during low and high rainfall years (**Figure 2**).

Lucerne and red clover

The lucerne in this situation is utilised for lambing hoggets from mid-September until December. The management of root reserves is the key to maintaining a productive stand. For example, it is well known that lucerne root reserves are depleted in spring as the plant maximises shoot production. However, in autumn the above ground growth rate is reduced as a higher proportion of assimilates are partitioned to roots and crowns.

This process can also be enhanced or reduced by grazing management. By grazing lucerne on a fixed 28-day rotation, one study carried out in 2021 showed that root reserves were depleted to almost zero with 2 t/ha of structural root biomass (**Figure 3**). In contrast, under an extremely lax regime (84-day grazing) the root biomass increased by 8–10 t DM/ha, but crops lodged and were largely unpalatable. Therefore, the 42-day regime provided a balance between shoot and root reserves and plant and animal requirements. In practice, a fixed rotation is not recommended with the emphasis on shorter rotations (28–35 days) in spring but longer (42–50) in autumn.

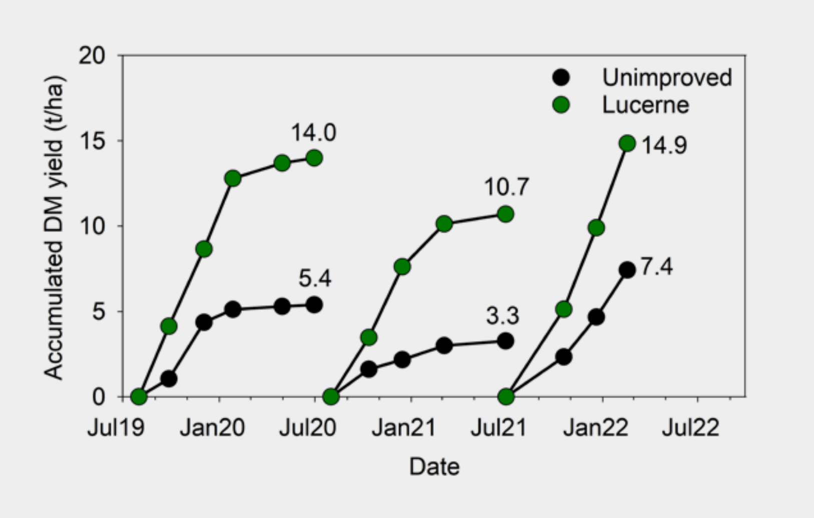

Figure 2: Comparison of accumulated dry matter (DM) production (t/ha) of unimproved resident pasture compared with a lucerne monoculture on Banks Peninsula, Canterbury. Note: Data shown for year 3 (2021/22) only includes measurements to mid-February 2022

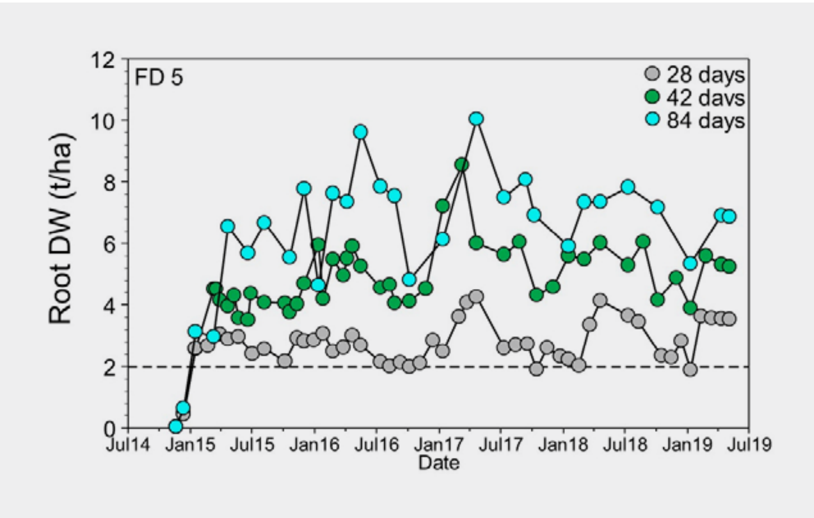

Figure 3: Change in perennial (root + crown) biomass (0-0.3 m) over time of irrigated 'Grasslands Kaituna' lucerne (fall dormancy (FD) rating = 5) subjected to regrowth cycles of 28, 42 or 84 days during active growth for five growth seasons (2014/15 to 2018/19) at Lincoln University, Canterbury (Data sources: Ta, 2018; Yang, 2020). The horizontal dashed line represents structural perennial biomass that cannot be remobilised

In short, rotational grazing of tap-rooted species like lucerne and red clover is considered best practice. It allows recovery of the canopy to maximise light interception, recovery of root reserves and the high grazing allowance of high-quality feed to maximise animal production. The rules may not be followed as strictly when grazing grasses, but the cyclical nature of depletion and recovery of reserves needs to ensure overgrazing does not result in reduced pasture persistence and dominance of low-quality species (such as browntop).

The impact of climate change may require us to become even more aware of these principles. Ryegrass is still going to need three green leaves to recover its carbohydrate reserves, and lucerne will still produce more feed in spring than in autumn because of the changes in partitioning. N is still going to be an important tool for recovery from adverse conditions.

However, the expected increases in summer-dry periods, and warmer winter and night temperatures (coupled with increased legislation around the use of N fertiliser and greenhouse gas emissions), will drive practice change. To maintain pasture production, persistence and farm profitability, farmers will need to make quicker decisions about how to manage their most important resource – feed supply. This will require changes in grazing management of existing pastures, with less set stocking and greater use of other grass species (such as cocksfoot and tall fescue).

For hill country, the future can be seen in the development of satellite farming, where small areas of high-quality feed (such as legumes and herbs) are well managed to maximise animal and plant performance. Other areas will be retired to trees to capture carbon.

In all cases, the efficient use of resources will start with maximising the interception of solar radiation with the world's most efficient green solar panels.

Acknowledgements

Funding for this project and manuscript preparation was provided by Beef + Lamb New Zealand, the Ministry of Business, Innovation and Employment (MBIE), Seed Force New Zealand and PGG Wrightson Seeds under the 'Hill Country Futures' research programme (BLNZT1701).

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SARMINI MAHESWARAN, JAMES MILLNER & LYDIA CRANSTON

NITRATE LEACHING UNDER SHEEP GRAZING DIFFERENT FORAGES

Nitrate leaching in pastoral systems is influenced by factors including forage type and grazing species. This article outlines the influence of different forages on nitrate leaching under sheep grazing during a three-year study at Massey University.

Nitrogen and nitrate leaching

Nitrogen (N) leaching losses in drainage and run-off from agricultural soils, particularly from intensively grazed pasture, is a significant cause of water quality deterioration in many parts of the world including New Zealand. Nitrate (NO_3^-) is the most common form of N leaching in drainage water. This is largely due to its negative charge, which means it is repelled by cation exchange sites in the soil, rather than being sorbed, so when water percolates through soil after rain or irrigation it carries nitrate with it. In contrast, the other important source of N in soil, ammonium (NH_4^+), does not generally move much through the soil because it is sorbed at cation exchange sites.

Nitrogen cycling in grazing systems is influenced by diet and the partitioning of ingested N in grazing animals. Between 75-95% of N ingested is excreted, with about 70% of that being urea (urine). Faecal N is in an organic form not rapidly mineralised, so it is not a significant contributor to N leaching.

Nitrate leaching may be lower under sheep grazing compared with cattle, but inferences about leaching losses from previous studies have been limited by the

Overview of the sheep drainage trial plots on Keeble's farm at Massey University (four drainage pits can be seen below the plots)

In the future, N leaching cap restrictions may be extended to livestock industries other than dairy, including intensive sheep farming.

indirect assessment of leaching losses, including soil moisture balance and porous ceramic cup samplers. To remain economically viable, sheep production systems in New Zealand (especially those on flat or undulating landscapes) have intensified over time, with greater use of N fertiliser and higher stocking rates than in the past.

The potentially adverse environmental effects of intensive farming on water quality has resulted in many regional councils placing N leaching caps on dairy farms. In the future, N leaching cap restrictions may be extended to livestock industries other than dairy, including intensive sheep farming. Knowledge of potential leaching rates under intensive sheep grazing systems is essential information for policy-makers.

Four forages

This research quantified and compared N leaching under sheep grazing on four different forages:

- Perennial ryegrass/white clover
- Plantain/white clover
- Italian ryegrass/white clover and forage brassicas
- Turnips year 1, swedes year 2 and kale year 3.

Different brassicas were used depending on the time of sowing (autumn year 1, late spring years 2 and 3) and the need to minimise the risk of clubroot (*Plasmodiophora brassicae*). Perennial ryegrass/white clover was compared with three alternative forages. Plantain has been shown to reduce urine N concentration in grazing animals, but data for sheep is limited.

Italian ryegrass was included as a treatment because it is winter active, which can increase the uptake of soil N when leaching risk is high due to wet soils. The brassica crop treatment was included because it remains an important supplementary feed in sheep systems, but may result in high N leaching after winter grazing.

Materials and methods

This study was carried out at Massey University's Keeble's farm near Palmerston North. The research site included an area with 20 drainage plots (five plots/forage treatment). Each plot was 40 × 20 m and had a hydrologically isolated mole pipe drainage system (see first photo).

The drainage plots were sown with the appropriate forage species on 21 March 2019 with a roller drill and chain harrows:

- The plantain/white clover and Italian ryegrass/white clover plots were oversown in April 2020
- Swedes were sown by direct drilling in the spring of 2019 and kale in spring 2020
- N fertiliser (urea; 46:0:0) was applied to the swede plots (30 kg N/ha) in March
- Nitrophoska (12% N) and urea were applied to the other three treatments (30 kg N/ha) in April and October 2020, respectively.

The drainage plots were grazed according to the cumulation of forage and best grazing management practices for these forages. Sheep (ewes) used to graze the drainage plots were run on adjacent farmlets which, for ewes grazing alternative forages, included an area (25% of the farmlet) in one of the alternatives. This allowed ewes grazing alternative forages to be transitioned from ryegrass/white clover prior to being grazed on the drainage plots (see second photo).

Each farmlet was stocked at 14 ewes/ha for the entirety of the experiment (46 ewes per farmlet). This stocking rate was chosen to reflect an intensive sheep farming operation for this farm class and area.

Drainage water from each individual plot was hydrologically isolated using mole drains that channelled water into pipes with individual tipping-bucket (~5 L) flow meters at the outlets, which were located in nearby drainage sampling pits (see third photo). Each tipping bucket was calibrated dynamically to account for larger tip volumes at higher flow rates. All tipping buckets were instrumented with data loggers to provide continuous flow rate measurements. A small sub-sample (~0.5 ml) of the drainage water from every second tip was automatically collected to provide a representative sample for water quality analysis.

Monitoring of drainage water commenced in late April 2020. After the completion of each drainage event, water samples (~100 ml) were collected manually. Filtered sub-samples were analysed for NO_3^-–N using a Technicon Auto Analyser. The amount of NO_3^-–N, losses (kg/ha) were calculated as the product of the measured drainage volume and NO_3^- concentrations.

The performance of the sheep used in the study was also monitored, which comprised production data (including liveweight, lambing % and lamb liveweight), as well as information on N metabolism (including urine urea content – seasonally). Only the N leaching information is presented here.

Results

The nitrate leached annually under each forage was generally low, ranging from just 0.22 kg/ha for plantain/white clover in 2019 to 11.78 kg/ha for plantain/white clover in 2021.

Table 1: Annual nitrate N leached (kg H/ha) under different forages grazed by mixed age ewes

Treatment	2019	2020	2021
Perennial ryegrass/white clover	1.36	0.90	2.06
Italian ryegrass/white clover	0.35	0.43	6.7
Plantain/white clover	0.22	0.44	11.78
Brassica	2.45	8.96	4.46

The annual pattern for the three permanent forages was similar, with the highest N losses occurring in 2021 for all forages apart from brassica. For the first two years of the study the brassica crop produced the highest leached N totals, whereas in 2021 only perennial ryegrass/white clover had lower N losses.

The annual N leaching losses in **Table 1** are much lower than N losses measured on the same soil type and same year under dairy cow grazing (also at Massey University). The brassica plots were intensively grazed during winter, followed by a period where the soil was left bare until soil conditions allowed replanting, which was typically in late spring. This demonstrates the potential for higher losses of NO_3^-–N resulting from urine patches in the absence of vegetation and plant uptake. Recent research has shown that N leaching losses from forage crops grazed by dairy cows during winter could be more than twice those under grazed pasture.

In the current study, ewes began grazing brassica plots in the latter part of the winter and had not completely eaten all the bulbs before set stocking for lambing. As a result, the total NO_3^-–N leached could have been greater if the ewes had been able to continue grazing and harvest all the bulb material. On the other hand, the N content of swede bulbs is generally lower than the leaf.

The results from the first two years of the study indicate that swards with plantain are effective at reducing N leaching under sheep grazing. Plantain contains bioactive compounds (aucubin and acteoside), which can reduce the production of NH_3 in the rumen, and they also have a

Plantain contains bioactive compounds (aucubin and acteoside), which can reduce the production of NH_3 in the rumen, and they also have a diuretic effect.

Romney ewes grazing one of the ryegrass-based treatment (each treatment was replicated five times)

In sensitive catchments, the use of forage crops (such as swedes and kale) to feed sheep rather than cattle over the winter period may be a useful strategy to reduce N losses.

diuretic effect. Urine N content collected from the ewes in this study revealed that urea concentration in the urine of ewes grazing the plantain sward was significantly lower than for other treatments in most seasons.

The 2021 year appears to be an aberration, with the plantain/white clover and Italian ryegrass/white clover treatments producing comparatively high N losses. Both of these treatments had become degraded by 2021 – the plantain/white clover due to ingress of a significant dock infestation and the Italian ryegrass/white clover from low vigour (low tiller density).

As a result, plots with these treatments were sprayed with herbicide (glyphosate) and resown on 14 April 2021 using a direct drill. Consequently, after grazing in February 2021 vegetative cover in these plots was minimal until early May 2021. Urine N deposited between late 2020 and February 2021 was probably converted into nitrate N, but with little plant uptake, so more was available to be leached once drainage commenced (June 2021).

In 2021, kale was used as the brassica crop and the plots were grazed between June and July. Nitrate leaching under brassica was low compared to that observed under brassica (swedes) in 2020 (8.96 kg N ha 1). The kale crop was the third successive crop in this treatment, meaning that available soil N was probably low, contributing to the low forage N content observed in the kale crop (the leaf N content of the kale was about half that of the previously grazed turnips and swedes).

There have been large annual and seasonal fluctuations in climatic conditions during the time of the study. For example, winter 2021 was the warmest winter on record in Manawatu, which resulted in good plant growth and potentially high rates of N uptake compared with previous winters. Ongoing research is required across multiple years with contrasting rainfall and temperatures to adequately understand N losses under different forages grazed by sheep.

The results from this study suggest that the drainage system is capable of picking up subtle differences in N leaching from different treatments and in response to seasonal and management factors. The trial will be continued with some modifications to include a direct comparison between sheep and cattle grazing and the use of a brassica/Italian ryegrass mix to maintain vegetative cover post-grazing in the winter.

PhD student Sarmini Maheswaran checking drainage flow meters in a drainage pit at Massey University

Implications

This study confirms the difference in N leaching potential between sheep and cattle grazing systems, and cattle (especially dairy systems) typically produce much higher N leaching losses. In sensitive catchments, the use of forage crops (such as swedes and kale) to feed sheep rather than cattle over the winter period may be a useful strategy to reduce N losses through leaching on sheep and beef farms. There is good evidence that plantain can be used to reduce N leaching under sheep grazing. Italian ryegrass may also be useful, a function of its winter activity.

Acknowledgements

The research reported here is part of a PhD project for Sarmini Maheswaran. Thanks to D. Burnham, M. Osborne, B. Toes and Keeble's farm staff for their technical assistance. The research was funded by the L.A. Alexander Trust, the C. Alma Baker Trust and Massey University.

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JAMIE GORDON

This profile looks at the life and career of Jamie Gordon, NZIPIM Board Member and sheep, beef and deer specialist at Macfarlane Rural Business in Canterbury.

Farming background

Jamie Gordon was born and raised on a sheep and beef farm near Bridge Pa, Hastings. In conjunction with being an agent for Borthwicks, his father finished and traded large numbers of lambs, grew lucerne hay and ran a small horse stud. So early life was a combination of drenching and dagging lambs, shifting irrigation pipes and making hay and chaff. Jamie was lucky enough to have ponies and horses and competed in show-jumping around the North Island until his mid-20s.

After schooling in Hawke's Bay, he started a job with a mixed cropping farmer who also undertook agricultural contracting. The owner had one of the first direct drills and as an 18-year-old Jamie did some of the early direct drilling on hill country. Having left school in the late 1980s, his father decided that farming was not the best occupation so encouraged him to go to university. Wanting a bit of adventure he decided to go to Lincoln University and studied B.Ag.Science focusing on Farm Management and Animal Production.

Five Star Beef

Following university, and still hankering for farm work and show-jumping, he headed back to the Hawke's Bay for two years. Around this time the Five Star Beef Feedlot in Ashburton was being established. With a passion for animal production, Jamie contacted the head office in Wellington and met the head of the parent company, Paul Phillips, who introduced him to the first General Manager of Five Star Beef, Mark Clarkson.

Arriving in Ashburton one month after the official opening of the feedlot with a saddle and bridle (and not much else), he began work in a Trainee Manager role, spending time riding the pens, driving feedtrucks, processing feed and generally learning about how a feedlot works. In the mid-1990s there was limited knowledge in New Zealand about feedlotting so there was a lot of hard work to make it a success.

After two-and-a-half years working at Five Star Beef Jamie travelled to Egypt to join his brother in the Middle

Early life was a combination of drenching and dagging lambs, shifting irrigation pipes and making hay and chaff.

East. Together they went overland from Egypt to South Africa for 10 months, hitching rides on trucks, boats, utes and buses, through all types of environments and even in some war-torn countries. In South Africa he worked capturing wild game and also went to a couple of World Cup games.

While in Africa Jamie remained in contact with Five Star Beef and was offered the job of Livestock Procurement Manager on his return, purchasing all of the cattle for the feedlot. This role was instrumental in him gaining an understanding of how livestock supply chains operate and what was required to develop relationships and trust with farmers. It also gave him an insight into different farm production systems and how the Five Star Beef programme was a small cog in the overall farm system.

New Zealand Angus genetics

During this time he also realised that the New Zealand Angus genetics lagged behind the rest of the world in key performance meat quality traits. With the help of an old Lincoln friend in Australia, Jamie imported high genetic merit embryos in the early 2000s to demonstrate what was possible with targeted global genetic selection. This programme continued for several years and in a small way contributed to the progress that the Angus breed has made over the last 20 years.

Jamie imported high genetic merit embryos in the early 2000s to demonstrate what was possible with targeted global genetic selection.

Important mentors

Following five years in procurement he progressed to Operations Manager and eventually to General Manager of Five Star Beef, where he was fortunate to report to Graeme Harrison, the Founder of ANZCO Foods. At that time, Five Star Beef was a stand-alone business and involved the whole supply chain from livestock and feed procurement, through operations and processing, to international marketing.

During his time with Five Star Beef and ANZCO, Jamie was fortunate to progress through a number of roles and be mentored by people such as Graeme Harrison and Mark Clarkson, Trevor Johnston and Gus Crawford. A key learning was that most people can do anything if they have the right attitude, are provided the opportunity and are given support.

ANZCO roles

After four years as General Manager of Five Star Beef, the parent company ANZCO asked Jamie to establish a farming company to assist with lamb and beef supply to their plants during shoulder periods. Farms were leased in the North and South Island and intensive farm systems introduced. Leasing farms was a tough business, particularly when competing with a buoyant dairy sector.

Some of the key lessons he learnt from the ANZCO farms experience were:

- Leasing is a hard way to make money and there is no capital gain
- Farming for the shoulders of the season is difficult and needs to be part of an integrated farm system
- The most important resource in an intensive farm system is the people, but they are also the highest overhead
- Most farmers at the time didn't know the liveweight gain of their livestock and there were no adequate data systems available. This has improved, but there are still a lot of gaps with this simple metric.

Jamie's last role with ANZCO was as General Manager of the Agricultural Division, encompassing farming, feedlotting, agricultural strategy and procurement support. This meant working across the Group and having involvement with farmer suppliers and international customers.

Macfarlane Rural Business

After almost 25 years with ANZCO and Five Star Beef, Jamie decided to have a change and joined Macfarlane Rural Business in 2016. Working in the sheep, beef and deer (SB&D) sector, he covers a range of farm types specialising in developing and analysing farm systems, livestock supply chain strategies, financial management and strategy and succession planning. He also provides advice for intensive livestock production systems, and beef genetics, and is involved in agricultural and meat-related projects beyond the farm gate.

Looking to the future

The past two years have shown the resilience and importance of agriculture, and Jamie believes the future looks bright with strong prices for almost all agricultural products. However, it is a given that costs will continue to rise, market requirements will continue to change, and regulations will alter – this is nothing new.

Jamie Gordon speaking at a Quality Beef event in 2021

Therefore, for him it is important that farmers continue to adapt and utilise the latest technologies and science so that profitability can be maintained. Sustainability has been a much-used term in recent years, but without economic resilience, environmental and ethical sustainability is more difficult to achieve.

SB&D farms are multi-faceted, often with a number of different livestock classes and crops, and in many cases are providing support to the dairy sector. Jamie says it is paramount that the farm system is finely tuned so that the basics of feed demand and supply are matched, the right mix and most profitable livestock are farmed, costs are minimised, and environmental requirements are met.

Simply put, pastoral farmers produce feed and require the best combination of livestock enterprises to extract maximum value from that feed. Rural professionals can play a key part in this, by providing objectivity to the feed and livestock systems that are implemented and ensuring the farm business is both resilient and sustainable. Information and recording systems play a key role in achieving this, but historically they have been limited in SB&D compared to cropping and dairy. Jamie feels there needs to be a continued focus in this area as it is difficult to assess and manage something you cannot measure.

Overall, he believes the future is bright with opportunities in markets and with new technology such

Jamie says it is important that a sound profitable farm system is maintained because it is rare that in-market premiums or new technology will fully compensate for productive inefficiency.

as drones, mapping, computer software etc. However, Jamie says it is important that a sound profitable farm system is maintained because it is rare that in-market premiums or new technology will fully compensate for productive inefficiency.

NZIPIM involvement

Being a late starter as a consultant, most of his early development occurred while at ANZCO. A member of NZIPIM for over 10 years, he is currently on the NZIPIM Board.

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