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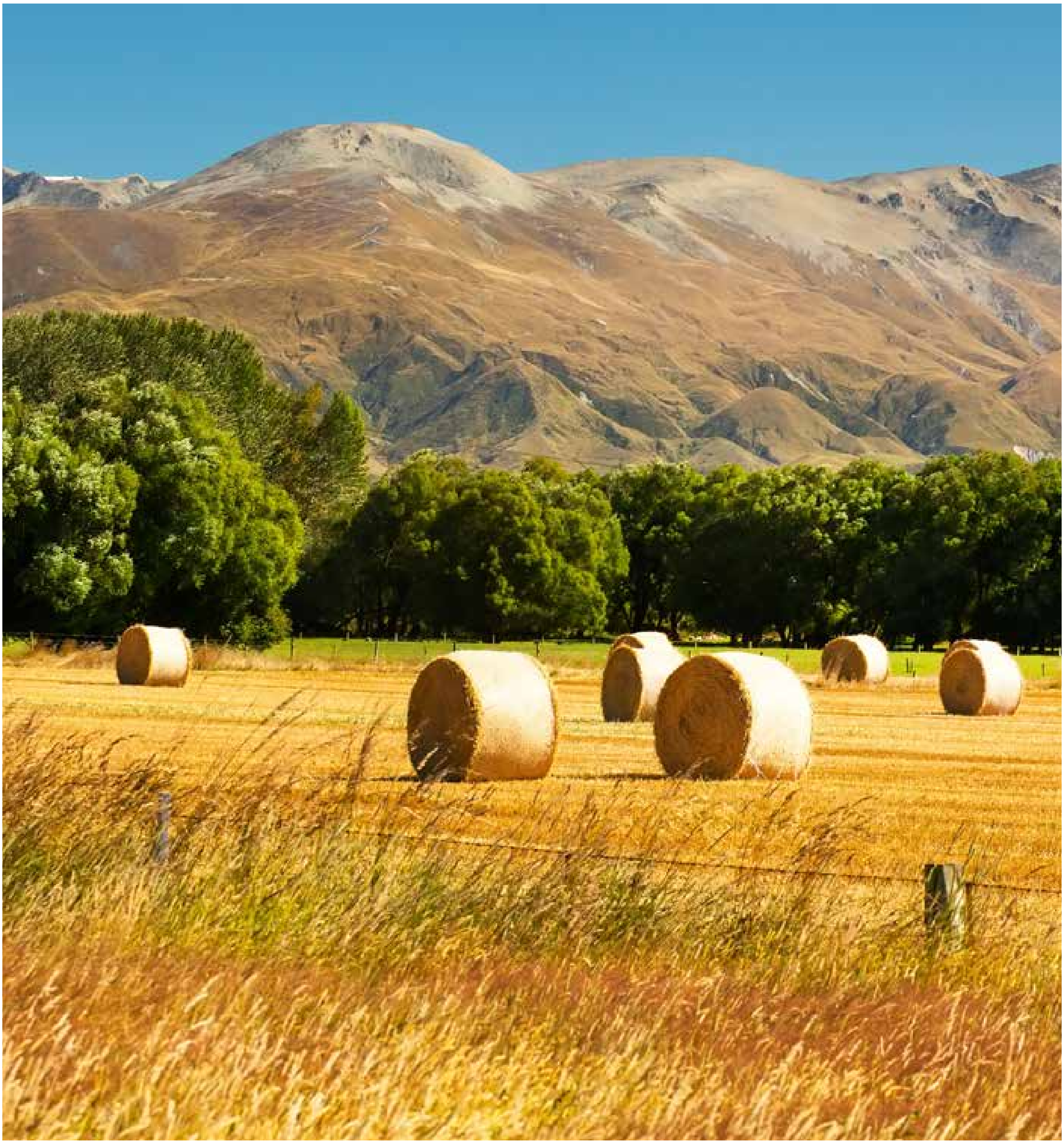

REFLECTIONS ON THE NZ MEAT INDUSTRY 2019/20 A YEAR OF MULTIPLE STRESSES FOR NORTHLAND
PRODUCING MILK THE WORLD WANTS INTEGRATING FORESTRY FOR PROFITABLE AND SUSTAINABLE LAND USE
HILL COUNTRY POPLARS AND WILLOWS EARTHWORMS AND SOIL HEALTH

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STEPHEN MACAULAY CEO

Integrating carbon farming into the farming business

On the back of escalating prices for New Zealand Units (NZUs) under the Emission Trading Scheme (ETS), and with funding assistance from central and local government for afforestation programmes, there has been a steady increase in the amount of (mostly sheep and beef) farms going into forests.

An analysis by Beef + Lamb NZ shows that since 2019 approximately 70,000 ha of sheep and beef farmland has been targeted for conversion into forestry. While this represents less than 1% of sheep and beef farmland, this is approximately 13 times more than the average annual amount of afforestation in New Zealand over the past five years.

Although the new Minister of Forestry, the Hon. Stuart Nash, indicated in June that resource consents would be required for forests on productive land (LUC 1-5) above 50 ha per farm, the amount of land being planted in forestry shows no sign of slowing down as the Government pushes onward for the country to be carbon neutral by 2050. To meet this target, the Parliamentary Commissioner for the Environment estimates that 5.4 million ha of land would need to be converted into forestry for New Zealand to be carbon neutral, which is about 60% of sheep and beef farmland.

With strong policy drivers in place for more forestry plantings, and large corporates seeking to offset their carbon dioxide emissions without necessarily needing to improve their efficiency in reducing carbon emissions, we can expect to see increasing levels of sheep and beef land converted into forestry.

Against this backdrop we have also seen a sharp increase in the carbon price with NZUs reaching new highs of $35/NZU during November (up from around $25/NZU in May) increasing the income potential from forest carbon. A recent economic analysis on a case study hill country farm (6.8SU/ha) completed by AgFirst compares the Internal Rate of Return (IRR) from sheep and beef production compared to timber and carbon returns ***(Table 1)***.

The returns from forestry over an investment period of 28 years do look considerably more attractive in the case study hill country farm, particularly if the price of carbon continues to rise (although timing of cashflows should also be considered).

Regrettably, this may lead to more sheep and beef farms going into forestry. This will also inevitably have a flow-on effect on the social fabric of rural communities in the regions as fewer employment opportunities become available through lower meat processing capacity and less service providers (e.g. shearers, vets, farm supply, etc) being needed.

While the forestry sector is still touted as providing employment opportunities in the regions, this may not necessarily be the case as some forests may never be harvested. Instead, it may be more economic for forestry blocks to be used for 'carbon farming', with the sole purpose of drawing down carbon dioxide emissions from the atmosphere and 'farmed' for NZUs over the life of the trees. In the case of *Pinus radiata*, this could be up to 80-100 years, or several hundred years for other exotic and indigenous species.

Table 1: Potential returns from carbon farming

	IRR	CARBON RETURN ONLY
Sheep & beef	4.0%	
Forestry (timber* only and not part of ETS)	7.5%	0.0%
Forestry (timber + carbon @$25/NZU**)	13.7%	8.7%
Forestry (timber + carbon @$35/NZU)	16.9%	14.3%
Forestry (timber + carbon @$50/NZU)	22.3%	21.3%

**Assumes 28-year harvest*
***Assumes using the new averaging scheme*

As the price of NZUs continues to climb, carbon farming could also become more profitable than milling the trees for export or further processing, more so if it is impractical to harvest the trees due to long distances from ports and/or significant on-farm infrastructure spend required in roading and environmental protection measures to access the trees for harvest is very high. As ***Table 1*** indicates, the higher the carbon price, the lower the relative benefit from timber returns.

Even the hastily passed Forests (Regulation of Log Traders and Forestry Advisers) Amendment Act 2020 during the COVID-19 lockdown could have little effect in meeting its objectives of reducing the number of logs being exported raw and directing more logs towards local sawmill production, particularly if carbon farming proves more profitable than harvesting the trees.

The contention with carbon farming is that once the land is planted in trees it will most probably remain in trees locking out future land use options, unless of course the landowner is prepared to pay the market price for offsetting the carbon claimed over the life of the trees. There would likely need to be strong economic drivers from some other lucrative farming enterprise to significantly alter the land use change out of carbon farming.

From a personal perspective, I am uncomfortable seeing vast tracks of land planted in monoculture plantation pines, as I am sure many other rural professionals and farmers are as well. But, as we have seen many times in the rural sector before, farmers will also look to adapt and change their farming systems to better optimise the profitability and value from their land within regulatory constraints. We only need to look at the impact of irrigation in changing land use from mainly dryland sheep production to dairy farming in Canterbury and Central Otago as an example of this.

Forestry is regarded as a key lever in achieving Government's goal to be carbon neutral by 2050. In view of this we should be more actively scrutinising the place of carbon farming as an alternative and ongoing income source within the farming business.

Integrating forestry into the farming business is an area that rural professionals should be thinking about (if you aren't already). In looking at the metrics contained in ***Table 1***, and assuming ETS policy settings remain relatively unchanged, forestry, including carbon farming, does represent a valid option particularly in less productive and inaccessible areas on the farm.

In many respects, integrating forestry into existing farming operations can readily be achieved by planting a small percentage of hill country blocks into forestry without significantly impacting the sheep and beef farming enterprises, as illustrated in an article by Parker and Dowling in this issue albeit on a dairy farm. This, coupled with a more open-minded approach by government policy-makers about how carbon can be captured and claimed for on-farm (through such areas as existing and regenerating indigenous vegetation, inclusion of shelter belts and riparian plantings, and acceptance of a wider range of tree types, e.g. nut and fruit trees), gives farmers and their advisors the opportunity to more actively explore how forestry and carbon farming fits within the farming business.

On a final note, this is the last issue for the year for The Journal. I wish to thank and acknowledge all the contributors in 2020, and the great work of the Editorial Committee ably led by Nico Mouton and very well supported by our Editor Helen Greatrex. J

TIM RITCHIE

International meat conference, Beijing 2016

OPPORTUNITY IN ADVERSITY

REFLECTIONS ON THE NEW ZEALAND MEAT INDUSTRY

Tim Ritchie's recent retirement has given him the opportunity to reflect on a 40 plus year career in the New Zealand meat industry. It has been a great ride – from a highly protected, subsidised industry to one which is truly market-led and, despite what the critics say, world class. Having taken advantage of the opportunities that adversity has presented during this time is the reason he believes that the sector is now in pretty good shape.

Capitalising on opportunities

Often that adversity has not been ours. Where it has been, at the time it seemed pretty terrible, but on reflection we can look back and see that it actually forced us to get out of what might have been a comfortable existence and swim, rather than putting our head in the sand and ignoring what was happening around us. Where the adversity has been someone else's, we have tried to act subtly and carefully, so as not to be seen as trying to take advantage of other's misfortune. That's important because often the adversity is disease, and the boot can very easily be on the other foot.

My experience has taught me that nothing is forever and there is nothing for nothing. Like fashion, we are in a continually changing world, whether it be the technology, social and environmental demands or values, and learnings from the past we forget at our peril. We cannot predict the future, but through agility and action we can continue to capitalise on the opportunities presented to us.

Open and predictable access to markets is the essential prerequisite to our market diversity optimisation model.

Finding a home for our product

Until this last decade, the previous 50 years were all about where we could find a home for our product. Now there is choice and it is much more about how we allocate product to markets to maximise earnings, compatible with the risk profile that we are prepared to take.

The best thing that happened to us was Britain joining what was then the European Economic Community (EEC) in 1973, and we then faced quantitative restrictions in our most important and traditional sheepmeat market. This forced us to look to the world as our market, rather than continue with a 'comfortable' model of supplying the motherland. We had all our eggs in one basket, little real leverage, and basically relied on goodwill from historical familial ties and being good allies. As we found out, such goodwill dissipates quickly as generations change and forget.

At the same time the business model was changing. It was becoming less attractive for the overseas owned companies who had built a significant asset base in the New Zealand industry – livestock procurement, slaughter and freezing, shipping and distribution to the market, and then (in the case of sheepmeat) distribution through their depots to their own butcher shops. Companies such as Borthwicks, CWS and Vestey owned the bricks and mortar as well as providing the working capital.

Two factors were at play. First, joining the EEC and pressure from the US brought a significant hygiene upgrade requirement for New Zealand processors costing hundreds of million dollars. Secondly, the traditional UK butcher shop was rapidly losing relevance as the supermarkets came on the scene. Those supermarkets did not want the bandsawed parts of a frozen carcase, square edged and covered in bone dust. They wanted only those cuts their customers most wanted, both frozen and chilled and with smooth rounded edges only possible from breaking down a chilled carcase at source in New Zealand.

So the offshore owned assets quite quickly became New Zealand owned, and the hygiene upgrade undertaken and significant investment was made in chillers and boning rooms beyond the slaughter-board. With further processing being undertaken in this country, industry was now able to look to the world as its market and in theory, at least, direct each part of the animal to wherever net revenue was maximised rather than forcing the whole animal on to just one market.

This is exactly the predicament the UK sheep industry has today. They have continued to rely on some 30% of their production crossing the channel as a live animal or carcase, changing nationality and being broken down and enjoyed by French consumers. The consequences of a hard Brexit are clear: that cross-channel business won't exist and the Brits are finding out that developing access to other markets can be a long and frustrating business, taking many years, if not decades.

Market access

Open and predictable access to markets is the essential prerequisite to our market diversity optimisation model. It is where New Zealand has done well through bilateral and multilateral arrangements, peeling back the tariffs and quantitative restrictions which (when accompanied by the World Trade Organization (WTO) rules-based framework) gave us some ability to control our destiny.

With more and more free trade agreements in place, overseas interests seeking to frustrate imports have turned to non-tariff barriers and this is where much of the Meat Industry Association's (MIA's) work is focused. Every day there are many unresolved issues. Their genesis is usually political, or has a protectionist objective dressed up as a technical issue, and that is why international standards (such as the Codex Alimentarius for sanitary and phytosanitary (SPS) matters and the OIE, the World Organisation for Animal Health, for animal welfare) are so important. Over the years, New Zealand has played an important role in international standards development and the adoption of equivalency in outcome-based regulation, rather than the traditional prescriptive approach. This allows us to innovate in the way we do things – it is achievement of the food safety outcome that is important, not how we got there.

There is huge benefit from many markets competing for the product. This, coupled with the different value perceptions placed on parts of the animal by each market (influenced by tradition and cuisine), has lifted the extractable value from each animal. In particular, the influence of the Asian markets coming on-stream means much less is going down the rendering chute.

We cannot stop here. We need to open the front door properly with markets like India, which for sheepmeat will be important to balance the concentration risk on China. India is an Aladdin's cave of opportunity, with a population of 1.3 billion and predicted to be the world's largest and youngest population by 2025, and where the US and Australia are investing heavily in building relationships. That said, their primary sector is still heavily protected, especially dairy, and that flows on to meat imports with high tariffs and tough SPS requirements (such as the need to demonstrate freedom from many ubiquitous on-farm diseases).

Tim Ritchie visiting feedlot in north-west China

The disruption to the rapidly expanding exports to China in 2013 was another example of opportunity in adversity.

Indonesia, with a population of 270 million, will also be important. It grew to become our number two beef market between 2000 and 2010 before embarking on a self-sufficiency strategy of trying to lift domestic production by restricting imports. This was before China came on the scene and it was a particularly important market for bovine offal and lower valued cuts. Although New Zealand and the US successfully took Indonesia to the WTO, their subsequent decision to allow imports of Indian buffalo meat from non-foot and mouth (FMD) zones undercut our business significantly. Despite this, they will continue to be an important market.

Processor and exporter ownership

The tension gained through the mix of ownership models and company strategies that we now have is positive, including farmer cooperatives, private proprietary and New Zealand/overseas ownership. The one model that does not work in the deregulated meat sector, given low margins, high risk and volatility in earnings, is 'city money'. In the 1980s we saw the so-called cream of public companies enter, only to exit after a few years and tears, and with tail between legs – including Fletcher Challenge, Goodman Fielder, Watties and Brierley.

Sector disinvestment from land-use change has also united players around a common imperative – to lift sector profitability. There is now more collaboration and focus on the real competition and other proteins, rather than letting egos rule and sand-bagging each other. The mix in ownership type and different strategies is, in my view, healthy and necessary.

Interdependence each side of the farm gate

This is absolute, and generally long gone are the days of each side trying to game the other. The weather does not help though: if the grass is green the leverage is with the farmer and companies may need to pay over the odds to draw out stock to meet customer needs, but if the grass is brown the leverage is with the processor. The net result is that the sector's profit often oscillates each side of that farm gate, with a roller coaster in returns for each side, making it harder for participants to plan their business.

This includes the whole-of-industry organisations like the MIA and Beef + Lamb NZ working together. Their joint 2012 strategy for the sector grew out of the absolute imperative of lifting sector profitability to stem the significant disinvestment that was taking place. The strategy was the genesis for a raft of initiatives, including the use of the government's Primary Growth Partnership Scheme. It also reinforced the necessity for each side of the farm gate to collaborate in order to lift profitability.

China

The disruption to the rapidly expanding exports to China in 2013 was another example of opportunity in adversity. It was a major wake-up call for New Zealand and centred on a technicality around the MAF to MPI name change on documents. New Zealand approached the matter in a Western way and there were consequences. While commercial relationships existed, the regulatory and whole-of-industry relationships were not sufficiently in place, unlike those with UK/Europe and North America which had been developed over many decades.

Sheep breeding unit in north-west China

Given the commercial consequences, the MIA sat down with government and a strategy to sort it was developed. MPI beefed up their China presence, including at senior Deputy Director General level in Beijing. New Zealand then had more agricultural staff on the ground in China than any other country, including Australia and the US.

The MIA part was the development of relationships with key Chinese whole-of-industry organisations – the China Meat Association, the China Inspection and Quarantine Association, the Chamber of Commerce (CCFNA) and the China Islamic Association. The MIA entered Memorandums of Understanding of cooperation, which has subsequently resulted in collaborative activity over the last seven years, including importantly on technical standards. The New Zealand industry has also taken up a senior delegation each year to demonstrate commitment to the market.

The investment by government and industry paved the way for the very significant growth in exports to China. The importance of relationships cannot be overstated. New Zealand's experience in other parts of the world has shown that professional relationships at the regulatory level, built around trust, can take the heat out of a potential issue before it is too late and the politics take over. The best relationships are then often the professional ones – like vet to vet.

There is a cautionary note that goes with the China business, now our largest market for both sheepmeat and beef. Their imports, especially sheepmeat, are relatively small compared to total consumption – they have been around 95% self-sufficient and so changes in consumer demand leverage straight through to imports. This gave rise to the 'hockey stick' as demand grew with rising incomes and, more recently, was fuelled by African Swine Fever (ASF).

It can turn the other way very quickly too, as we saw earlier this year with the coronavirus shutdown. What that reinforced is the absolute importance of New Zealand maintaining relationships with all its markets, and having a Plan B to divert exports, although with reduced returns. That resilience and product moving from our cold stores enabled processing to continue at a crucial time and in the face of the widespread drought.

Halal

This is another great example of the opportunity in adversity. New Zealand's response to the 1970s oil shocks was to farm its way out by producing more of what we knew we did well, but with little thought as to where it might be sold. My first job was in Treasury and it was all about getting more money behind the farm gate and incentivising increased production.

That set me up for my second job with the MIA's legacy organisations – the NZ Freezing Companies Association and the Meat Exporters Council. The challenge then was what to do with the massive boost in production, which was largely unsuitable for traditional markets and where in any event we now faced quantitative restrictions. Iran came to the rescue, and at one stage one lamb in three was destined there.

Although the Iranian market did not last, the silver lining was that we cut our teeth on halal processing. The real benefit was to be realised decades later and is one of the key factors underpinning sector viability today. It enables us to trade with the 13 Muslim markets in Asia and the Middle East where halal is a condition of market access.

There is no single set of international halal standards, with different interpretations on some matters and it being often used by countries vying to position themselves as the premium halal hub. This created uncertainty for processors, especially on the standards against which they would be

Although the Iranian market did not last, the silver lining was that we cut our teeth on halal processing. The real benefit was to be realised decades later and is one of the key factors underpinning sector viability today.

audited by their various markets. Plant de-listings resulted and the associated uncertainty was commercially untenable, so the MIA went to government and asked MPI to put a regulatory framework around the New Zealand halal production business. This would enable government to negotiate directly with their marketplace counterparts on a single verified base New Zealand halal standard.

Industry worked very closely with MPI and a regulatory system was promulgated, covering processing requirements, halal slaughtermen qualifications, and the requirements of the Approved Halal Organisations with whom MIA contracts the provision of halal auditing and certification services to processors and exporters.

That initiative was (and still is) a world first and has enabled industry to build a robust business with real integrity with the Muslim world. Its importance cannot be underestimated. Almost all animals are slaughtered in the halal manner and some 45% of all meat and offal exported is now accompanied with a halal certificate.

Interestingly, the significant growth in halal certified product has not come from the 13 Muslim markets in the Middle East and Asia where it is a condition of market access – their aggregate imports from New Zealand have not changed much over the decades. The exponential growth in demand has come from non-Muslim markets, but where there is a Muslim population looking for halal product.

The most important new demand is from China, and in 2016 the Chinese government at the highest level publicly recognised the New Zealand halal system. This gave confidence to their 23 million Muslim consumers on the integrity of our halal certified product and now some two-thirds of New Zealand's halal certified exports go to China.

Disease

Disease has had a major impact on world supply and demand for meat and, therefore, New Zealand's fortunes:

- Bovine spongiform encephalopathy (BSE) compromised beef's positioning as king of the meats and helped re-position lamb, which was particularly important for New Zealand in the pre-China years. Likewise, FMD in the UK and other countries such as in South America and India
- Avian influenza (bird flu) assisted with our access to China's front door given the importance of protein for their significant Muslim population. Sheepmeat and beef were two of the six commodities singled out for special import treatment
- In more recent years, ASF has had a major impact on the world meat market, particularly increased demand from China where their pork production capability was decimated. We benefited from the flight to other proteins – poultry, beef and sheepmeat.

Conclusion

There are many areas I have not touched on. I believe the few that I have mentioned reinforce the importance to sector viability of the tension between markets bidding for our product – an open and predictable market access is therefore fundamental. There is no one right business model, and a blend of company ownership structures and strategies keeps the system honest and avoids complacency. A real challenge that remains is the lack of a level playing field between sectors competing for land use (not tilted such as with forestry currently) distorting the real underlying profitability signal and condemning the land to sub-optimal use for generations.

The sector has matured, and while there is healthy tension between each side of the farm gate, there is also now real collaboration given the absolute interdependence on each other, the imperative to lift sector profitability, and the realisation that the real competition is elsewhere.

For the whole-of-industry organisations, the focus must be on delivering outcomes for constituents in those areas where there is real market failure and where the initiative will often take many years to be realised. This is a constant challenge for organisations reliant on the Commodities Levies Act 1990 funding mechanism where the flag must be run up the pole as often as possible, given the need to re-mandate with levy payers every six years. This is less of a challenge for trade organisations, such as the MIA where membership is voluntary, and so the focus is always on delivering real returns for members on their subscription investment.

The one adversity that seems to have everyone stumped is crossbred wool – why have we not been able to capitalise on the absolute adversity faced in recent decades, especially with a sustainably produced product which should mean everything in today's world? Perhaps wool should look to the meat sector model and work to ensure each end of the value chain is connected and responsive to the other's needs, rather than being at the mercy of totally fragmented interests in the middle.

Tim Ritchie retired in April 2020 after 12 years as Chief Executive of the Meat Industry Association. Prior roles included General Manager for meat exporter Towers International, sales and corporate positions for public company Waitaki International, including a period in London as Managing Director of its UK and European subsidiaries. Subsequent roles included General Manager Marketing and Commercial for P&O Containers NZ, Managing Director Advanced Foods of New Zealand, and several general management positions with the NZ Meat Board including a posting to Brussels. Email: tdritchie@xtra.co.nz. J

ROBERT MCBRIDE AND DOUG EDMEADES

THE SOIL FERTILITY STATUS OF SOUTH ISLAND PASTORAL FARMS – A SNAPSHOT

Pastoral farming is New Zealand's biggest industry and its competitive advantage internationally is based on clover-based pastures. Clover not only fixes 'free' nitrogen but is also a better feedstock for ruminants. How well do South Island pastures measure up? This article shows that there is room for improvement.

Clover costs and advantages

The grazing of dairy and beef cattle, sheep and deer relies heavily on growing temperate, mixed pastures. The ability to grow white clover year-round provides an economic advantage of both inexpensive (4-5 cents/kg DM) and high-quality livestock feed. Although supplemental feeding and the grazing of winter crops are common, it is the utilisation of clover-based pasture that provides the greatest economic return. However, growing clover comes at a cost – the clover plant has a higher requirement for all nutrients relative to grasses and crops. Therefore, if there is a soil fertility limitation it will be seen first as a decline in clover production. With the loss of clover comes diminished nitrogen inputs, resulting in a decrease in grass production, and ultimately the proliferation of unproductive low-fertility species.

Ten years of pasture data

In the course of providing professional advice to farmers, agKnowledge Ltd assessed the soil fertility and pasture quality on 284 South Island farms between 2010 and 2020. The distribution of the farms was as follows: Southland (38%), Canterbury (37%), Otago (21%) and Westland/Tasman (4%). The data that has been compiled

Mavora – low productivity pasture

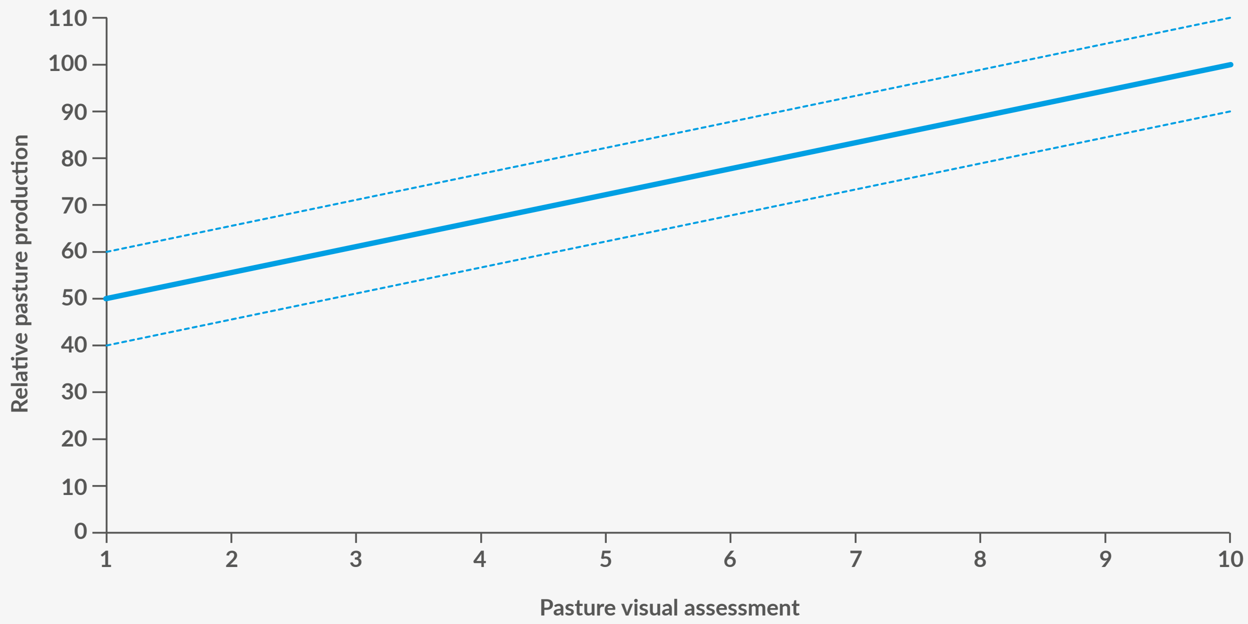

Figure 1: Qualitative relationship between PVA and relative pasture production

is from the initial farm visits and represents a snapshot of soil fertility, pasture quality and composition, and relative pasture production on these farms.

For the purpose of developing fertiliser plans, farms are divided into blocks based on land use, topography and soil nutrient status. For example, tussock high country is treated as a separate block from the developed downs. In this data set, the 533 separate blocks are distributed as follows: 146 milking platforms, 73 effluent blocks and 308 dry-stock blocks. The dry-stock blocks were further divided based on stocking rate into 'low' (104), 'typical' (129) and 'high' (75).

Visual assessment

Prior to the development of standardised soil and plant tissue testing, soil fertility has been assessed since the mid-1960s visually using what was then called the pasture Fertility Index (FI). It has been known since then that there is a direct relationship between FI and pasture production. The original 20-point scale has been modified in this research down to a 10-point scale (pasture visual assessment, PVA), which is more relevant to today's pasture types, and related to pasture production *(Figure 1)*.

For reference, a '1' pasture has little or no clover and is dominated by low-fertility species, such as browntop, sweet vernal and flat weeds. Also, a '1' pasture is yellowish to brownish in colour and the excreta patches are very obvious. By contrast, a '10' pasture is 30-40% clover, and is dominated by high-fertility grass species, such as ryegrass, and is dark green and even in colour with indistinct excreta patches. Specific nutrient deficiency symptoms and clover content are also noted.

Soil test results are inherently variable and this can result in misdiagnosis of any underlying nutrient limitations, especially if the proper protocols are not

Table 1: PVAs of South Island pastures based on 480 observations between 2010 and 2020. Each observation is an average of multiple paddocks within a block

BLOCK AND NUMBER OF SAMPLES	PASTURE VISUAL ASSESSMENT (PVA)	
	SCORE (1-10)	CLOVER CONTENT (%)
All (480)	4.9	15.9
All dairy (208)	5.5	16.6
Milking platforms (139)	5.3	15.8
Effluent blocks (69)	5.8	18.4
All dry-stock (272)	4.5	15.4
Low stocking (90)	3.5	11.1
Typical stocking (111)	4.7	17.5
High stocking (71)	5.4	17.8

followed. On the basis that 'pastures do not lie', visual assessments provide a basis to 'ground-proof' soil test results. Invariably, if the visual assessment and the soil test data do not agree, the error is with the soil sampling.

The average PVA indicates that South Island farms are operating at about 60-80% of their potential *(Table 1 and Figure 1)* and dairy pastures are slightly better than those on dry-stock farms. There is some suggestion that effluent blocks are better than milking platforms and that pasture vigour increases with stocking intensity. The average clover content in most of these pastures is about half of what is regarded to be optimal (30-40%).

Clover-only data

Clover-only samples are used to evaluate the sufficiency of nutrients within the clover plant. Unlike with soil testing, which gives an indication of the size of the soil nutrient pools and can therefore be used to calculate fertiliser requirements, clover samples only signify whether or not sufficient nutrients are available to meet plant needs.

For the dairy farms, the results *(Table 2)* show that overall 67% of the blocks sampled were potassium (K) deficient and 26% were molybdenum (Mo) deficient. The results were similar for effluent blocks and the milking platforms. Furthermore, similar results *(Table 3)* for K (53%) and Mo (25%) were found on the dry-stock farms, which were also often phosphorus (P) (26%), sulphur (S) (35%) and boron (B) (24%) deficient.

Table 2: Nutrient concentrations in clover-only samples from milking platforms and effluent blocks on 128 South Island dairy farms between 2010 and 2020

NUTRIENT DEFICIENT	N (%) <4.4	P (%) <0.30	K (%) <2.0	S (%) <0.25	MG (%) <0.15	CU (PPM) <5	MO (PPM) <0.10	B (PPM) <20
All blocks (128)								
Average	5.0	0.4	1.7	0.3	0.3	9.6	0.4	24.6
% deficient	22	6	67	10	0	2	26	20
Milking platforms (103)								
Average	5.0	0.4	1.7	0.3	0.3	9.7	0.5	24.6
% deficient	22	7	72	10	0	2	26	20
Effluent blocks (25)								
Average	4.9	0.4	2.0	0.3	0.3	9.4	0.4	24.5
% deficient	20	4	48	12	0	4	25	16

Table 3: Nutrient concentrations in clover-only samples collected from 313 South Island dry-stock farms between 2010 and 2020

NUTRIENT DEFICIENT	N (%) <4.4	P (%) <0.30	K (%) <2.0	S (%) <0.25	MG (%) <0.10	CU (PPM) <5	MO (PPM) <0.10	B (PPM) <20
All blocks (313)								
Average	4.6	0.4	2.0	0.3	0.7	9.2	0.4	24.7
% deficient	38	26	53	35	0	4	25	24
Low stocking (107) (<10 su/ha)								
Average	4.5	0.4	2.2	0.3	0.8	9.2	0.5	23.1
% deficient	43	31	35	37	0	2	19	28
Typical stocking (130) (10-14 su/ha)								
Average	4.5	0.4	1.8	0.3	0.8	8.9	0.3	24.4
% deficient	42	29	62	39	0	5	33	22
High stocking (76) (>14 su/ha)								
Average	4.8	0.4	1.9	0.3	0.3	9.8	0.6	26.9
% deficient	23	15	56	25	0	4	19	25

Nutrient deficiencies are not being identified or are not being remedied in current fertiliser policies and practices.

Soil data

The soil test results from the dairy farms are given in *Table 4* and show that P is very often below the economic optimal range (82%), and that K (65%) and S (sulphate S 61%, organic S 67%) were below the respective biological optimal ranges. For the dry-stock farms *(Table 5)* S (sulphate 62%, organic S 78%) and K (57%) were most often deficient followed by P (42%).

What is the data telling us?

The PVA data indicate that, on average, South Island farms are operating at 60-80% of their potential. The clover-only samples are a more direct and accurate means of diagnosing nutrient limitations, and these results indicate widespread deficiencies of K and Mo for both dairy and dry-stock farms. In addition, S is often deficient on dry-stock farms. The soil test data for K and S is consistent with the clover-only analysis, and also indicate that a high proportion of both dairy and dry-stock farms are operating below the economic optimal Olsen P range. It is reasonable to conclude that the unexceptional vigour and clover content of South Island pastures can be directly attributed to sub-optimal soil fertility.

The question becomes why? With the establishment and maintenance of high-quality productive pastures as a top priority for producers, and considering the effort and expense being directed toward optimising grazing management, genetics, drainage and pasture renewal, it would seem unlikely that farmers are intentionally holding back on fertiliser inputs. This suggests that, for some reason, nutrient deficiencies are not being identified or are not being remedied in current fertiliser policies and practices.

Poor - pasture at the low end of the visual and productivity scales

Patchy - distinct excreta patches

Good - pasture at the high end of the visual and productivity scales

Table 4: Soil test results from 219 South Island dairy blocks between 2010 and 2020

ALL BLOCKS (219) Optimal	OLSEN P 35-40	MAF QT K 7-10	S04 (PPM) 10-12	ORGANIC S (PPM) 10-12	MAF QT Mg 8-10	MAF QT NA 3-4	PH 5.8-6.0
Average	26.1	6.6	10.5	8.4	22.0	6.6	6.0
% below optimal	82	65	61	67	2	5	11
Milking platforms (146)							
Average	24.6	5.7	10.7	8.3	21.1	6.4	6.0
% below optimal	89	79	60	68	3	4	11
Effluent blocks (73)							
Average	29.2	8.5	10.2	8.7	23.9	7.1	6.1
% below optimal	68	36	64	63	1	6	10

Table 5: Soil test results from 308 South Island dry-stock blocks between 2010 and 2020

ALL BLOCKS (308) Optimal	OLSEN P	MAF QT K 7-10	S04 (PPM) 10-12	ORGANIC S (PPM) 10-12	MAF QT MG 8-10	MAF QT NA 3-4	PH
Average	19.9	6.9	9.6	7.6	24.2	6.7	5.9
% below optimal	42	57	62	78	2	11	26
Low stocking (104)							
Optimal (<10 su/ha)	10-20	7-10	10-12	10-12	8-10	3-4	5.5-5.6
Average	15.5	8.0	8.0	6.7	28.3	5.9	5.7
% below optimal	18	36	67	39	1	17	49
Typical stocking (129)							
Optimal (10-14 su/ha)	20-25	7-10	10-12	10-12	8-10	3-4	5.8-6.0
Average	20.4	6.1	9.5	8.2	22.3	6.8	6.0
% below optimal	50	72	60	74	2	5	16
High stocking (75)							
Optimal (>14 su/ha)	25-30	7-10	10-12	10-12	8-10	3-4	5.8-6.0
Average	25.0	6.6	11.9	8.0	21.7	7.9	6.0
% below optimal	61	61	57	74	3	13	13

Manapouri - developed hills and flats have the same production

Takitimu - developed tussock pasture

There is considerable opportunity to increase the productivity of pastoral farming in the South Island, which can be captured by the application of known information and technology on soil fertility and pasture nutrition.

It is possible that changes in farming practices in the last few decades have caught farmers and their consultants unaware – fertiliser 'recipes' that worked well in the past are no longer applicable. For example, the widespread deficiency of K may be a consequence of relying on historical fertiliser formulas where little (if any) K was used. K levels, once adequate in many soils, have been mined down and are now not meeting modern production requirements.

Livestock health concerns are often cited as reasons for not applying K and Mo. However, continuing to farm with deficient levels of any nutrient is detrimental to clover growth and hence overall pasture production.

Perhaps the largest contributing factor to the misdiagnosis of nutrient limitations is not applying the appropriate protocols when soil testing. Soil test results are the most heavily relied upon information for making fertiliser decisions. Unfortunately, soil samples are prone to erroneous results, particularly when the proper well-established protocols are not followed.

Sampling errors most often result in inflated values. Ironically, the poorer the sampling, the 'better' the results appear. For example, if a single core from a fresh urine patch is included in the 15 to 20 cores that make up a sample, the reported result can be more than double the actual soil level. It is very common to find excellent looking soil test results from terrible looking pastures. It becomes necessary to recognise and discard erroneous data, and to have a firm grasp of the variability associated with biological systems in order to make effective fertiliser recommendations.

Opportunities

The data suggest that there is considerable opportunity to increase the productivity of pastoral farming in the South Island, which can be captured by the application of known information and technology on soil fertility and pasture nutrition. This will only be achieved by appreciating the importance of clover-based pasture and learning, or learning anew, the well-developed skills of soil fertility and pasture nutrition required to grow clover-based pastures.

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KATE TAYLOR

POPLARS AND WILLOWS
HILL COUNTRY HEROES

Right tree, right place, right time. Poplars and willows are extremely versatile trees that can deliver significant cost savings and provide excellent support in achieving environmental outcomes for farmers. This article looks at the benefits of planting these trees, including erosion control, improved water quality and as a feed source for stock.

Erosion control

New Zealand still has about 700,000 ha of pastoral hill country in need of space-planted willows or poplars for erosion control. Their deep and extensive root systems provide the best means of minimising soil erosion and, in turn, help to keep rivers healthy. Most rivers require willows for bank stabilisation to manage flooding and waterways need shade. Poplars and willows provide shade and shelter for stock and can also be used for fodder in summer; willows also provide food for bees in spring. When planted appropriately, space-planted poplars and willows can qualify for the Emissions Trading Scheme (ETS).

Studies show that well-spaced planted poplars and willows on hill country can reduce soil loss by as much as 90% compared with unprotected land. Where erosion does occur, research shows it takes 30+ years for eroded hills to recover 70% of original production, with slow gains to 80% after 60+ years – that's at least two generations of farmers.

Poplar and willow research

The New Zealand Poplar and Willow Research Trust was formed in 2011 to fund poplar and willow research. Poplars and willows have an important role in developing greater resilience in New Zealand's farming systems. The Trust's role is: to improve the quality, suitability and use of these resources; to support the end users through breeding, testing and releasing new poplar and willow clones with pest and disease tolerance that are suitable for a wide range of climates; and to provide extension services. Breeding and improvement programmes are employed internationally to maintain genetic variation to create options for the future.

Poplars and willows have excellent aesthetic value when combined with natives

Poplars and willows can be planted to protect farm assets (e.g. fences that are prone to slip damage, tracks prone to drop-outs, unstable ground around farm buildings or vehicle crossings, culverts and bridges).

Poplar and willow poles

Much erodible hill country can be stabilised and sustained as farmland by planting poles into vulnerable pastoral areas. As well as minimising erosion, they allow for good pasture growth below the trees, which enhances stock carrying capacity. Annual pasture production/ha in areas with wide-spaced unmanaged trees is reduced by only 8-13% compared with areas with open pasture.

A pole is a young tree stem between 2-3 m long, which roots and sprouts when planted in the ground. The advantage of planting a pole instead of smaller material is that its height gives it a 'head start', so it is less likely to be damaged by browsing animals. Poles can be successfully established on hill country where soil is sufficiently deep and moist for them to take root. The Trust website has 'how to' videos on choosing the best sites to plant a pole, best practice planting methods and care of young trees, as well as tree management information including pollarding and coppicing (see www.poplarandwillow.org.nz).

Pole survival depends on a number of factors – the most significant is available soil moisture during the spring-summer immediately following the planting of the pole. In 2013, sample regions in a research study experienced an extreme drought that extended into summer. Survival of poles was just over 50% in 2013. In contrast, rainfall during spring 2011 and summer 2012 was above normal. Survival of poles in 2012 was 96.5% in Wairarapa. Likewise, 2018-19 had good seasonal rain and pole survival was 94% in Wairarapa. Other lesser factors affecting pole survival are associated with:

- Planting management – insufficient soaking before planting, poor siting, planting to a shallow depth, not re-ramming in clay-dominated soils, exposure to cattle
- Nursery management – undersized poles, diseased poles, poor storage
- Feral animals – deer, possums.

Willows are planted up small, steep gradient watercourses on hillslopes where there is risk of gullying by storm run-off. They can be planted along the lines of sub-surface tunnels (under runners or tomos), which are also at risk of blowing out into open gullies. On permanently flowing channels the poles are usually planted in pairs, one on each bank. On ephemeral channels, which only flow after heavy rain, a single line of trees within the channel is more common.

On easier slopes or valuable grazing country, poplars or willows can be space-planted in pasture at risk from soil slips, earthflows and slumps. Their lateral roots interlock for distances of up to 12 m from the trunks, and form very dense mats for about 5-6 m out, binding unstable subsoil and even anchoring weathered rock beneath. The trees also reduce frequency of waterlogging in the soil, by extracting water through their roots and transpiring it through their leaves.

Poplars and willows can be planted to protect farm assets (e.g. fences that are prone to slip damage, tracks prone to drop-outs, unstable ground around farm buildings or vehicle crossings, culverts and bridges). The average cost per farm following a big storm on the East Coast in 2011 was $235,000 – 43% being production loss and 57% through damage to infrastructure.

Water quality

The improvement of water quality is a major environmental issue. Soil erosion and farm run-off result in nutrient loss into waterways with an adverse effect on water quality. Nitrogen (N), phosphorus (P), sediment and animal faecal matter from soil erosion and farm run-off are the main pollutants; waterway margins form an important buffer zone between land and water.

Stream bank erosion can typically contribute 50-90% of the stream's sediment and P load. P behaves very differently to N, as it binds with soil and only dissolves slowly in water over time. Waikato Regional Council scientists have reported that excluding stock from streams reduces stream bank soil and P loss significantly, exceeding 90% in some situations. If riparian tree buffers are included this P loss can be further reduced. Poplars and willows take up inorganic forms of P (from applied fertiliser or as mineralised P in the soil) and return P in organic forms at leaf fall and through root death. They do not store P, but recycle it, since most P is used in the leaves. By reducing the rate of run-off and increasing infiltration these trees reduce the overland flow and loss of P into waterways.

Soil erosion on pastoral land can occur in any location where the soil is not bound and so is exposed to erosive factors, notably gravity, stock action, wind and water. Erosion moves soil from the upper to lower slopes, buries topsoil, exposes subsoil, adds sediment to waterways and redistributes plant nutrients. The plant nutrients shifted by erosion can be lost to pastures through leaching, overland flow, microbial oxidation and in sediments moving into waterways.

Willows and poplars planted as waterway buffers stabilise the stream or drain bank, trap sediment entering the buffer zone, intercept nutrients and sediment from overland flow or erosion, shade the stream and cool the water, provide a handy shade and fodder source for stock, and intercept N from subterranean flow.

Mesh cage for controlled release of parasitoid wasp Pauesia nigrovaria as biological control agent for giant willow aphid

Poplars and willows are deep rooting and draw moisture in times of drought, providing nutritious feed when pasture has died off.

The trees should be planted back from the stream edge, leaving the edge for herbaceous plants such as Carex grasses. Other shade options should be provided for stock to prevent camp sites forming near to the riparian buffer. Willows (and poplars) can act as nurse plants for an understorey of native shrubs, trees, grasses and ferns. The native seedlings arrive in bird droppings or can be intentionally planted. The willows can then be removed progressively as the native vegetation becomes established.

Get advice from your local regional council when deciding what willow to plant in your riparian buffer zones. Do not collect and plant unidentified willow material from any location (e.g. stay away from crack willows and grey willows that spread and can choke up waterways).

Valuable feed source

Known for their erosion control and shade qualities, palatable poplars and willows should also form part of a farm drought resilience plan. Poplars and willows are deep rooting and draw moisture in times of drought, providing nutritious feed when pasture has died off. Both poplars and willows are resilient and respond well to the removal of branches by growing more. This pruning system is known as pollarding, with the upper branches of a tree cut back to a stump above cattle grazing height, promoting a dense head of foliage and branches.

Cattle will eat trimmings up to 10 mm and sheep up to 5 mm in diameter. The feed value is well above stock maintenance requirements at 65-70% dry matter digestibility, about the same as lucerne hay. A crude protein level of 15% is well above that required for livestock maintenance. The leaves contain valuable compounds called condensed tannins (CT) and phenolic glycosides (like aspirin) and these have health benefits for stock.

Massey University research found 5-10 year-old trees yield up to 22 kg dry matter per tree of edible forage, and that poplars and willows were similar in nutritive value. CT levels are usually higher in willows. Willow leaves are also high in zinc and magnesium, which are important animal health minerals. However, sodium (salt) levels can be low in willow leaves, and if little or no pasture is on offer a salt block should be provided. Tree bark also has good nutritive value.

Mature poplars and willows shed a large quantity of leaves in autumn and early winter. Once trees are about five years of age, leaf fall can provide 60 kg or more of dry matter per tree.

The Trust website has a wealth of information and how to videos about pollarding and using poplars and willows as a feed source.

Bulls grazing under poplars

FIELD TRIALS

Populus maximowwiczii x nigra trial sites

Parakai, Northland
Rissington, Hawke's Bay
Mapiu, Waikato
Ashhurst, Manawatu
Windwhistle, Canterbury
Millers Flat, Otago
Little Annie, Gisborne

Populus deltoides x ciliata trial sites

Sites in Taranaki, Taupo, Wairarapa

Experimental poplars and willows

Central Hawke's Bay
Coastal and inland Southland

NURSERY TRIALS

Napier (Hawke's Bay Regional Council)
Masterton (Greater Wellington Regional Council)
Aokautere (Plant and Food Research)
Clyde (Plant and Food Research)

Figure 1: Trial sites since 1998

Breeding programme

The Trust's breeding programme, run by Plant & Food Research scientists Trevor Jones and Ian McIvor (who is also the Trust's General Manager), creates tailored poplar and willow cultivars to test in field trials ***(see Figure 1)***. In the nursery, issues such as phenology, disease resistance, branch angle, stem form, brittleness and plant vigour are evaluated. The best seedlings are then selected for field trials and monitored in the field for up 15 years to evaluate survival, growth, and compatibility with grazing stock and pests.

Water use efficiency, rooting capability, ease of propagation, tolerance to wind and drought, and wood properties are also examined. Severe rain events provide unique opportunities for the scientists to measure the stabilising effect of poplar and willow species, tree spacing and size.

Current research is investigating how tree root development on slopes varies with age, soil type and pollarding management. The Trust's research also develops strategies for minimising the impact of pests and diseases through cultivar selection and management. Using the results of their intensive research, they provide an advisory service to regional councils, and support users through their website, publications and speaking at field days and workshops.

Having good, validated science demonstrated on-farm is a key to uptake by farmers. The Trust's partners can also take information from the Trust and package it in a way that aligns their business to the adoption of sustainable practices.

Space-planted poplars and willows for erosion control are eligible for the ETS and the associated ability to claim carbon credits, provided they meet the definition of forest land and are planted on 'post-1989 forest' land.

The poplar breeding programme is focused on selecting a range of clones suitable for soil conservation and windbreaks. Important selection criteria include high resistance to current pests and diseases, high rooting ability from unrooted cuttings, rapid growth and straight stems. Desirable criteria are a basic wood density of at least 360 kg/m^3 and a low incidence of pathological black heart caused by bacteria. Soil conservation trees require rough, thick bark by five to six years of age, narrow to intermediate width crowns, high wind resistance, and a low incidence of epicormic sprouting following pruning.

The willow breeding programme aims to develop tree willows that form rough bark at an early age as protection against browsing by livestock, and with low palatability to possum and insect pests. Improvement work in willows is being directed towards the introduction and development of a wide range of species and clones of diverse genetic origin. Those showing good local adaptation, or other desirable attributes, are incorporated into the breeding programme.

In today's climate, drought resistance is also an objective. The shrub willow improvement programme develops a range of clones with bitter foliage unpalatable to possums, and also a multiple stem habit. This makes them suitable for gully planting, stream bank stabilisation, roadside planting and mountain land revegetation where tree willows are not suitable.

Demonstration site

A poplar demonstration plot was planted in winter 2017 adjacent to SH1 near Utiku, south of Taihape. This is a partnership between the Trust, Beef + Lamb NZ and Horizons Regional Council (with help from Ravensdown). The plot was planted with 16 poplar clones – 12 are available commercially with the other four expected to be in the near future. The commercial clones in the demonstration plot are Veronese, Fraser, Toa, Otahuao, Weraiti, Crowsnest, Mapiu, Pecam, Kawa, Shinsei, Rotorangi and Kaimai. The novel clones are two of *Populus maximowiczii* × *trichocarpa* and two of *P. trichocarpa* × *nigra*. They vary in form, growth rate, colour, and when they burst bud and drop their leaves.

Carbon credits

Space-planted poplars and willows for erosion control are eligible for the ETS and the associated ability to claim carbon credits, provided they meet the definition of forest land and are planted on 'post-1989 forest' land. The forest land definition requires land coverage to be at least a hectare in size, that it has (or will have) tree crown cover of more than 30% in each hectare, and it has an average width of at least 30 m. This coverage needs to be maintained over time. Forest trees include poplar and willow, but they need to meet the criteria of reaching at least 5 m in height in the place where they are growing.

Post-1989 forest land is land that is currently forest land and either:

- Was not forest land on 31 December 1989, or
- Was forest land on 31 December 1989, but was deforested between 1 January 1990 and 31 December 2007, or
- Was pre-1990 forest land that was deforested on or after 1 January 2008, and any ETS liability has been paid.

Two things to note: to participate in the ETS there is a requirement to measure carbon growth and the rules differ for less than 100 ha and more than 100 ha; and the pruning or pollarding of trees is permitted, but is categorised as silviculture and could impact on carbon measurement if the registration is more than 100 ha. But, as an example, the shape of erosion control plantings may be linear or in isolated pockets, so they can be ineligible because they do not meet the criteria of 30 m average width, 1 ha size or the potential of 30% canopy cover. Some ways of rectifying this are:

- Additional poles can be added to increase size and link existing stands. By using several rows rather than a single tree/line linking, the link is less likely to be affected by poor survival
- Monitor registered stands and replant to make sure eligibility criteria is always met. Units must be repaid if the carbon stock declines
- The stands can be considered permanent as long as tree crown cover is maintained. To maintain canopy cover, undertake selective removal of trees that deteriorate over time resulting from insufficient management of form, ill thrift or age. These can be replaced with improved clones. Poisoning, felling or harvesting for timber are appropriate actions. More information is available on www.poplarandwillow.org.nz.

Giant willow aphid

The Environmental Protection Authority (EPA) gave approval in December 2019 for the release of the parasitoid wasp *Pauesia nigrovaria* as a biological control agent for the giant willow aphid. The first releases took place in February 2020 at the Bay of Plenty Regional

The EPA gave approval in December 2019 for the release of the parasitoid wasp *Pauesia nigrovaria* as a biological control agent for the giant willow aphid.

Council willow nursery near Whakatane and the Trust's willow collection at Massey University, Palmerston North. It has since been released at nine sites.

The establishment and monitoring of the wasp in New Zealand is being funded by a three-year MPI Sustainable Food & Fibre Futures (SFFF) project, with co-funding from the Regional Council River Managers Group, Zespri International and The Honey Trust.

Ambassadors

The Trust has appointed a group of farmers to act as ambassadors – these farmers are experienced in the planting and management of poplars and willows. Their purpose is to encourage other farmers to include poplars and willows in their farm plans, enhance farmer understanding of the role of poplars and willows on farms, and to ensure farmers have access to information about selecting, planting and managing trees. So far ambassadors have been appointed in the following regions: Waikato, Bay of Plenty, Gisborne, Hawke's Bay, Taranaki, Horizons, Greater Wellington, Tasman, West Coast Murchison.

More ambassadors would be welcomed in the South Island and the northern North Island.

The ambassador's role is essentially one of education. They could be invited to speak at field days or other rural events, talk one-on-one or accept visits with farmers wanting advice about poplars and willows, or be a point of contact for regional council land managers or other rural professionals offering extension services to farmers such as DairyNZ, Beef + Lamb NZ or fertiliser or consultancy companies.

Each of the ambassadors will act on their strengths or areas of knowledge. Most of them have been planting poplars and willows for decades, and some have won environment awards and held positions on catchment groups and other industry organisations. Their point of difference is their belief in the value of poplars and willows on their farms.

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Sheep feeding on foliage from form-pruned poplars

LEIGHTON PARKER AND LES DOWLING

INTEGRATING FORESTRY FOR PROFITABLE AND SUSTAINABLE LAND USE – A 2020 CASE STUDY

Phase two of the Te Uru Rākau One Billion Trees collaborative project provides 10 case studies across the Bay of Plenty, Rangatikei and Waikato regions demonstrating the integration of forestry to support individual landowners to meet their land management objectives. The forestry options analysed are specific to their farm and farming aspirations. Financial and environmental analysis demonstrate potential returns, reductions to the farm's environmental footprint, and total farm business performance of the integrated options compared to the existing farm system. This article takes a look into one of these case studies – Holdem Farm (2017) Ltd.

Farm overview

Holdem Farm a 308.4 ha multi-generational family-owned business based in Mamaku, 15 km north-west of Rotorua. The property includes 278.6 ha of effective pasture, 27.2 ha of native bush (mainly rimu, tawa, tāwari, māhoe and kāmahi), and 1.4 ha of newly planted riparian margin. The farm's topography is mostly flat to rolling with some steep gullies and rhyolite tors *(Table 1)*.

The Holdems are interested in how trees can support their goals, including increasing farm system efficiency and 'enjoyment of the business'. Integration of forestry offers the opportunity to build environmental resilience, diversify income, enhance the property's biodiversity and aesthetics, and support the dairy operation (shade and shelter plus land optimisation).

Other farm business goals are to:

- Become more efficient, optimising the farm financially while meeting environmental obligations
- Operate within the surplus nitrogen discharge allowance (NDA) by adopting new technology/management practices and/or secure more NDA to lift the feeling of 'doing wrong'.

Table 1: Summary of key status quo farm system details

FARM DETAILS		CURRENT FARM SYSTEM	
Nearest town and catchment	Mamaku	Herd size (peak lactation)	720
Season's rainfall (Overseer[FM])	2,150 mm	Breed and liveweight	Crossbred 470 kg
Soil type(s)	Mku_1a.1 (57%) Mku_11a.1 (8%) Oraka_1a.1 (35%)	Farm system (% feed brought in)	3 (25%)
Topography	Flat (55%) Rolling (35%) Gullies/steep (10%)	Comparative stocking rate (kg Lwt/t DM)	81
Total farm size (ha)	308.4	Stocking rate (cows/eff ha)	2.58
Effective area (ha)	278.6	N fertiliser (kg N/ha/yr)	129
Dry-stock support area (ha)	N/A	Per cow production (kg MS)	382
Labour (FTE)	4	Per ha production (kg MS)	987
Effluent irrigation area (ha)	66.8	Planned start of calving	27 July
Stand-off pad/ herd home infrastructure	Feed pad	BW	112/49
Shed type	50 HB	PW	149/63
Native and riparian trees (ha)	28.6	Young stock	Grazed off
Timber woodlots (ha)	0	Wintering MA cows	200 for 7 weeks

A view across Holdem Farm to Lake Rotorua

Distance to port or processor has the largest impact on the profitability of small woodlots due to transport costs.

Factors motivating tree planting and land use change

Physical constraints

- Factors such as climate, variable topography and pasture species constrain management and physical productivity and lead to the question: 'If the less productive areas were retired and planted in trees what would the overall impact be on the business?'
- Pasture management is challenging due to the low stocking rate and farm contour. The tors and gullies contain unimproved pastures and produce poor quality feed, which constrains herd performance.

Environmental constraints

- The farm operates under the Lake Rotorua Nutrient Management Plan Change 10. Annual N loss needs to reduce by 29% by 2032. In the absence of land use change, modelling indicates the farm will need to reduce peak cows milked from 720 to 600 by 2032 and minimise the use of N fertiliser.
- While greenhouse gas (GHG) reduction targets (except N fertiliser, fuel and electricity) are not yet explicitly in the Emissions Trading Scheme (ETS), all farmers under the Zero Carbon Act 2019 will need to reduce biogenic methane emissions by 10% from the December 2017 baseline by 2030.

Table 2: Summary of farm physical parameters of the scenarios compared to the status quo system

FARM PARAMETERS	BASE SYSTEM	SCENARIO 1	SCENARIOS 2 & 3
Effective pastoral area (ha)	278.6	250.8	219.1
Timber woodlots – *Pinus radiata* and/or redwood	0	17.7	49.27
Native (ha)	27.2	34.5	33.3
Riparian (ha)	1.2	4.0	5.3
Peak cows milked	720	690	600
Stocking rate (cows/ha)	2.58	2.75	2.74
Production	275,000	268,000	234,000
Per ha (kg MS/ha)	987	1,069	1,068
Per cow (kg MS/cow)	382	388	390

Integrated forestry analysis

The Holdems are interested in *Pinus radiata* and redwoods as timber options. Their goals for increased efficiency and farm business resilience make radiata an obvious component of tree planting scenarios, complemented by native and riparian planting for property beautification. Radiata pine has good growth in a wide range of sites and well-established log markets.

Redwoods are more sensitive to site quality and weed competition and have more variable growth rates, especially on windy sites where soils are shallow or nutrients are restricted. Redwoods provide a longer-term carbon storage option and are suitable for the valley bottoms on the property.

Both species grow well at this site and have strong supporting local infrastructure and supply chains for planting, silviculture, harvest and the sale of timber. Distance to port or processor has the largest impact on the profitability of small woodlots due to transport costs. The farm is within 50 km of several local processors for radiata pine and the Port of Tauranga is 81 km away.

Three scenarios were tested to assess the value of integrating trees and all included timber woodlot, riparian and native planting. Woodlots were assessed for their economic potential (including carbon), while riparian and native plantings were included as costs for establishment less any grants available for planting, plus any carbon revenue that would accrue over time if eligible for the ETS.

The integrated forestry analysis that follows shows the physical, financial and environmental impact of three forestry options on the farm business. Modelling analysis was completed in Farmax and Overseer^{FM} software.

Scenario design

Scenario 1 – Conservative planting regime

Scenario 1 targets planting only the steeper contoured and less productive land. This accounts for 27.7 ha, made up of approximately 4 ha of rhyolite tors and 23.7 ha of gully systems. A combination of woodlots (17.7 ha), native (7 ha) and riparian planting (3 ha) is used to support 'right tree, right place and right purpose' *(Table 2)*. The woodlot areas are all located in the property's gullies, with the gully floors planted in permanent natives to reduce soil and contaminant loss at harvest.

Native and riparian plantings are targeted in areas around power lines, to protect views, near houses which provide beautification, and steep areas that are considered not suitable for timber woodlots due to their size and/or location.

Changes to the dairy enterprise include reduced pastoral area (-27.8 ha), increased stocking rate (+0.17 cows/ha), and per cow productivity (+6 kg MS/cow) associated with improved feed quality and land contour.

Scenario 2 – Extended woodlot planting

Scenario 2 models trees planted over 59.5 ha. The woodlots are all planted in *Pinus radiata* (as with Scenario 1). The riparian areas and native planting follow the same principles as Scenario 1, with planted areas covering 5.2 ha and 5.1 ha, respectively.

Scenario 3 – Extended woodlot with redwood planting regime

Scenario 3 has the same planted area as Scenario 2, but has 29 ha in redwoods (*Sequoia sempervirens*), with the remaining 20.3 ha in *Pinus radiata*. The redwoods are primarily grown for carbon, with no investment to enhance log quality.

Dairy farm system changes for Scenarios 2 and 3 were modelled together as the pastoral area removed remained the same. The effective area decreases by 59.5 ha (21%), while the stocking rate and animal performance remained consistent with Scenario 1.

Results of forestry scenario analysis

Table 3 summarises the investment outcomes from two full forest rotations, both excluding and including carbon revenues:

- Scenario 1 provides the second highest return per hectare planted of the three scenarios, but the lowest overall return, as measured by the present value (PV) from all log and carbon revenues, due to the smaller area retired. Forestry represents a small decrease in productivity compared to the current pastoral use (50% less pasture yield than better land)
- Scenario 2 provides higher revenue per hectare from better quality land, but with slightly lower log quality. Lower log quality did not impact revenue as the assumed prices for lower grades reflect historically high demand. This could change in the future and can be managed by delaying harvest to improve both log quality and yield. Applying a discount rate of 6% to the whole term provided a positive PV of $152,102 ($3,085/ha) and internal rate of return (IRR) of 8.48%, the highest of the three scenarios. If the safe tradeable carbon is sold, the net pre-tax return (logs + carbon) increases to $283,173 ($4,759/ha)
- Scenario 3 provides much lower timber revenue, as 29 ha is planted in redwoods rather than radiata but derives more income from carbon. Applying a discount rate of 6% provided a positive PV of $120,362 ($2,023/planted ha). The investment's IRR was 8.9%, the lowest of all scenarios. Scenario 3 provides the greatest potential to offset the dairy farm's carbon liability, reduces exposure to log price risk and increases exposure to carbon price risk. Considering the outlook for higher carbon prices to discourage emissions, the redwoods scenario could present more lucrative returns with conjecture that carbon prices could go to $50/t in the mid-term.

Impact on the dairy enterprise

Milk production

Total milk production for Scenario 1 only decreased 7,000 kg MS compared to the base scenario, reflecting lower productivity land being changed to forestry *(Table 4)*. The loss of overall pasture production is partially offset by increased per cow production due to dairy consolidating onto the better land with higher feed quality. These improvements are reflected in per hectare milk production and pasture eaten increasing by 8.3% (1,069 kg MS) and 7% (+0.7 t DM), respectively.

Scenario 2 and 3's removal of a further 31.7 ha reduced total milk production by 17.5% (-41,000 kg MS) compared to the base system. The provided the highest net returns from forestry and support greater reductions in livestock emissions and contaminant losses (GHG and water contaminants) compared to Scenario 1.

Profitability

Scenario 1 has a 2.5% reduction in total cash operating surplus (-$12,913) from farming, but generates higher cash returns on a per hectare basis *(Table 5)*. The removal of less productive land provides a higher margin per hectare.

Table 3: Summary of individual investment performance for the forestry investments under each scenario

PLANTED AREA	SCENARIO 1 30.2 HA		SCENARIO 2 59.5 HA		SCENARIO 3 59.5 HA	
Area in *P. radiata*	17.7	ha	49.3	ha	20.3	ha
Area in redwood	-	ha	-	ha	29.0	ha
Area in ETS qualifying native and riparian	2.5	ha	10.2	ha	10.2	ha
Returns over two rotations (56 years)	Total	/woodlot ha	Total	/woodlot ha	Total	/woodlot ha
NET PRE-TAX LOGS (undiscounted)	855,997	48,361	2,563,170	51,991	909,056	18,439
PV for whole term (WACC = 6%)	46,339	2,618	152,102	3,085	-37,957	-770
Internal rate of return (IRR)	8.2%		8.5%		5.1%	
	Total	/planted ha	Total	/planted ha	Total	/planted ha
NET PRE-TAX LOGS & CARBON (undiscounted)	955,658	31,644	2,851,276	47,921	1,446,640	24,313
PV of free cashflow (WACC = 6%)	91,712	3,037	283,173	4,759	120,362	2,023
Internal rate of return (IRR)	11.0%		11.4%		8.9%	

Table 4: Summary of physical performance indicators for the dairy enterprise only

FARM PARAMETERS	BASE SYSTEM	SCENARIO 1	SCENARIOS 2 & 3
Effective pastoral area (ha)	278.6	250.8	219.1
Peak cows milked	720	690	600
Stocking rate (cows/effective grazing ha)	2.58	2.75	2.74
Production	275,000	268,000	234,000
per ha (kg MS/ha)	987	1,069	1,068
per cow (kg MS/cow)	382	388	390
FEED EATEN			
Dry matter intake (t DM)/ha	15.1	16.3	16.4
Imported feed eaten (t DM/ha)	4.3	4.7	4.6
Winter grazing (t DM/ha)	0.9	1.0	1.0

Table 5: Summary of financial performance indicators for the dairy enterprise only

FARM PARAMETERS	BASE SYSTEM	SCENARIO 1	SCENARIO 2	SCENARIO 3
Gross farm income ($/ha)	$6,529	$7,061	$7,057	$7,057
Farm working expenses ($/ha)	$4,674	$5,052	$5,142	$5,142
Total dairy cash operating surplus	$516,674	$503,761	$419,540	$419,540
Change from base system		-$12,913	-$97,135	-$97,135
Operating surplus/ha ($/ha)	$1,855	$2,008	$1,915	$1,915

**Dairy enterprise financials KPIs are calculated with a status quo $6/kg MS milk price and a $0.20/share dividend. Per hectare prices are calculated from the effective pastoral area from each system.*

Rhyolite tors on Holdem Farm

Native canopy

Table 6: Summary of water contaminant losses

NITROGEN AND PHOSPHORUS*	BASE SYSTEM	SCENARIO 1	SCENARIOS 2 & 3
Total farm N loss (kg N)	20,184	19,368	16,898
N loss/ha (kg N/ha)	65	63	55
N surplus (kg N/ha)	182	178	154
Kg MS/kg N leached	13.6	13.8	13.9
Total farm P Loss (kg P)	799	673	580
P loss/ha (kg P/ha)	2.6	2.2	1.9

**Environmental indicators are reported from Overseer^{FM} v6.3.2 and against the total farm area.*

Overhead costs remain relatively unchanged due to a smaller milking platform, while variable costs relating to the land and cows proportionately decrease.

Scenario 2 has a large drop in dairy cash operating surplus (-$97,135 or -19%) with more trees and a smaller dairy platform. As some of the operating expenses show little to no change (e.g. overheads, management labour) the reduction in profit is greater than the reduction in milk production (-18.8% vs -17.5%). This highlights a loss of scale and ability to dilute fixed expenses.

With less free operating cashflow available it is important to understand whether the business still generates enough cash to meet debt repayment, CAPEX requirements and drawings. To remain viable the business would need to operate with less debt than either the base system or Scenario 1.

Environmental performance

Water contaminant losses (N and P)

Scenario 1 demonstrated a small reduction in total N loss relating to reduced milk production (-2.5%), pasture eaten (-3.9%) and fertiliser N use (-1.5%) *(Table 6)*. This scenario achieves compliance for the farm's 2022 NDA, but would require further reduction and system change by 2027 and 2032. Assuming an N value of $200/t, this represents a capital cost to the business of approximately $1,003,400 directly by purchasing NDA (as modelled) or indirectly through the cumulative impact of implementing farm system changes.

Scenarios 2 and 3 have a much larger reduction in total N leaching due to the retirement of productive land (65 kg N/ha) to forestry (3 kg N/ha). These two scenarios are compliant under the farm's 2027 NDA and would not require further changes until 2032. The current market value of the reduction in NDA liability is $657,200 (3,286 kg N x $200/kg).

Table 7: Summary of water contaminant losses

GREENHOUSE GASES*	BASE SYSTEM	SCENARIO 1	SCENARIOS 2 & 3
Total bGHGs (t CO_2 eq./ha/yr)	9.8	9.4	8.2
Methane (t CO_2 eq./ha/yr)	7.7	7.4	6.4
Nitrous oxide (t CO_2 eq./ha/yr)	2.1	2.0	1.8
GHG emissions efficiency (kg CO_2 eq./kg MS)	11.6	11.4	11.3

**Averaged across forest life-cycle.*

Reported phosphorus (P) loss decreases by 0.4 kg P/ha and 0.7 kg P/ha for Scenario 1 and Scenarios 2 and 3, respectively. These reductions primarily relate to reduced P fertiliser use and exclude any reductions associated with improving land stability and providing contaminant buffers. The ecosystem service provided by the latter changes are not costed in the analysis, but would provide meaningful benefits to Lake Rotorua.

Biological greenhouse gas (bGHG) emissions

The bGHGs at a whole property level reduced by 266 t CO_2e/yr for Scenario 1 and 596 t CO_2e/yr for Scenarios 2 and 3. This was mostly from lower methane emissions (less feed intake), but also less nitrous oxide emissions (less N fertiliser use). Assuming these emissions were similarly priced to carbon NZUs, this would save the business $14,900 p.a. at $25/t CO_2e *(Table 7)*.

Figure 1 provides the net accumulated bGHG emissions over 56 years (two rotations), accounting for reduced livestock emissions and the safe tradeable carbon if not sold (assuming the landowner was willing to accept lower cash flow and IRR), for the three forestry scenarios compared to the base system. The safe carbon claims provide a modest short-term offset, while operating fewer livestock provides for significant long-term reductions. Scenario 3, with the inclusion of redwoods, provides the largest potential offset, almost twice as much as Scenario 2 and five times the amount of Scenario 1.

Whole-farm business analysis

Scenario 1 with the 17.7 ha of pines and 12.5 ha of permanent retirement was the most profitable integration option, with an aggregate net present value (NPV) from the farming and forestry enterprises over 56 years essentially the same as that of the present farming operation. This option also had an IRR of 15.6%, which is 0.4% greater than the base farming enterprise. Total equity is expected to be $625,000 higher by the end of the first

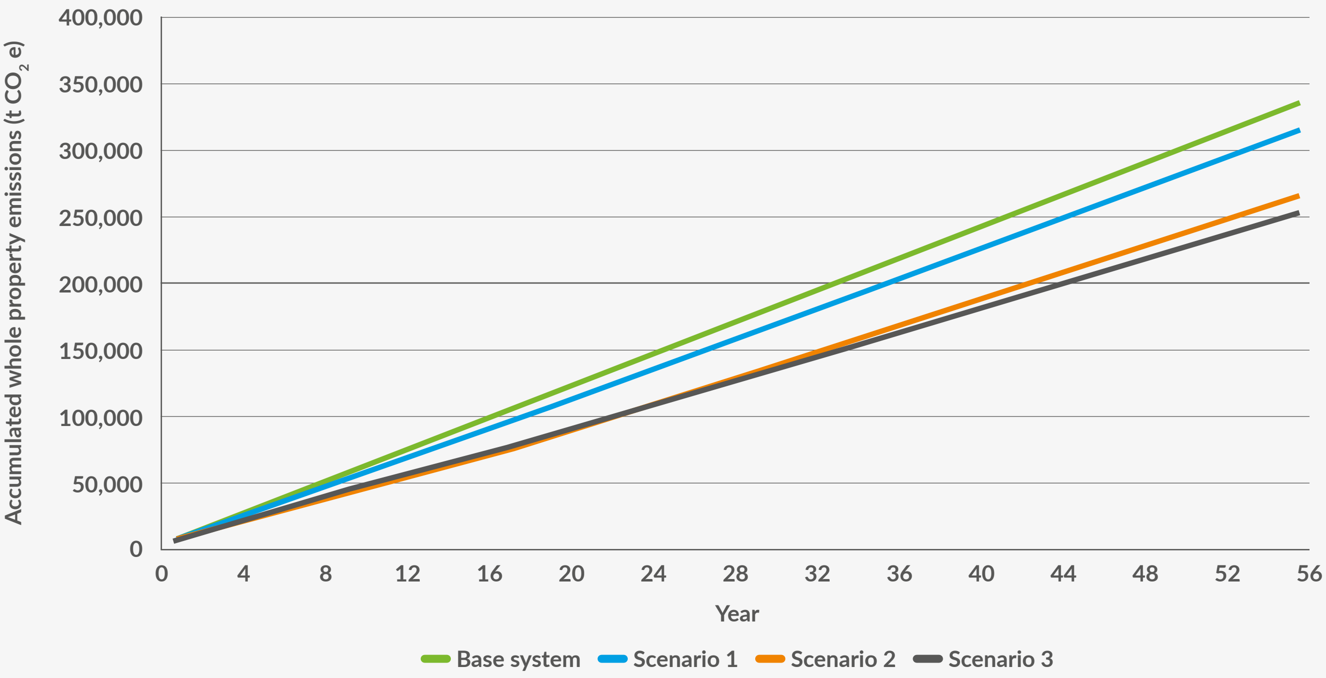

Figure 1: Comparison of accumulated bGHG emissions over time

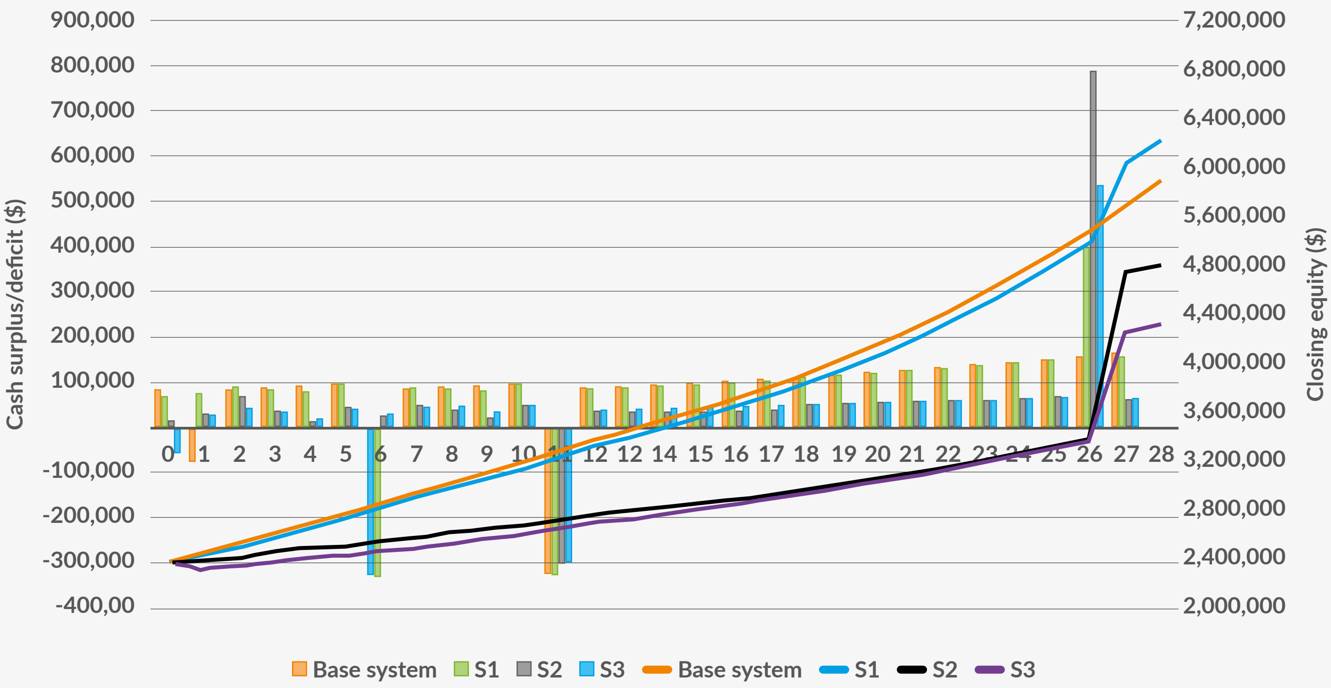

Figure 2: Comparison of total business cash surplus/deficits before principal repayments (LH axis, bars) and closing equity position (RH axis, line) for the three forestry scenarios compared to the base system, including the sale of carbon. Note average closing liabilities ($24.51/kg MS) were sourced from the 2017/18 DairyNZ Economic Survey, allowing the farm's actual debt and equity position to remain undisclosed

rotation than the dairy farming operation *(Figure 2)*. This is because forestry provided similar returns to dairy on the poorer quality land and reduced N losses to the extent that additional rights to pollute or a more costly system change to lower annual N losses would not be necessary.

Over the 56 years, projected profits from Scenarios 2 and 3 from timber and carbon revenues were found to be insufficient to offset the lost dairy farm profits from either scenario, even after accounting for the financial benefit of lower N loss to water arising due to less dairy area. Furthermore, at current carbon prices more tradeable carbon from the redwood plantings did not compensate for the lack of timber income.

The 17% reduction in annual methane and nitrous oxide emissions from the land use change in Scenarios 2 and 3 may also have significant value if legislation requires farmers to monetarise their bGHGs.

Summary

Scenario 1 provides the closest alignment to the owner's objectives, and has the highest IRR and equity growth with minimal impact to cashflow, provided One Billion Trees Fund and BOPRC grants are used. Productivity differences between pasture and trees on various land classes highlight an opportunity to retire poor quality land and achieve productivity increases through an alternative land use.

The case study highlights the multiple dimensions of evaluating how to best integrate trees into a pastoral farm business. Landowners need to bring together a wide range of advice to consider the options and support high-quality tree planting outcomes.

Tree planting grants provided by the One Billion Trees Fund alleviate cashflow constraints (giving farmers the option to convert marginal land), provide lower environmental losses, and diversify income streams with limited impact on farm profitability.

It is important to understand current performance to plan how the business is best positioned to meet environmental challenges. Including the cost of environmental externalities (N and P loss to water, bGHG emissions) and the benefit tree plantings provide is crucial for evaluating the integration of trees on-farm.

The planning and analysis provided in this case study demonstrates the integration of the 'right tree in the right place to achieve the right purpose': optimising land use while meeting environmental obligations and improving animal welfare through the provision of shade and shelter. Retiring marginal land would also diversify income, and improve farm aesthetics and the long-term value of the business.

Acknowledgements

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BOB CATHCART

NORTHLAND 2019/20 A YEAR OF MULTIPLE STRESSES

Northland has been in the grip of an extended dry spell, with annual rainfall being 40% less than average for the last four or five years. This has caused groundwater levels to decline and streamflows to fall or even cease. This reduction and/or cessation of flow has occurred earlier each year. The region has also experienced record summer temperatures. Is this the new 'normal' and how can we adapt our primary industries to cope?

The new normal?

Call it what you like, 2019/2020 has been a difficult year for rural Northland. We have experienced a seasonal drought, continued a long-term groundwater/river flow deficit, and suffered two pandemics. Yes two, *Mycoplasma bovis* and COVID-19, both of which have had a damaging effect on the regional economy and the wellbeing of rural residents. But is this the new 'normal'? Are the changes in rainfall distribution, high summer temperatures and their effects on pasture, crops, man and beast just the downside of a series of natural cycles happening to coincide with biosecurity incursions. Or is this the reality of climate change? Is this our future?

Whatever the case, we still need to better match our land use systems to our natural resources, including a highly variable rainfall, and to buffer our systems against the extremes. However, that is a work in progress and this article focuses on what rural Northland has endured over the last two or more years, but first what makes the region so susceptible to these vagaries.

Northland east coast hill country. Photo courtesy of Northern Advocate

2019/2020 has been a difficult year for rural Northland. We have experienced a seasonal drought, continued a long-term groundwater/river flow deficit, and suffered two pandemics.

The Northland region

The Northland region is the northern 80% of the 326 km long North Auckland Peninsular, extending north-west from the Auckland Harbour Bridge. While the highest point is only 781 m above sea level, it does have a number of peaks and ranges over 450 m which normally attract rain. Rainfall totals and distribution are highly variable, winter having the most rain days, but sub-tropical summer-autumn storms usually bring heavier, high-intensity rain from the north-east.

A review of pasture production data from across the region shows a very wide variation in yields from year to year. In one trial on 'typical' Northland hill country and involving eight years of data, annual dry matter production ranged from 7,800 to over 15,000 kg DM/ha/yr (i.e. dry matter production in a poor (dry) growing season can be half that of a good year).

Part of the reason for these yearly variations is the thin layer of topsoil on large areas of the region. Many Northland soils have a shallow topsoil, 100 mm or less, over a heavy clay, silica pan, or a subsoil high in iron and aluminium. None of these are a friendly habitat for plant roots so pastures are shallow rooted and very susceptible to even short periods without rain. This thin topsoil dries out quickly and can also reach temperatures at which temperate pasture species cease to grow or they die.

Northland Regional Council, NIWA and MetService records suggest that temperatures are rising, with spells of several days to a week at a time over the last three years being the highest in over 50 years of records (see *Further reading* section). With temperate grasses like perennial ryegrass closing down when temperatures reach the early to mid-20 degrees Celsius, and air temperatures in the high 30s occurring any time between the beginning of December and the end of March (and for days at a time), it rules out temperate pastures during that part of the year. A soil surface temperature of almost 50 degrees Celsius on sandy soils in the Far North certainly requires us to re-think our plant breeding programme.

These spells of high temperatures and humidity affect not only plants, but also animals. Fonterra has recorded sudden and significant dips in milk collection during these 'heat waves', as cows find it too hot to eat during the day and their appetite fails them during humid nights. One dairy farmer recorded peak milking cow drinking water consumption at 200 litres/head/day during these hot spells.

Water resources

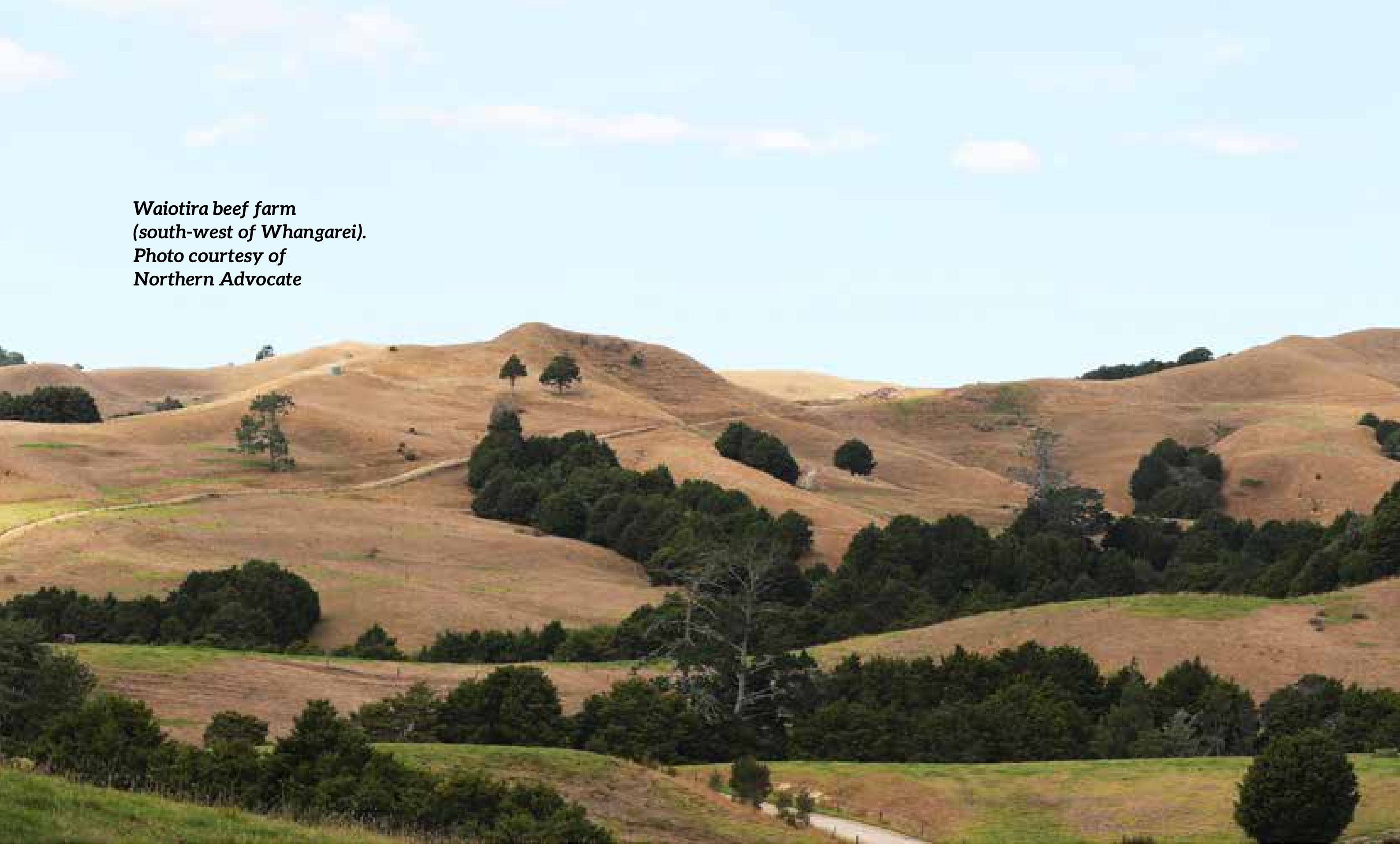
The peninsular has drowned coastlines with short rivers, many tidal for some distance inland, and which discharge into harbours or estuaries rather than directly to the sea. Having little hard rock within their catchments, few rivers have gravel beds (most having soft sediments on the beds and banks) and are mangrove-lined in their lower reaches. Water in these tidal reaches is saline for at least part of the year, with the saline interface working its way up-river in a drought.

The region's largest river, the (Northern) Wairoa River, drains one-third of the region into the northern Kaipara Harbour. Because it drains old soils with a very high proportion of colloidal clays, the river is severely discoloured after rain. This discolouration is not due to extensive active erosion within the catchment, but to the dispersive nature of the clay ('a small quantity goes a long way'), and being colloidal it remains in suspension, a feature of tropical rivers.

Flocculating and filtering out this extremely fine sediment to enable the water to be used for municipal, industrial or rural water supplies is not practically or economically feasible. There is a lack of both groundwater and surface water storage. Much of the region comprises fine-textured rocks (sandstones, mudstones, shales and soft limestones), impervious material which slid in during the Northland Allochthon. While good groundwater can be tapped with bores into the Waitemata banded sandstones closer to Auckland, such bores are totally unreliable in the finer-textured Allochthonous rocks.

Small farm dams ('turkey nest' dams trapping seepage or run-off from a small catchment) have been the traditional source of stockwater on hill country where streams from quite large catchments cease flowing in most years. These sources are too small for the cattle numbers now being carried, so the only reliable sources of water in these areas are the large farm dams that were built by dairy farmers in the mid-to-late 1990s under the guidance of the Northland Dairy Cooperative.

The greywacke bedrock, which is a surface feature on the east coast, is sufficiently fractured to store some water and to sustain streamflow longer than the soft rocks, as are the Tangihua volcanics, large chunks of which slid in as part of the Allochthon. Porous basalt lava flows and scoria of recent volcanics, while not a large groundwater reservoir, have supported horticulture and lifestyle blocks on the Whangarei and Bay of Islands volcanic fields, but available resources are fully committed.



Waiotira beef farm (south-west of Whangarei). Photo courtesy of Northern Advocate

The only large groundwater resource is in the sands which make up the Aupouri Peninsular in the very Far North. However, the use of this resource for large-scale avocado orchard development is being contested because of possible effects on remnant wetlands. There may be deep groundwater reserves in the sand peninsular extending down the west coast from Maunganui Bluff, near the Waipoua Forest to Pouto on the North Head of the Kaipara Harbour, but these have not been explored.

The region has over 400 lakes, but most of these are small dune lakes on the Pouto and Aupouri Peninsulars (all fed by small catchments and in a delicate ecological balance), so they are only capable of supplying stockwater – not irrigation water. Lake Omapere, with a very small catchment, is the only lake in the river networks of the region and, apart from the string of wetlands along the Kawakawa River tributaries, most natural storage has been lost as wetlands have been drained.

In short, despite an average rainfall of 1,500 to 2,000 mm per year, the region has very limited water resources – the answer lies in water storage.

Mycoplasma bovis and other incursions

While a long way from the initial South Island epicentre of this first pandemic, Northland has been seriously affected by *Mycoplasma bovis*. With winter-wet soils over much of the region, many former sheep and beef breeding properties have converted entirely to dairy-bred bull beef farming. Buying in recently weaned calves, they raise the young bulls, many on 'efficient grazing systems', Techno or cell grazing, but quit before they have to carry heavy animals through their second winter.

The farmers are skilled operators who optimise pasture growth and utilisation while minimising winter pugging with rotations extending out to 80 days or more at times during the year, achieving high per-animal and per-hectare production with only beneficial effects on soil depth and structure. Because they source weaners from throughout the North and South Islands, these farmers were hit hard by *M. bovis*. There is also a lot of movement between farms and farmers in Northland, complicating the tracking of animals.

Yes, lessons have been learned and we hope better implementation of our systems will enable the next biosecurity threat to be prevented or more quickly brought under control. While some may have been critical of the poor tracking, and perhaps breaches of animal movement rules, more recent events (with the observance of COVID-19 lockdown requirements and escapes from quarantine facilities) suggest farmers and others involved in the movement of stock were no different to the general population of New Zealand.

But *M. bovis* is only the latest in a long line of pest incursions to have affected Northland, some only Northland (so far). Southern saltmarsh mosquito (which spreads Ross River fever in Australia), tropical grass webworm, guava moth and a more recent anthracnose fungal disease of feijoa have already reached Northland, as well as myrtle rust, poplar rust and other North Island-wide incursions. More are in Australia and the Pacific, just waiting for slightly warmer temperatures. An effective monitoring, early warning and response system is certainly needed.

While a long way from the initial South Island epicentre of this first pandemic, Northland has been seriously affected by *Mycoplasma bovis*.

The 2019/20 year

We need to go back a couple of years to fully understand this last year. Northland Regional Council rainfall, streamflow and groundwater monitoring records show that for the last three years, since 2017/18, the annual rainfall has been significantly lower than the long-term average, with 2018/19 and 2019/20 more than 40% below average.

While timely summer rains in those years were able to maintain grass growth and primary production generally, there had been insufficient total rain during the year to recharge groundwater and maintain streamflows. Warning levels for takes from streams have been occurring earlier and earlier each year.

So, in 2019/20, Northland was affected by two droughts (the long-term rainfall deficit which affected streamflows and groundwater levels and a seasonal drought), and the second dry summer-autumn in a row (starting with a dry spring and followed by an even drier summer and early autumn).

Maize crops that had been planted early enough (and had been lucky enough to catch a couple of the rare late spring showers or thunderstorms) managed to get away, but later plantings failed. By late January and into February, dairy farmers were cutting and feeding their maize crops and using up any spare supplementary feed they had managed to save just to extend the production season.

With a drought extending across the whole of the North Island and the northern part of the South Island, meatworks throughout the North Island were under considerable pressure and so were supplies of hay, silage, grain and meal. Further restrictions due to water shortages, and then COVID-19 social distancing requirements within the works, further slowed the kill rate. This meant that large numbers of animals were being held on-farm and fed bought-in hay, silage, meal and PKE.

Add into the mix the high incidence of *M. bovis* in Northland and the need to destock farms – the situation was critical. Feeding the animals was not the big issue – supplying drinking water was. We had reports of one farmer tankering in water for 800 prime cattle while they waited for killing space.

Low groundwater levels and river flows reduced to a trickle meant that pump intakes were left high and dry, which affected not only the farming community but also the urban population. Only Whangarei District, with an integrated supply system involving groundwater, river takes and dam storage, was able to continue supplying its urban citizens (and later other Northland centres).

Kerikeri was the other exception, where dams built on two river tributaries in the 1970s to supply horticulture also supplied the town's growing urban area.

Other towns, including Kaitaia, Kaikohe and Dargaville, were on limited supplies from November and Kaitaia and Kaikohe had run out by February, relying on water tankered by Fonterra as their collections dwindled. The Silverfern Farms meatworks at Dargaville, reliant on the municipal water supply, was on reduced kill from November due to water restrictions and AFFCO at Moerewa came under restrictions over the summer.

The Northland Rural Support Trust (RST) and an-aligned Drought Relief Committee worked closely with Federated Farmers, the Ministry for Primary Industries, Northland Regional Council and other rural service personnel to coordinate help, both local and from further afield. The RST had been active for the last couple of years dealing with the effects of *M. bovis* and an earlier drought, and was therefore well practised, with experienced counsellors working with some very stressed people. Then along came COVID-19 and the March lockdown. The RST and Drought Relief Committee took it in their stride, switching to weekly Zoom meetings as required.

Has the drought broken?

Rain in mid-to-late April followed by 180 mm in late May saw an end to the seasonal drought, but the April rain brought its own problems. Nitrogen released by decomposing soil organic matter during the drought was quickly soaked up by pasture species. High nitrate-nitrite levels in the rapidly growing pastures led to staggers and to nitrite or 'kikuyu poisoning'. While staggers, if caught early enough, can be treated, the first symptom of nitrite poisoning is 'you find 'em dead!' Fortunately, DairyNZ, Beef + Lamb NZ, Northland veterinarians, and various formal and informal farmer networks responded quickly, circulating advice.

As for the longer-term groundwater and streamflow deficit, a mild June and July with regular rain helped farmers, pastures and stock recover. What has been claimed as a 1:500 year high intensity rainstorm dropped up to 300 mm in a few hours during the night of 17 July, which well and truly broke the drought and brought Whangarei's winter rainfall to over 1,000 mm.

Parts of the Kaipara District, south of Dargaville, did not get the heavy rain and streamflow and groundwater levels in this area are still in the '40% deficit'. For the record, we are having a dry spring, having had no significant rain for most of September, so will the cycle continue?

The future

Whether this is the 'new normal', or we are in a very dry five or more year cycle, there have been some very important lessons learned:

- Our private and public, urban and rural water supply systems, apart from the Whangarei urban area, have fallen way behind the 21st century demands. Farms across large areas of the region were developed and settled by the Lands and Survey Department between the 1950s and 1970s and there were a few community water supply schemes built through this same period. The demands being placed on these schemes cannot be met so major upgrades are required
- Adequate water, quality and quantity is necessary for plant and animal production and is also an animal welfare issue
- Run-of-stream and groundwater resources are inadequate across most of the region to meet current demand, let alone enable diversification into horticulture, so water storage is required. It is more cost effective to create larger reservoirs, but this is currently being hindered by government 'rules' effectively prohibiting on-stream storage
- The campaign to portray irrigated pastoral farming as just an excuse to carry more dairy cows, with the consequential effects on the environment, does not recognise the reality faced by farmers in the most drought-affected parts of Northland. Most farmers spoken with would milk less cows, but would be able to produce the same volume of milk consistently regardless of large fluctuations in pasture growth rates
- Farmers growing maize for silage and/or grain will be able to avoid imported PKE, and they and the Dargaville kumara growers (98% of New Zealand's kumara) will be able to guarantee pasture re-establishment and grazing soon after their crops are harvested. They will be able to grow crop and pasture species shown to reduce methane emissions from livestock. They will also be able to diversify into vegetables, soya beans, sorghums and the like, land uses not possible without adequate water
- The *M. bovis* incursion is not the only biosecurity problem the region has faced in the last 20 years. From tropical grass webworm in 1999, through to guava moth, theileria (we have always had heavy infestations of cattle tick), anthracnose fungi in feijoa, Southern saltmarsh mosquito and myrtle rust, we have had them all – what is next as temperatures rise? We need an effective monitoring and response system as these pests and diseases don't need to come in through our airports.

Further reading

Northland Regional Council regular climate reports online at: www.nrc.govt.nz/environment/river-and-rainfall-data/hydrology-climate-report/

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Northland summer landscape February 2020. Photo courtesy of Northern Advocate

SARAH DIRKS AND PAUL BIRD

Environmental work on farm

PRODUCING MILK THE WORLD WANTS WITH THE OUTCOMES NEW ZEALAND NEEDS

With the dairy industry facing impending changes, this article examines high-level key performance indicators (KPIs) when reviewing farm systems. These can be used by rural professionals to holistically assess a farmer's business and help them adapt to be 'future fit'.

Challenge ahead

There is a challenge ahead for the dairy sector as we get ready to adapt to meet climate change and water quality commitments. Adaption is not new for the sector – it is woven into our DNA. From rotary dairy sheds in the 1960s, the elimination of agricultural subsidies in the 1980s, to the growth of the national dairy herd in the 2000s, we know how to adapt. In 2017, the sector committed to the Dairy Tomorrow strategy that incorporates reducing greenhouse gases (GHGs) and improving water quality, aiming to be the world's most competitive and resilient dairy farming businesses.

Subsequently, policy has set standards for what 'good' or minimum requirements are within the sector. Each of these policies, including the Zero Carbon Act and Action for Healthy Waterways, set responsibilities and timelines for action. The agricultural sector now has a target of reducing methane emissions by 10% by 2030 based on the 2017 year. The clock has started for the industry to prepare to achieve this goal.

Step Change project

To be ready to meet the goal, farmers and their advisors will need to review their farm systems with performance measures to assess how 'future fit' they are in their environmental footprint and capacity for financial resilience. To help with this, DairyNZ's Step Change project is looking to provide an integrated approach to help farmers achieve financial gains, while making progress towards environmental goals and adapting to pending regulations.

To support farmers to make this change, the Step Change project has looked to identify high-level KPIs for farm system review in preparation for future requirements. These KPIs are especially relevant when used for benchmarking. Collectively, they can identify potential gaps or opportunities for financial performance, GHGs and water quality, in particular nitrogen (N) and phosphorus (P) levels. Some of the KPIs will be affected by future policy decisions such as He Waka Eke Noa (for GHGs), so exact targets will not be clear until a process is worked through.

Future-focused system priorities

The fundamentals of a profitable system have not changed, but there are a few priorities to consider for future-focused systems:

- We are now constrained by total dry matter intake (DMI), with its current direct link to methane emissions, as well as N surplus/ha and its link to leaching and nitrous oxide (N_2O) emissions. Therefore, where possible, we need to increase profit/kg DMI and profit/kg N surplus
- Dairy businesses need to be highly profitable to survive and thrive in the current scenario of high debt and no capital gain, and be able to handle potential profit fluctuations due to both milk price and environmental limits
- Before implementing change, farmers will need to know their numbers for all KPIs, set targets, identify gaps and take action to meet the targets.

KPIs for on-farm action

There are three 'groups' of KPIs that can be used with farmers to review their business holistically, including financial performance, water quality and GHG KPIs, which are outlined in *Tables 1 and 2*. The environmental footprint KPIs cover two aspects of environmental management – water quality and GHGs.

Financial performance KPIs

When a farmer is considering changing their farm system, it is important that they assess their current financial

Table 1: Financial performance KPIs

KPI	COMMENTS	CALCULATION
Debt:asset ratio (%)	Indication of financial risk of the business	Closing total liabilities/ closing total assets x 100
Operating profit ($/ha)	Best benchmarking KPI for operating performance as it has all the adjustments required for a fair comparison (e.g. owned run-off, depreciation, value change in livestock)	Use DairyBase methodology
Pasture and crop harvested (t DM/ha)	Correlated with profit	Use DairyBase methodology

Table 2: Environmental footprint KPIs

RECOMMENDED KPIs	COMMENTS	CALCULATION
Total GHGs ($t\ CO_2e/ha$)	This is a sum of all sources of methane, CO_2 and N_2O	Estimated using Overseer[FM] or the Agriculture Inventory Model (AIM)
Enteric methane ($t\ CO_2e/ha$)	Methane produced by rumination, influenced through feed eaten	Sourced from Overseer[FM], AIM or calculated using the formula (21. 6 g CH_4 /kg DM eaten x 25) /1000 = t CO_2e/ha
N_2O ($t\ CO_2e/ha$)	Influenced through decreasing N surplus	Only estimated using Overseer[FM] or AIM
Purchased N surplus (kg N/ha)	Difference between purchased N and N loss through milk production	Calculated through (N in fertilisers + N in imported feed) – N in milk (it could also include meat and exported feed)
kg N leaching/ha	Best used benchmarking between seasons on an individual farm rather than between farms	Can only be estimated by Overseer[FM]
kg P loss/ha/yr	Best used benchmarking between seasons on an individual farm rather than between farms	Can only be estimated by Overseer[FM]

Dairy businesses need to be highly profitable to survive and thrive in the current scenario of high debt and no capital gain.

situation. There are a few financial performance KPIs that can be used to support this.

As outlined in *Table 1*, each KPI helps to measure different aspects of the farm's financial performance. For example, the debt:asset ratio acts as a risk indicator. The higher the debt:asset ratio, the higher the business risk. This is compared to operating profit, which measures farm profitability across dairy farms on an equivalent basis. Understanding these factors, as well as the environmental footprint KPIs, is important to gain an overall view of how the farm business is performing and what areas can be improved.

Environmental footprint KPIs

Greenhouse gases

There are three GHGs relevant to on-farm emissions, with a different global warming potential (GWP) estimated over a 100-year period. The GWP of the gases is expressed in relative terms to carbon dioxide:

- Carbon dioxide (CO_2) is equal to 1 GWP and stays in the atmosphere for a very long time
- Methane (CH_4) is equal to 25 GWP and stays active in the atmosphere for about 12 years
- Nitrous oxide (N_2O) is equal to 298 GWP and stays active in the atmosphere for a very long time.

The primary contributor to methane emissions from New Zealand dairy farmers is enteric methane generated from rumination.

Enteric methane

Enteric methane has a direct relationship to feed eaten, so it is a key KPI to consider for on-farm change and adaption. Enteric methane can easily be estimated from DMI/ha using the calculation outlined in *Table 2*. However, when benchmarking GHG emissions there are a couple of key things to consider:

- GHG emissions in Overseer[FM] are estimated over the total area of the farm, but DairyBase and dairy company environmental reports use effective hectares

Most farmers purchase more N as fertiliser and supplementary feeds (inputs) than they sell in products as milk, meat or crops (outputs).

- At present, the GHG emissions reported for dairy farms are potentially reported from the milking platform only. This excludes emissions from when replacements and dry non-lactating cows are grazed off the property (often wintering). Accounting for enteric methane calculated from the annual feed used for MS production, when some of this feed is eaten other than on the milking platform, is currently under discussion.

Water quality

Some farmers will have limited access to GHG KPI information. Therefore, an alternative management option for farmers is to instead focus on reducing purchased N surplus as it indicates farm performance and environmental impact.

N surplus compared to purchased N surplus

N surplus is the difference between N inputs and N outputs (i.e. how much N was lost in the N cycle of the production of milk, meat, wool, crops, supplement exported off-farm etc). Purchased N surplus focuses specifically on the management factors that are within farmer control via farm policy and day-to-day decision-making, but it varies widely between farms.

Benefits of reducing purchased N surplus

Reducing purchased N surplus generally reduces N loss to the environment while increasing the cost-effectiveness of N use. Most farmers purchase more N as fertiliser and supplementary feeds (inputs) than they sell in products as milk, meat or crops (outputs). By reducing fertiliser and feed inputs and becoming more efficient, many farmers will be able to maintain production and reduce costs, thus increasing profitability.

Soil type, climate and factors influencing gaseous losses control how much of the N surplus eventually leaches below the root zone. For example, the same N surplus results in higher leaching from freely draining, compared to poorly draining, soils. The relationship between purchased N surplus and N leaching is illustrated in *Figure 1* for dairy farms in Canterbury.

As well as farm factors affecting N leaching, when using purchased N surplus as a KPI, there are two key considerations:

- Nitrogen conversion efficiency (NCE%) shows the relationship between N inputs and N outputs as a percentage. Farmers need to be aware that improvements in NCE do not always result in reductions in purchased N surplus and N leaching/ha

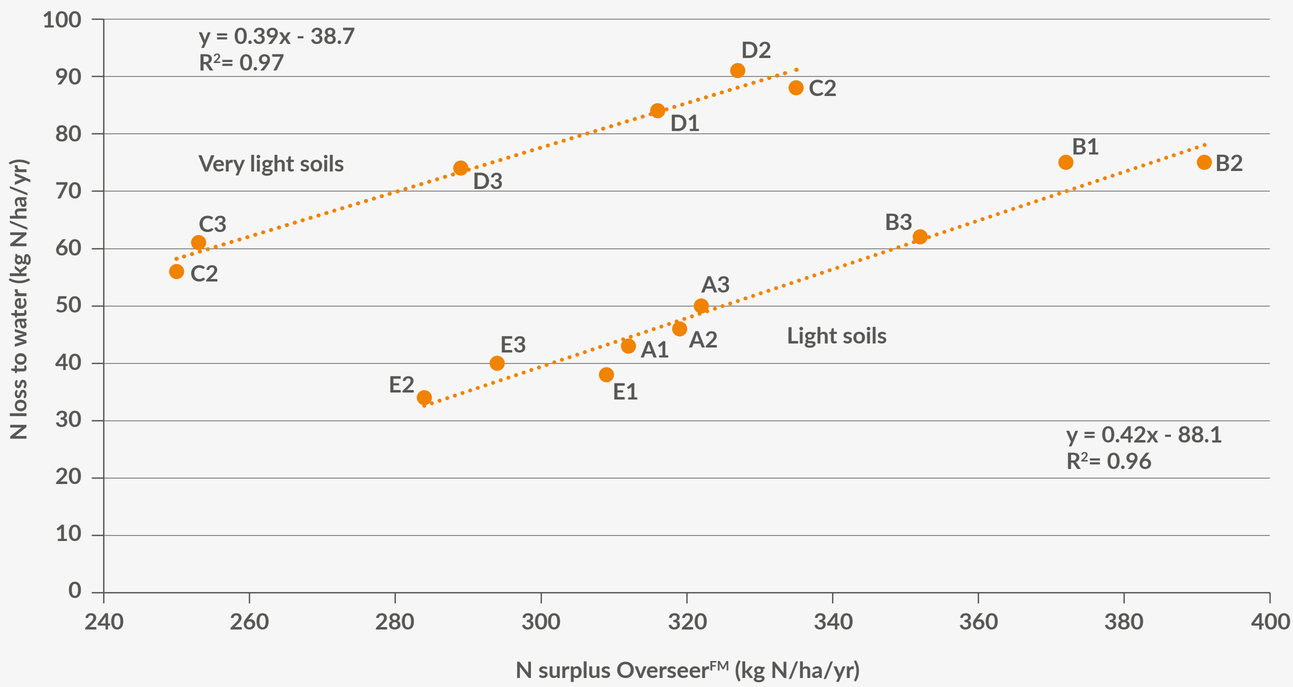

Figure 1: OverseerFM 6.30 three-year estimates of N loss to water (mainly N leaching) and farm N surplus for five Canterbury dairy farms

- Purchased N surplus is accessible from many farm dairy supplier environmental reports
- N leaching is a good KPI to track progress over time on an individual farm, rather than benchmarking across different farms
- Purchased N surplus will differ depending on what is included as inputs and outputs.

Equations and R2 for linear regressions are given for farms on very light soils (top line) and farms on light soils (bottom line). The R2 indicates how closely the data are to the fitted regression line (R2 = 1 if the regression explains all variability).

Farm system adaption – advice for RPs

When looking to adapt a farm system, it is important to set a meaningful goal and then determine what adjustments and changes are required to meet that. Going forward, when rural professionals are working with clients they should consider:

- Adaption will be required – in future, farm systems will have new parameters they need to meet
- As an industry we have a fixed timeframe to meet timelines
- Be proactive now and review your client's farm systems to see what adaption may be required. There are benchmarking resources available at www.dairynz.co.nz/stepchange to compare a client's farm to regional performance
- Seek to understand the gap they need to close to be 'future fit'. How many seasons has it taken to develop the farm system they have? How many seasons might it take to adjust if required?

Our role as dairy rural professionals is to help our farming clients better understand the relationships between the inputs and outputs of their businesses in relation to their goals and the context in which they farm. We can help farmers get ready to adapt by applying sound economic and science-based principles that are well understood regarding profit, GHGs and water quality. 'What if' scenarios developed with the integrated aim of improving profit, reducing GHGs and improving water quality in relation to a farmer's goals will help prepare them and their business for the future.

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Corrigan and Sam Sowman

CASE STUDY: ADAPTION IN ACTION

Uruwhenua Farms is the Sowman's family business in Takaka, Golden Bay. Two brothers, Corrigan and Sam, with their wives Ruth and Cara, manage the 500 ha operation consisting of a partially irrigated 268 ha dairy platform, dairy support and a recently established dairy beef operation.

The family has always tried to have an environmental focus, but a series of events triggered a farm system review that has resulted in a lower cost structure and reduced environmental footprint *(see Table 3)*.

Historically it was a System 3-4 farm with imported supplement of PKE, grain, silage and winter grazing. Over the years this business model allowed them to invest in significant capital development and repairs, as well as providing regular rostered time off and away from the farm – while repaying debt.

However, when the milk price fell in 2014 the Sowman's felt it was time to create an even more financially resilient system. At the same time, there was increasing community interest in local farming because they are in a recharge area for an aquifer for the Te Waikoropupū Springs. These factors triggered the brothers to consider change as they wanted to reduce their business risk, both for the environment and their balance sheet. They knew that adapting their system now would make their business more bankable in the future.

To start their on-farm change journey, they first considered their current farm situation and measured their performance through KPIs. After understanding these, they decided to focus on having a cash surplus business goal. Now their target is to have $1/kg MS of free cash after capital re-investment, while also focusing on protecting the environment and creating a simpler farm system. This included having a key goal to stop using PKE on-farm, which they have done.

Before they started assessing their situation, Corrigan suspected the farm system was possibly inefficient with feed in relation to their cow numbers and N use. After realising that was the case, they dropped their N fertiliser use in half over the course of a year, and the positive results emphasised they had indeed been operating inefficiently.

The farm system changes they adopted were based on the results sifted from the Resource Efficient Dairy (RED) trial, the Lincoln University Dairy Farm system and Pastoral 21 (P21).

Cow numbers have been reduced to 700 milking cows, down from 830 previously. A total of 20 tonnes of grain is fed during spring as a mineral carrier, with grass and maize silage brought in from the run-offs.

After their shift in farm system, there were a few key changes they noticed on-farm:

- Total production has dropped, although free cash has increased
- Purchased N surplus has dropped by more than 100 units, and therefore N_2O emissions and N loss to water have decreased
- Estimated enteric methane emissions between the two systems is down compared to previous years
- Per cow production is similar in both systems, but less feed is required with the new system. Even as summer droughts have worsened, they have been able to maintain the amount of imported feed, excluding PKE.

Corrigan believes that some farmers would say they have failed since their milk production has declined over the years. However, it had essentially been propped up by their inputs and high stocking rate. His view is: 'I am more interested in measuring our business on its ability to produce the protein the world wants, with the environmental footprint New Zealand needs.'

As with any system there are still opportunities to evolve. Farm working expenses rose in the 2019-20 season, with $0.58/kg MS associated with setting up a new dairy beef block and calf rearing, another dry summer and additional labour support.

Table 3: Uruwhenua's farm system shift

	2007–08	2012–13	2016–17	2019–20
Dairy platform (ha)	288	268	268	268
Dairy support block (ha)	124	130	130	130
Peak cows	990	827	815	695
Stocking rate	3.4	3.1	3.0	2.6
MS per hectare	1,210	1,374	1,246	1,075
MS per cow	352	445	410	445
Dry matter intake (DMI) tonnes per ha (DairyBase data)	16.2	17.4	15.2	14.6
Pasture and crop eaten as a % total DMI	82%		85%	85%
Tonnes imported supplement per ha	2.0		1.8	2.2
Nitrogen per hectare	300		206	76
Milk income per kg MS	$7.28	$6.52	$5.77	$6.94
Farm working expenses per kg MS	$4.16	$5.09	$3.84	$4.84
Operating profit ($/ha)	1,566	1,034	1,396	1,827 (estimated)
Estimated purchased N surplus (kg N/ha)	262		172	52
Estimated enteric methane (kg CO_2e/ha)	8,748	9,374	8,208	7,884


Earthworm and cast


Earthworm in burrow

NICOLE SCHON

EARTHWORMS AND SOIL HEALTH

Soils contain a diversity of life that is important for the functioning of soil and the provision of ecosystem services. Earthworms are a key component of the soil biology and they are recognised as indicators of soil health. With an increasing interest in soil health it is timely to recognise the contribution of these underground workers.

Importance of earthworms

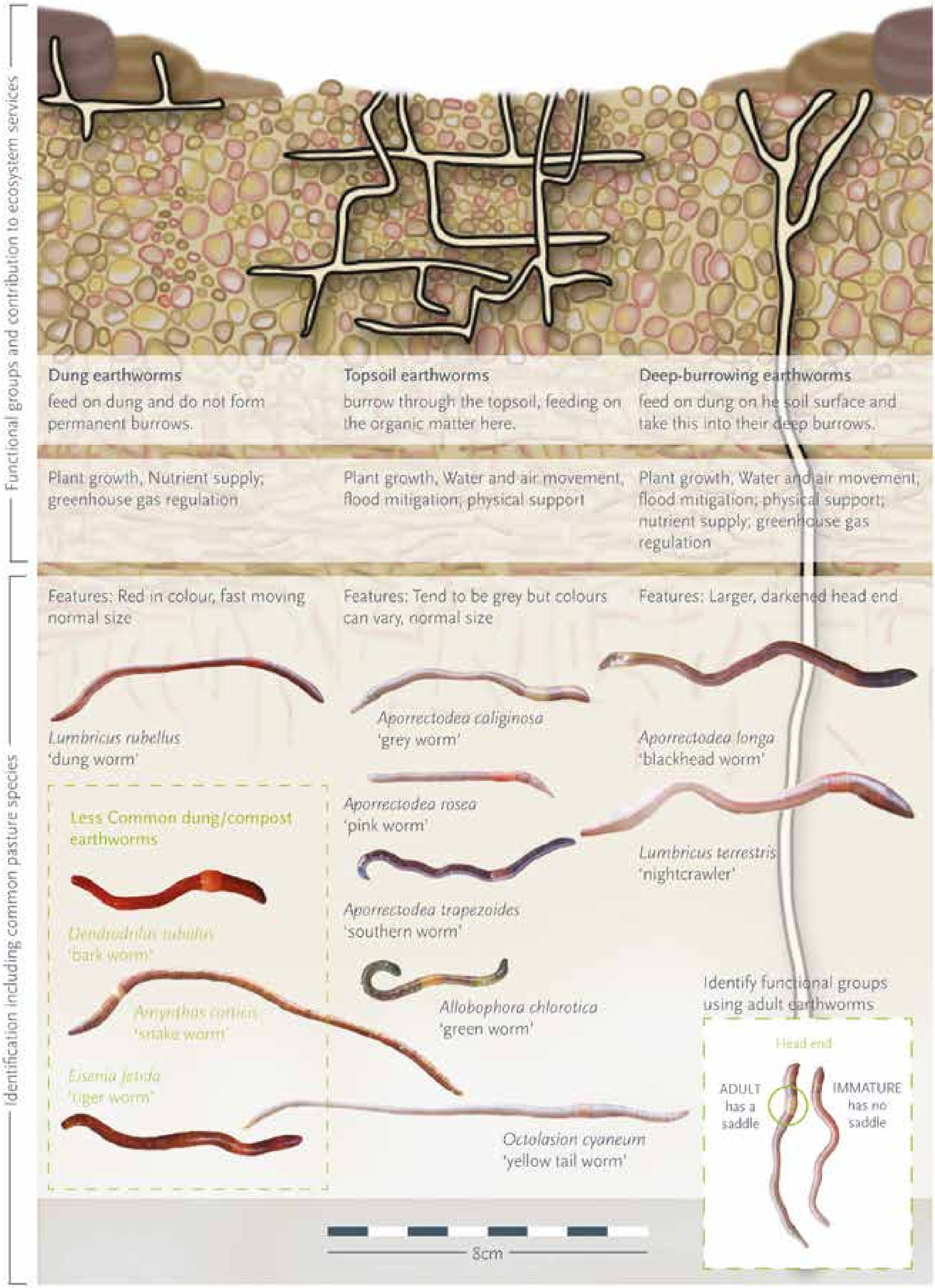
Earthworms benefit the soil by enhancing both the chemical and physical properties of the soil. They feed on organic matter on the soil surface and within it, helping to break down dung pats and incorporate this carbon into the soil. The casts they produce contain a higher concentration of plant-available nutrients in comparison to the bulk soil.

Earthworms break down organic matter into smaller-sized carbon fractions and improve the soil's water-holding capacity. Simultaneously earthworms burrow through the soil, improving macroporosity and water infiltration. Earthworm burrows aid the growth of plant roots down the soil profile. With all their activity within the soil it is no wonder that earthworms are able to enhance plant growth. Research in both New Zealand and overseas has shown that their presence in the soil increases plant growth by 20%, especially when abundances are over 400/m^2.

Three different types

There are three different types of earthworms in our soils: dung, topsoil and deep burrowing ***(Figure 1)***. The different feeding and burrowing behaviours of these earthworm types impact soil functions differently:

- Dung earthworms live and feed on organic matter near the soil surface, incorporating carbon and nutrients into the soil, having little impact on soil porosity
- Topsoil earthworms burrow extensively throughout the topsoil, forming semi-permanent burrows to benefit water, air and root movement, and feed on the organic matter within the soil
- Deep burrowing earthworms are larger and form burrows, which extend to depth but remain open to the soil surface to improve water infiltration. They also feed on organic matter at the soil surface and incorporate this to greater depths.



There are 200+ native species which vary in size and colour. They are not common in pastures and not included here. For more detailed assessment of earthworm species go to www.agresearch.co.nz/earthworms. Photos by R. Gray.

Figure 1: Identifying earthworm functional groups

Earthworms are active during the wetter months and the best time to assess their populations is in late winter/spring.

To get the greatest benefit of earthworms in our soil we want to see all three functional types of earthworms working together.

A diverse earthworm community, containing the deep burrowing earthworm, has been shown to benefit the incorporation of dung into the soil profile. The incorporation of dung into the soil accumulates carbon in the smaller-sized, and potentially more stable, carbon fractions.

Earthworm abundance

Recent research has further explored how earthworm functional diversity and abundance impacts soil functions. The greatest benefits are seen when all three types of earthworm functional groups are found in abundance and in combination *(see Figure 2)*. This study had initial abundances of no, low (110/m^2), medium (225/m^2) and a high (570/m^2) number of earthworms, of either a single species or a combination.

Potentially available nitrogen was greatest in a diverse and abundant earthworm community. Water infiltration rates were greatest in the presence of the deep burrowing earthworm (*A. longa*), but having a smaller number of this species in a diverse earthworm community (as would be seen in a pasture setting) also improved infiltration rates.

Great Kiwi Earthworm Survey

Earthworm abundances vary seasonally and are sensitive to management. To determine whether you have healthy populations of earthworms (>400/m^2), you can get out with a spade and take a closer look at what is in your soil.

Earthworms are active during the wetter months and the best time to assess their populations is in late winter/spring. Once you have dug up a spade square you need to manually remove the earthworms from the soil and place them into a container of water, as this will make counting and identification easier.

More detailed instructions on what to do and how to partake in the Great Kiwi Earthworm Survey, including an identification key, can be found at www.earthworms.nz. Any data, along with photographs collected, can be entered on the website as part of the citizen science project. This information will be collected and will help to identify the distribution of earthworm abundance and diversity across New Zealand.

Improving our understanding of how earthworm abundance and functional diversity varies across New Zealand will enhance our ability to maximise the capacity of our soils to function. Although we have nearly 200 native species of earthworms in this country, these tend to be found in our less disturbed native ecosystems, and we

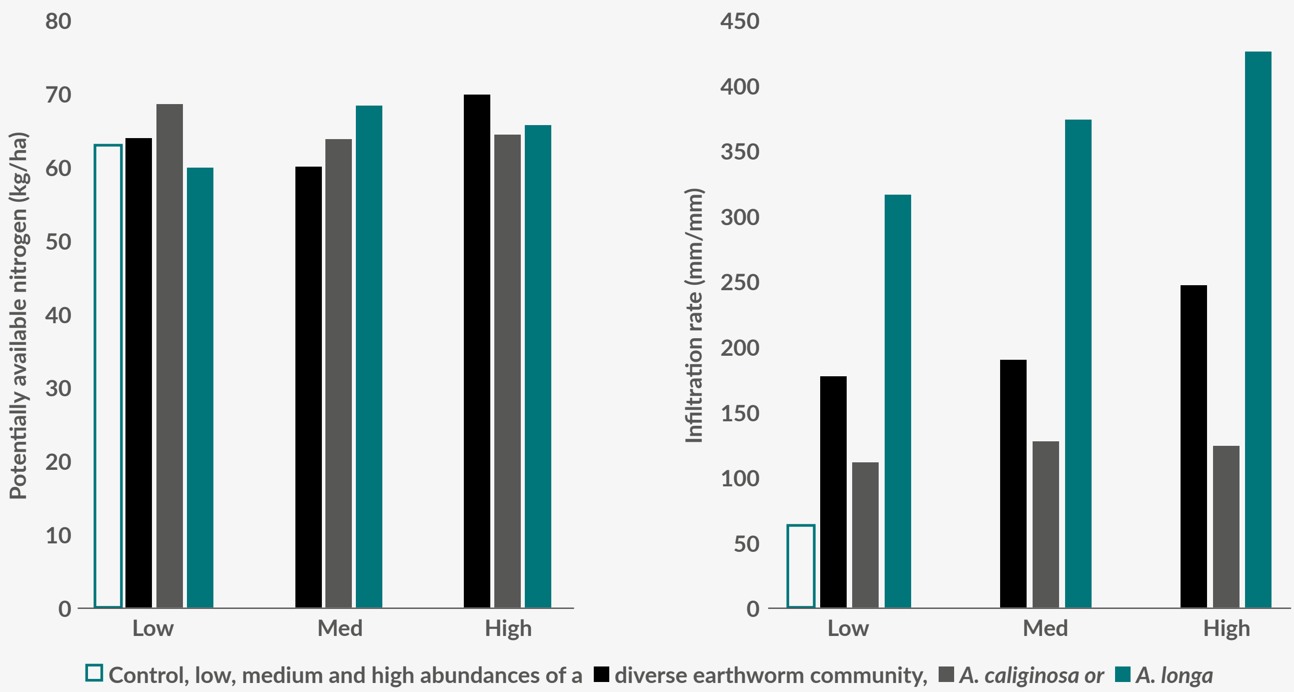


Figure 2: Influence of earthworm abundance and species diversity on potentially available nitrogen and soil infiltration rates

The Great Kiwi Earthworm Survey builds on earlier surveys that have found that the distribution of exotic earthworms remains sporadic in New Zealand.

rely on a handful of exotic species to support our primary industries. The exotic earthworms that are found in our agricultural systems arrived accidentally, being thought to have been transplanted into the environment with fruit trees and the dumping of ships ballast by European settlers.

The Great Kiwi Earthworm Survey builds on earlier surveys that have found that the distribution of exotic earthworms remains sporadic in New Zealand. Although there are still areas that lack earthworms, including those converted from pine plantations, most areas have some present. Our most common types of earthworms found in most pastoral landscapes are either dung or topsoil, while the deep burrowing earthworm is less common.

It is estimated that large areas of pasture land, especially in hill country and the South Island, contain only up to two earthworm functional groups and lack deep burrowing earthworms. The addition of this third functional group to the earthworm community has been shown to benefit soil functioning, and even at low abundances their benefits are quantifiable.

Improving earthworm populations

Early researchers in New Zealand recognised the absence of earthworms from pasture soils and set about introducing them into areas with none. By spreading earthworms across a landscape at 10 m spacings it took six to seven years for them to establish. Their establishment in the environment broke down the thatch layer and improved the movement of water and nutrients into the soil, changing pasture composition and improving pasture growth. This capital investment into earthworms remains beneficial today.

More recently, the introduction of deep burrowing earthworms into pasture soils has been assessed. Earthworms were introduced across a diversity of soils and landscapes and were monitored over a four-year period. Establishment was successful over this time period, although their abundances remained too low to see a measurable benefit to soil functioning, and more time is required for their populations to cause significant benefits.

Earthworm abundance and functional diversity may be a result of historical artefacts, but can also reflect current management. To get the benefits from earthworm activity in the soil, we know there is a need to increase earthworm abundances above 400/m^2 and to have all three earthworm functional groups represented. If this is not the case, we can work towards improving their habitat through both increased food supply and reduced physical disturbance. We know that earthworms will respond quickly and increase in abundance as conditions are improved, resulting in a benefit in soil functioning.

Earthworms respond to increases in food supply, in the form of organic matter, which ensures the populations can flourish. Organic matter may be enhanced by increasing plant growth or applying compost and manure.

Fertiliser application may be one way to stimulate plant growth and earthworm populations. For example, at the long-term sheep-grazed fertiliser trial at Ballantrae, Manawatu, where farmlets have received either no, low (125 kg/ha) or high (375 kg/ha) applications of superphosphate since 1980, earthworms were most abundant at high fertility. The farmlet receiving no fertiliser has low pasture production with low-quality pasture species, reflecting less palatable organic matter available for earthworms. In contrast, the high-fertility farmlet has high pasture growth and a greater proportion of dung earthworms, reflecting a readily available source of organic matter for them.

The application of compost and manure can also stimulate earthworm populations, with the application of 20 t/ha of either straw or manure causing their numbers to double in six weeks in comparison to the control.

Just as the supply of food is important for earthworms, so too is their physical environment. Physical disturbance of the soil (through either compaction or cultivation) makes it more difficult for earthworm populations, reducing their abundance and their ability to benefit soil functions.

The impact of pugging events is moderated by soil type. As stocking rates increase, it is those soils most vulnerable to compaction that will have the greatest impact on earthworms and the soil environment. For example, as dairy cow stocking rates increased from 2.3 to 3.8 cows/ha on two co-occurring and contrasting soils in the Waikato, earthworm populations decreased only in the Gley soil (where the severity of compaction was enhanced and bulk density was higher) in comparison to the Allophanic soil.

Reducing the intensity and frequency of cultivation will also benefit earthworm populations, as these may be halved during a single cultivation, and the greatest earthworm abundances are seen under permanent pastures rather than in arable soils.

Exchangeable calcium and soil pH and are also important, but pH appears to be more important in the first instance. The optimum pH range for pastures (pH 5.8-6.0) is also appropriate for optimum earthworm activity.

Earthworms are important underground workers and an essential component of the farm landscape. Managing our soils to improve conditions for earthworms will ensure that the soil is better able to function with fewer interventions. Earthworms are not only a sign of a healthy soil, but also cause a better functioning soil. Make time to take stock of the earthworms in your soil: visit www.earthworms.nz.

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NZIPIM PROFILE

SCOTT CAMERON

This profile looks at the life and work of Scott Cameron – Chair of the NZIPIM Central Districts Branch, Fonterra employee and entrepreneur.

Scott was born and raised on a dairy farm in Taranaki, and the 250 cow Jersey herd on 80 ha ignited his passion for agriculture and dairying. Leaving high school, he studied a Bachelor of Agricultural Science at Massey University, graduating in 2012 before taking on his first job at DairyNZ.

DairyNZ roles

The DairyNZ graduate programme took him to Northland for two years, where he worked with farmers between Whangarei and Auckland. Scott noticed the community feel in each of his discussion group areas, making it very easy to fit in during his first job out of university. The warm climate at times often makes farming difficult, but make the off-farm activities – like surfing and fishing – very enjoyable. The resilience of his farmers in the area resonated with Scott as working in Northland can be particularly challenging. In his short time there he noticed they went through two dry summers/drought, a flood, insect pressure, and had to deal with a range of soil types and the challenge of kikuyu and ryegrass, along with making a profitable business. Their 'can do' attitude and ability to look for the positives always stood out, making it a great place to work.

The following four years Scott spent working for DairyNZ in the Manawatu, largely Horowhenua, but also up to Wanganui and Waverley. He led the heifer grazing focus farm, a new initiative at the time, with the goal of heifer development and their potential. The focus farm was mainly run on a heifer/beef/cropping farm in Marton, with a few field days held in the Hawke's Bay and Wairarapa. The objective of the field days was to grow better heifers, talk about what was important in their management, what influences decisions, and how to achieve good results. Ultimately, better results included improving herd reproductive performance and farm profitability.

Fonterra experience

In 2018, Scott started at Fonterra as Business Development Manager across the Lower North Island. He had always had an interest in the grass-to-glass concept, and when the role came up it was very appealing. The home farm supplied Fonterra, and the legacy companies as well, dating back to one of the original Kiwi founders, T.L. Joll Co-operative. In recent years, the expansion in dairying has also meant an expansion in dairy companies in this country. Scott believes New Zealand is fortunate to still have a co-operative as a leading milk processor and marketer when compared with other countries. The co-operatives turn 150 next year, and with all the bumps along the way the three key philosophies have not changed from when the very first co-operative was established in Otago:

- Pick up milk every day so it does not spoil
- Pay the maximum milk price
- Divide the profits evenly between shareholders.

COVID-19 has tested all businesses, and the scale, networks and agreements that Fonterra has in place have been a real strength over the last 10 months. For instance, getting shipping containers for product, and then stacked and shipped around the world, with the ability to divert ships if needed and still sell your farmers' milk for a good price. The ownership of shares secures that advantage.

While working at Fonterra, Scott has co-launched a business called Gear Hub (www.gearhub.co.nz), which is a place for farmers to rent machinery from other farmers in their area. The natural disasters of both floods and droughts that Scott has been involved in, low payouts, and the frustration of needing equipment to complete a job inspired the idea. Farmers list idle machinery on the website, including price and location. This can be booked by another farmer nearby, payment is made, and the item is picked up and dropped off. Hire contract is included in the booking and insurance can be provided on request. The objective is to help make farming that little bit easier, with farmers helping farmers.

This is a new concept to agriculture, and at only one year young, those who are using the website are certainly reaping the benefits. Airbnb and Uber are the new norm, and Gear Hub's goal is to be that norm in this sector.

Community and NZIPIM involvement

Scott's time at DairyNZ also showed him how much time and planning goes into running events. His thinking was that to attend an event, he should also do what he could to give back for future community events and clubs. Following this belief, he joined the Whangarei Young Farmers as Vice Chair, coached U13 rugby league along with being on the club committee, and was one of the founding members of the Manawatu Young Professionals Network board, to name a few roles.

He also does what he can to raise money for Movember, even with the inability to grow much facial hair! Scott rallied his work colleagues to join his team and get behind this initiative, as he feels that any donation is a good donation for a great cause.

Scott attended his first NZIPIM event while up in Northland, not knowing much about the organisation at the time, but saw the importance of the rural professional connection while upskilling. He has been a member ever since and took over as Chair of the Central Districts Branch three years ago. The primary industry is constantly changing and adapting. Scott sees the NZIPIM as a great way for rural professionals to connect, share ideas and upskill, ultimately improving the service provided to our clients along the way. He also initiated an annual student event, alongside having a student representative on the committee. When students leave Massey, he wants them to be already connected with the Institute (regardless of where their first role is), and to be able to connect with other NZIPIM members as a kick start for their careers.

Scott is very positive about the future of the primary sector, particularly dairy, which he has most knowledge about. Whether farmers are looking at buying their first farm, another farm or succession options, he believes it can be a promising time for all.

Northland discussion group

Scott recently held an event in Taranaki where the room was full of farmers at all ages and stages. One of the farmer speakers purchased their first farm by takeover in June 2020. In his presentation he noted:

- All the uncertainty heading into June as New Zealand had just come out of lockdown. At the time the payout by one bank was picked to be in the $5 range per kg MS. He was concerned about the quantity of debt he was carrying, and whether he had made the right decision. He had been nervous putting in the offer back in November last year, and his anxiety was definitely amplified over the following six months
- By November his biggest challenge was too much grass and not enough sunny days to make silage. Payout had more certainty, cows were milking well, and with the cash surplus generated this season he plans to pay back debt and buy some shares for the future. This provided some confidence that he made the right decision a year ago.

Role of rural professionals

Scott believes that having a strong support network as a farmer (including using rural professionals) is essential in making the right decisions. Farmers need strong unbiased rural professionals who can support their business, aid in decision-making, and provide facts and solutions. They also need a level of community engagement, whether it be through discussion groups, a beer and cheese night, or the rugby club – like-minded people to act as a sounding board.

The connection amongst rural professionals is also important, as it is a natural network to support and share ideas. For Scott, it was encouraging to see so many members come to the recent NZIPIM conferences that were held around the country, and he says thanks to Melissa, Stephen and the team for organising these. He was glad these could and did go ahead.

Scott feels privileged to have worked in the dairy industry and to have been involved with so many great people over his short career. As always, there is a level of uncertainty as to what the future will look like. However, he is confident that by being solutions-focused, surrounded by a strong team or network, rural professionals will continue to support our clients to cope with difficulties and achieve a good outcome.

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Working for the good of the Rural Profession

NZ Institute of Primary Industry Management

www.nzipim.co.nz