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ON-FARM MITIGATION OF GREENHOUSE GASES IMPROVING AGRICULTURAL EXTENSION
RUMINANT ANIMAL WELFARE IN SUMMER SETTING WATER QUALITY LIMITS **IRRIGATION UPDATE**

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Contents

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Brexit – how did it come to this and what's next?

Watching from the sidelines, it has been interesting to observe the machinations that have followed the decision by the UK in June 2016 to leave the EU, the world's largest trading bloc.

How did it come to this? In an effort to move the Conservative Party away from 'banging on about Europe' the Prime Minister David Cameron found it impossible to resist pressure from his backbenchers and increasingly difficult to shake off past election promises, and decided to call for a referendum on the proposal to leave the EU.

Cameron's gamble did not pay off. He seriously misread British public sentiment against the backdrop of populist antagonism towards Europe's political elite, the EU's onerous rules, widespread discontent about the scale of immigration, and the traction generated by the pro-Brexit movement led by some very charismatic individuals. The rest, as they say, is history.

Following the referendum result, the UK Government became the first ever EU member to invoke Article 50 of the Treaty of Lisbon, starting a two-year countdown to negotiate an exit package with the EU. Negotiating a complete and comprehensive arrangement with the EU within that timeframe was a hugely ambitious task, given the length of time it normally takes to negotiate trade deals.

As the March 2019 deadline approaches, a clearer picture is beginning to emerge of the possible scale and content of a future deal between the UK and EU. We are also starting to understand the implications for New Zealand exporters of the UK's divorce from the EU. Within the UK and New Zealand the respective governments have initiated a process of public consultations about a future bilateral trade accord. The clock is ticking.

Recently the UK and EU notified New Zealand, and other WTO members, of their plan to impose a split of the EU's Tariff Rate Quotas (TRQs) on the basis of a three-year reference period of imports from 2013 to 2015. In its submission on this proposal, the New Zealand Government and exporters made it clear that this approach would not be acceptable. It would undermine the flexibility New Zealand exporters have had since the Uruguay Round of negotiations ended in 1994, to maintain market stability by responding to shifts in consumer demand and changing market conditions between Europe and the UK markets.

Reduced flexibility in trading product between the UK and Europe under TRQs, particularly for lamb exports, would have an economic impact on exporters and the potential to upset market dynamics. It would also negatively affect local suppliers providing product to these markets.

Looking ahead, a provisional agreement on the withdrawal package has been reached by negotiators and endorsed by the UK Cabinet and EU member states. However that provisional agreement now needs to pass through a number of additional steps before it can enter into force. The required vote in the UK parliament will be critical, but based on media reports this would appear uncertain. Much more political jostling appears inevitable, meaning several more scenarios could play out. The possibility of the UK departing the EU without a deal cannot be ruled out.

A 'no-deal Brexit' would mean that the free circulation of goods between the UK and EU would cease. This would have significant downside implications for exporters, importers and consumers. It would cause severe disruption along the supply chain for New Zealand's exporters trading into Europe through the UK.

The prospect of the UK leaving the EU without a deal remains unlikely, given the mutual interests of the UK and the EU in securing a satisfactory negotiated outcome. But as David Cameron's decision to hold a referendum on Brexit clearly showed, there are no guarantees in such a volatile political environment.

New Zealand has strong historic links with Britain and current two-way trade is worth almost NZ$6 billion annually. The priority for New Zealand is to move quickly to start negotiating a new long-term free trade agreement with the UK, to safeguard the position of our exporters in that market, and allow goods and services to continue to flow unhindered between the two countries.

On a final note this is the last Journal article for the year. I would like to thank and acknowledge all the contributors to the Journal in 2018, and the great work of the Editorial Committee ably lead by Nico Mouton and supported by our Editor Helen Greatrex. I also wish to recognise the tremendous contribution of Kevin Wilson and Keith Woodford who retired from the Committee this year. J

PHIL JOURNEAUX

ON-FARM MITIGATION OF GREENHOUSE GASES

This article follows on from various articles in the previous edition around greenhouse gases (GHGs) and climate change. It discusses work investigating the implications of mitigating GHGs at an on-farm level carried out over the last four years.

The intensity of emissions is a good news story for New Zealand, as our pastoral farming is very efficient and therefore has a low intensity level.

Real farm modelling

This work involved modelling a number of real farms, and regional models, in Farmax and OVERSEER. The farms and models were developed in Farmax so changes in farm systems could be modelled as to their physical and financial effects, with the information then transferred into OVERSEER to calculate the impact on GHG emissions. Land use change, in the form of forestry and horticulture, was also modelled as part of this work. The GHGs of interest are the 'biological' gases – methane (CH_4) and nitrous oxide (N_2O). Within this, of the farms modelled, approximately 75% of the biological emissions were methane and 25% nitrous oxide.

A summary of the modelling is shown in *Tables 1* and *2*. The intensity of emissions is a good news story for New Zealand, as our pastoral farming is very efficient and therefore has a low intensity level. The bad news is that all international treaties, and the ETS, deal in absolute emission levels. The ranges indicate a wide variation, largely relating to the level of intensity of farming; generally the higher the intensity of farming the higher the absolute emissions and the lower the level of intensity of emission.

Table 1: Average GHG emissions/ha (CO_2e)

	AVERAGE TONNES GHG/HA	RANGE TONNES GHG/HA
Dairy	12.5	8.0 – 18.0
Sheep and beef	3.5	1.0 – 5.0

Table 2: Intensity of emissions kgCO_2e/kg product

	AVERAGE	RANGE
Dairy	11.5	7.5-14.5
Sheep and beef	21.0	5.0-37.0
Hill country	25.0	
Intensive	15.0	

The modelling of farm system changes at the farm level showed the impacts as illustrated in *Tables 3* and *4*. Note that the change in GHG emissions and EBIT and *Tables 3 and 4* are relative to the original base system. Also note that these are not all of the scenarios modelled, but a range to indicate the level of changes obtained. Perhaps the first point is that every farm was different; the impact of any system change depended very much on the original system and how intensive, or otherwise, it was. As a generalisation, the various changes resulted in a +/- 5-10% change in GHG emissions and a variable impact on farm profitability.

Reduction in stocking rate

A reduction in stocking rate, especially on dairy farms, is often indicated as a silver bullet to GHG (and nitrogen) emissions, which it isn't. The situation is much more nuanced; as stocking rate was reduced, the first step was to reduce supplements bought in, which saved cost. Often there was a resultant surplus of pasture, which allowed for an increase in per cow production.

Whether the farm had a resultant lift in profitability depended on where they were on the marginal cost/ marginal revenue curve. If marginal cost (MC) was greater than marginal revenue (MR), then a reduction

Table 3: Dairy on-farm system change

		CHANGE IN GHG	CHANGE IN EBIT
Reduce stocking rate by 10%	Farm 1	-6%	12%
	Farm 2	-7%	-4%
	Farm 3	-8%	-3%
	Farm 4	-3%	14%
Replace N fertiliser with bought in feed		-11%	-18%
In-shed feeding with increased cow numbers		11%	12%
In-shed feeding, no increase in cows		10%	9%
Grow maize instead of buying in PK		-4%	0%
Limit N fertiliser to 100 kgN/ha		-5%	-12%
Shift to once-a-day milking		3%	21%

Table 4: Sheep and beef on-farm system change

		CHANGE IN GHG	CHANGE IN EBIT
All male progeny as bulls		-6%	12%
Convert to deer (finishing weaners)		0%	-19%
Shift to 50:50 sheep:beef		-10%	13%
Increase sheep:cattle ratio			
	Farm 1	-1%	0%
	Farm 2	1%	10%
	Farm 3	-1%	-20%
	Farm 4	0%	19%
Intensive lamb finishing		7%	22%
Increase lambing % (135 to 160)		0%	12%
Develop 100 ha techno beef unit		9%	33%
Replace breeding cows with finishing bulls and heifers		-8%	78%
Convert to dairy sheep		17%	68%

in stocking rate would (usually) result in an improvement in profitability. If the farm was operating such that MC (roughly) equalled MR, then often a reduction in stocking rate resulted in a reduction in profitability. Added to this is the expertise of the farmer in grazing management. If good, often per animal production could be increased. If not, then pasture quality would decline, along with per animal production. So again, every farm was different.

In a similar situation, increasing productivity levels on sheep and beef farms (i.e. increasing lambing or increasing final carcass weights, both of which improved profitability) was often offset by the need to reduce capital stock numbers to free up feed to achieve the increased productivity levels. So the goal was to achieve an equilibrium point, which may or may not reduce GHG emissions, and may or may not lift profitability. But, overall, the modelling did indicate that there was some gain (albeit limited) in reducing GHG emissions via farm system change.

A reduction in stocking rate, especially on dairy farms, is often indicated as a silver bullet to GHG (and nitrogen) emissions, which it isn't.

The largest reductions in GHG emissions were achieved via land use change, which was mostly modelled as forestry. An illustration of the results is given in *Table 5*. Forestry profitability was calculated as an annuity, discounted at 5%, to compare it to the farm EBIT (the main tree species modelled was *Pinus radiata*). This was always less than the dairy average EBIT, hence the reduction in profitability when forestry areas were planted on dairy farms.

For sheep and beef farms the situation varied, as in a number of farm cases the forestry annuity was greater than the farm EBIT, and the addition of forestry resulted in an improvement in farm profitability. On other farms, the areas (modelled to be) planted in forestry tended to be the steeper less productive areas, and while the whole farm EBIT was used in the analysis, in many cases the specific area to be planted was probably contributing little to the overall farm income.

Within the modelling, this was accounted for to some degree by splitting the hill country farms proportionally into 'steep', 'rolling' and 'flat' land, with pasture growth adjusted accordingly (less on the steep areas, more on the flat areas), and with the trees planted on the steep area, which had a lesser impact on farm profitability.

The returns from forestry are affected by a range of issues, particularly the 'harvestability' on-farm, which often relates to access and the steepness of the terrain and the distance of the farm to mills or ports. While forestry is a means of producing significant GHG offsets, the other thing to remember is that it is not a long-term solution. In essence, it offers a (say) 30-year window to develop a more permanent solution. This is in the sense that assuming (say) 100 ha is sufficient offset; in year 28 when it is harvested, the initial 100 ha needs to be replanted, plus a further 100 ha to offset the next 28 years. And so on.

Forestry planting to offset emissions

The planting of forestry to offset farming emissions is somewhat complex and outside of this article to fully describe. Under the current ETS rules, if forestry is harvested, then approximately 80% of the sequestered carbon is deemed to be released and any credits claimed need to be repaid. Consideration of this can affect the area of land needed to be planted, as shown in *Table 6*.

In *Table 6*, 'total' carbon relates to a regime where the trees are never harvested, whereas the 'safe' carbon relates to the amount of carbon that remains after harvest (i.e. stump, roots etc, often referred to as 'trade without penalty'), which is the amount of carbon that can be sold or used as an offset without having to pay it back.

As ***Table 6*** illustrates, dairying has something of an issue, given there is often little marginal land on most farms that can be planted, whereas most sheep and beef farms have some marginal areas that can be planted, although if a 100% offset was required the issue becomes problematic. Also, if you are a dairy farmer thinking of buying a sheep and beef farm to plant up, have a good financial analysis done, because potentially you are about to write off a lot of capital. Interestingly, many of the farms where forestry was modelled as an option were very interested in forestry, but in anything but radiata.

The forestry modelling did incorporate other species, particularly manuka, as well as totara and lusitanica. While other species have their place, generally radiata provides the greatest economic return, as well as having the fastest carbon sequestration rate.

Table 5: Impact of forestry land use change

	WAIKATO DAIRY FARM		NORTH ISLAND HILL COUNTRY FARM	
	Change in GHG	Change in EBIT	Change in GHG	Change in EBIT
5% forestry	-6%	-8%	-18%	-7%
10% forestry	-14%	-15%	-33%	-12%
15% forestry	-22%	-20%	-49%	-20%
20% forestry	-30%	-35%	-64%	-24%
30% forestry	-45%	-50%	-93%	-35%

The largest reductions in GHG emissions were achieved via land use change, which was mostly modelled as forestry.

Table 6: Hectares of radiata forestry required as an offset

% OFFSET	5%		10%		50%		100%	
	Total	Safe	Total	Safe	Total	Safe	Total	Safe
147 ha dairy farm	3.3	15.3	6.6	30.6	32.8	153.1	65.6	306.3
627 ha sheep and beef farm	3.9	18.3	7.8	36.6	39.2	182.9	78.4	365.8

Permanent horticulture (e.g. kiwifruit, pipfruit) is also an option as an alternative low carbon emitting land use.

Permanent horticulture (e.g. kiwifruit, pipfruit) is also an option as an alternative low carbon emitting land use, as average emissions are of the order of 0.1-0.2 tonnes/CO_2e/ha. Modelling growing chestnuts (central North Island – cold winter) is shown in *Table 7*. The reduction in GHG emissions on the sheep and beef farm were relatively modest, mainly due to the size of the farm (928 ha effective). While the impact was significant on the area converted to chestnuts, the area involved was quite small relative to the size of the whole property.

Point of obligation

The point of obligation is also an important aspect which will affect how farmers react. Currently under the ETS, the point of obligation will lie with the processors. Assuming agriculture comes within the ETS, they will be required to purchase NZUs relative to their market share, and then pass the cost of this on via reduced schedules and payouts. While this approach is administratively simpler, it provides no direct incentive to individual farmers to reduce GHG emissions. In many respects this approach socialises the impact of increasing GHG emissions from a single farm; if one farm increases its GHG emissions, the cost is spread across the whole sector. To provide an incentive for individual farmers to act, the point of obligation would need to be at the farm level.

The likely impact of the point of obligation being at the processor level on meat schedules and milksolids payouts is shown in *Tables 8* and *9*. For the technically minded, the figures in *Table 8* are based on an emission intensity of 22.5 kgCO_2e/kg carcass weight (for sheepmeat) and for *Table 9* on 8.0 kgCO_2e/kg milksolids. Potentially the cost will be slightly higher, as the companies will undoubtedly look to recover their administration costs.

If the point of obligation is put down to the individual farm then the impact, based on the average emissions as shown in *Table 1*, would be as set out in *Tables 10* and *11*. What *Tables 8* to *11* illustrate is that if farming is operating in the upper left-hand quadrants, then the cost (albeit a

Table 7: Impact of permanent horticultural crop

	CHANGE IN GHG	CHANGE IN EBIT
Dairy farm		
+ 10 ha chestnuts	-5%	96%
+ 40 ha chestnuts	-24%	346%
Sheep and beef farm		
+ 10 ha chestnuts	-1%	14%
+ 40 ha chestnuts	-3%	61%

Table 8: Indicative impact on meat schedule ($/kg)

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	**$20**	**$30**	**$50**	**$100**
5%	$0.02	$0.03	$0.06	$0.11
10%	$0.05	$0.07	$0.11	$0.23
50%	$0.23	$0.34	$0.56	$1.13
100%	$0.46	$0.68	$1.13	$2.25

Overall, mitigating farm GHGs is not necessarily straightforward. While altering farm systems can achieve some reductions, generally these are somewhat limited around the 5-10% level, with varying impacts on profitability.

Table 9: Indicative impact on milksolids payout ($/kg)

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	$20	$30	$50	$100
5%	$0.01	$0.012	$0.02	$0.04
10%	$0.016	$0.024	$0.04	$0.08
50%	$0.08	$0.12	$0.20	$0.40
100%	$0.16	$0.24	$0.40	$0.80

Table 10: Cost/ha dairy farm

	PRICE OF CARBON ($/t/$CO_2$E)			
GHG reduction	$20	$30	$50	$100
5%	$13	$19	$31	$63
10%	$25	$38	$63	$125
50%	$125	$188	$313	$625
100%	$250	$375	$625	$1,250

Table 11: Cost/ha sheep and beef farm

	PRICE OF CARBON ($/t/$CO_2$e)			
GHG reduction	$20	$30	$50	$100
5%	$4	$5	$9	$18
10%	$7	$11	$18	$35
50%	$35	$53	$88	$175
100%	$70	$105	$175	$350

deadweight cost) is annoying but survivable. If farming ends up operating in the bottom right-hand quadrant, then the cost starts to become prohibitive.

Mitigating farm GHGs

Overall, mitigating farm GHGs is not necessarily straightforward. While altering farm systems can achieve some reductions, generally these are somewhat limited around the 5-10% level, with varying impacts on profitability. Land use change into forestry offers greater levels of GHG offsetting, but again comes with issues of its own.

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PETER D. KEMP

CLOSING THE GAP – WHAT CAN BE DONE TO IMPROVE AGRICULTURAL EXTENSION IN NEW ZEALAND?

Agricultural extension in New Zealand is successful in increasing farm productivity and sustainability. However, it can be improved by researchers directly communicating with farmers more often, more social science research on the fundamentals of farmer learning, and by the provision of professional development courses for all advisors.

Farmers assessing forage plants' roots and density

On-farm performance suggests that farmers collectively are effectively incorporating innovations and new technologies into their farm systems.

How to improve agricultural extension so it results in practice change by more farmers and at a faster rate has a long history of research, but in recent years this has been more in the style of feedback surveys than fundamental social science research. In this article it is suggested that agricultural extension is successful in New Zealand for increasing farm productivity but we could do better, especially in the public good arena, by putting more effort (and funding) into fundamental research on agricultural extension and how farmers learn. A case study example is given to support this viewpoint. It is also noted that an investment in professional development courses for agricultural extension practitioners would advantage the primary industries.

Provision of extension services

It is a widely-held view that it can take 20 years for an innovation, or a new technology, that requires a complex change to farm systems to be fully adopted by farmers. A corollary of this slowness of the widespread adoption of a practice change is that there is a time lag between early and later adopters. This gap between initial provision of agricultural extension advice on an innovation and its widespread use by farmers has long been a focus of extension providers and a concern of industry and government.

Since the demise of New Zealand Government provision of agricultural extension in 1995, farmers have been served by a range of private providers and their own farmer-to-farmer networks. Farmers are well served by industry-specific providers (e.g. DairyNZ, Beef + Lamb NZ), national and regional providers (e.g. AgFirst, PerrinAg, BakerAg), agribusiness providers (e.g. PGGWrightson, Ravensdown), and individual consultants.

A drawback of private providers of agricultural extension is in the provision of public good advice and education on issues such as climate change, greenhouse gas emissions, and non-proprietary innovations or technologies to increase the sustainability of farm systems. Private providers can (and do) cover such topics, but not usually on a nationwide basis and not without the perception (fairly or unfairly) they have a commercial interest that influences the advice they provide.

The New Zealand Government recently recognised this problem with public good extension by launching a pilot programme called the Extension Service Model Initiative through the Ministry for Primary Industries (MPI). Whether or not this initiative morphs into a back to the future national extension service remains to be seen.

Increased farm productivity

Although we have had over 20 years evolving from a publicly-funded extension service to a service provided by private industry and co-operatives, farm productivity has shown impressive gains. For example, lamb carcass weight per ewe increased 3.1% per year over the 10 years from 1998/2008 to 2008/09, and milksolids production per hectare increased by 1.8% per year over the same period.

These productivity gains result from years of research and innovation, but the on-farm performance suggests that farmers collectively are effectively incorporating innovations and new technologies into their farm systems. That is, although farmers might potentially be able to make more rapid productivity gains, the current totality of farmers, advisors, scientists and industry representatives is resulting in substantial productivity gains on farms. There have also been decreases in nutrient losses and soil erosion from farms, but the rate of improvement in these is more difficult to quantify. So, we are definitely still making gains but how might we do better?

Case study – Enabling Farmer Learning Project

An example of research on agricultural extension is the Enabling Farmer Learning Project funded by the Sustainable Farming Fund (No. 408095). The project was run by a team of social and agricultural scientists from Massey University and sheep and beef farmers from the lower North Island. The project was two projects in one: the team of social and education researchers guided the extension methods using the latest findings from socio-cultural research on learning; and then collected data via interviews, focus groups and observations to analyse the results.

The agricultural researchers provided a programme on the use and management of summer perennial forage species to improve sheep and cattle production. The emphasis was on providing farmers with the knowledge and understanding of the research available so they could decide how best to incorporate summer perennial forages into their farm systems.

The Enabling Farmer Learning Project resulted in all the farmers involved increasing their use of summer perennial forage species such as plantain, lucerne, chicory and red clover in their farm systems. The farmers met four times a year for three years to learn about aspects of the management of the perennial forage species and the sheep and cattle productivities that result.


Discussing sheep production on lucerne

The Enabling Farmer Learning Project resulted in all the farmers involved increasing their use of summer perennial forage species such as plantain, lucerne, chicory and red clover in their farm systems.

These visits were mainly to Riverside Farm near Masterton where the farmers viewed and discussed field experiments evaluating sheep production on summer perennial forage species. They undertook a variety of practical exercises that helped interpret the state of the forages and the sheep (e.g. sheep condition scoring and weed percentage estimation), and participated in presentations and discussions on all aspects of summer perennial forages, including weed control, grazing management and animal nutrition.

Broader interest topics such as working dog nutrition and sheep parasite and disease management were included from time to time to add variety. All the talks were by the scientists doing the research or by the farm managers.

The project was highly successful in encouraging practice change, but it was also time-intensive and relatively more costly than some other approaches to public good extension. However, it is also reasonable to conclude that there is not a cheaper and faster way to encourage all farmers in a group to learn new technology that they then adopt (and adapt) to their own farm systems.

Also, there were positive spin-offs from this project. Many farmers involved became known in their communities for their expertise in summer perennial forages and advised and supported other farmers to adopt these. The interaction between farmers and scientists resulted in co-development of further experiments on summer perennial forages, with the early weaning research generating great interest among the wider farming community. These positive spin-offs clearly added value to the core extension project.

The participation of scientists undertaking the research on summer forage options in the extension project was highly rated by the farmers, who perceived getting the information direct from the researchers as objective and unbiased and that it enabled direct questions on the research. The success of this approach deserves

Farmers engaged in calculations

To improve the effectiveness of agricultural extension in New Zealand we need more research on farmer learning and agricultural extension, and better access to formal professional development courses for extension professionals.

further adoption, as it enhances the interaction between researchers and farmers and enables farmers to form their own view of the usefulness of the research for their farm system. Both DairyNZ and the Red Meat Profit Partnership (RMPP) have taken on board greater direct use of agricultural researchers in some of their extension projects based on the farming learning project findings.

Five learning principles

The research by the social scientists involved in the Enabling Farmer Learning Project highlighted educational principles that promote farmer learning. The social scientists identified five learning principles that are briefly unpacked here:

1. **Community** – is recognition that we learn through interaction with other people, and in the extension context this works better when there is a balance of power in the relationships between providers and participants, and the providers of information are perceived to be independent. Farmers appreciated discussion with the scientists undertaking research on the new technology or innovation being considered as they felt this was independent and non-promotional advice
2. **Interest** – is provided by a variety of multi-sensorial experiences, such as working on problems in groups, assessing plants and livestock in the field, and expert guest speakers
3. **Connection** – is about deliberately relating to the farming systems of the individual farmers and recognising that they need to determine how best to adopt practice changes for their own systems and objectives
4. **Alignment** – is using activities that align the research results to the new technology (i.e. summer perennial forages), and revisiting the key ideas in different ways to provide reinforcement
5. **Inquiry** – is promoted by exposure to field experiments in progress and encouraging farmers to gather and analyse data from their own farm systems.

Major improvements in closing the 'gap' between the fast and slow adoption of innovations and new technologies being incorporated into farm systems require well-funded social science and education research.

Professional courses

A major recent project in Australia led by Ruth Nettle from Melbourne University and supported by major primary industry organisations (https://rirg.fvas.unimelb.edu.au/ag-extension) concluded that there was a need for professional development courses for all agricultural extension practitioners if the effectiveness of extension was to go through a step change.

Perhaps it is time to provide professional development courses that are available to all practitioners in New Zealand, to help what is now a very diverse industry stay in touch with the latest research in extension methods and factors that affect how farmers learn and adopt practice change.

Conclusion

To improve the effectiveness of agricultural extension in New Zealand we need more research on farmer learning and agricultural extension, and better access to formal professional development courses for extension professionals. Major improvements in closing the 'gap' between the fast and slow adoption of innovations and new technologies being incorporated into farm systems require well-funded social science and education research.

We need to bring in fresh ideas from education research and networking research rather than just polishing and refining currently used methods to take agricultural extension into a new era. It is not whether extension providers are private or government, or national or regional, so much as how we can better support extension professionals by providing research-informed and evidence-based extension methods.

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Lucerne at Riverside Farm, Massey University

KARIN SCHÜTZ

Cows in shade

EFFECTS OF SUMMER CONDITIONS ON THE WELFARE OF RUMINANTS IN NEW ZEALAND

Summer is here and whereas most of us are enjoying sunny days, warm weather can cause problems for our production animals that are mainly managed on pasture all year round. Animals try to cool down in warm weather by increasing their breathing rate and changing their behaviour, such as shade seeking and drinking more water. However, if they are unable to maintain normal body temperature, this will lead to reduced feed intake and production, and impaired welfare.

Concerns about the effects of climate on farm animal welfare are growing.

Effects of climate

Most of New Zealand's large farm animals are managed outdoors all year round in pastures with or without shade and shelter. Whereas the temperate climate in this country in general allows livestock to be managed outdoors, there are periods where inclement weather (both in winter and in summer) imposes challenges for the welfare and productivity of animals.

This article describes the effects of warm weather on animal responses and discusses when and how mitigation strategies should be implemented to reduce the negative effects of inclement weather. Most of the existing research about the effects of warm weather in New Zealand has been undertaken on dairy cattle so it mainly considers dairy cows.

Concerns about the effects of climate on farm animal welfare are growing. Global warming is predicted to increase the frequency of heat waves and extreme weather events as well as global mean temperatures, indicating, for example, that the negative effects of heat stress may increase in future. Whereas new knowledge about animal responses to the environment continues to be developed, managing livestock to reduce the impact of climate remains a challenge, in particular in pasture-based systems.

Heat load and heat stress in dairy cattle

Warm summer conditions, such as high air temperature, relative humidity and exposure to solar radiation, cause cattle to gain heat. Cows dissipate heat mainly through evaporation by increasing breathing rate, panting, and to a limited extent, sweating. Cattle will try to maintain a normal body temperature (38.0-39.3°C) by changing their behaviour and by breathing faster. However, when this is insufficient body temperature may rise and negatively affect milk yield and reproduction, and in extreme cases can result in death.

Even though New Zealand has a temperate climate, where the number of consecutive hot days may be fewer, solar radiation levels are higher in this country than in many others. Also, New Zealand cows often walk long distances to be milked (up to 2 km per trip is not uncommon) during the warmest part of the day and a peak in body temperature can be seen at this time.

Heat load has been estimated using a range of environmental measures, including ambient air temperature, and black globe temperature which takes into account solar radiation. Two common indices used to determine heat load in cattle include:

- The temperature humidity index (THI), which combines the effects of air temperature and relative humidity
- The heat load index (HLI), which incorporates the effects of air temperature, humidity, wind speed and solar radiation.

Cattle can tolerate higher temperatures at lower relative humidity as their natural capability to dissipate heat load by sweating and panting is compromised in humid conditions.

Cattle responses to heat load

Warm weather will cause cattle to gain heat. Cows will try to avoid a rise in body temperature by using a variety of strategies that can be used as indicators to detect animals that are trying to avoid the effects of warm weather. These strategies include increased sweating and breathing rate, shade seeking, water intake and time around water, and reduced lying.

There is also anecdotal evidence that cattle will huddle together in a group or stand in a line with heads shaded by another cow, which suggests that unshaded cows will try and create a cooler microclimate by shading their heads. Perhaps the best recognised effect of warm conditions is decreased feed intake, which will lead to a reduction in milk and meat production.

When is cooling needed?

The Code of Welfare for Dairy Cattle acknowledges that the weather conditions (in summer and winter) in New Zealand at times can create welfare risks. The Minimum Standard for shelter states that, 'all classes of dairy cattle must be provided with the means to minimise the effects of adverse weather'. Special attention should be given to calves and sick animals that are at greater risk of impaired welfare from adverse weather.

The Minimum Standard also states that where animals develop health problems associated with exposure to adverse weather conditions, priority should be given to remedial action that will minimise the consequences of such exposure.

So when is cooling needed in summer? The literature about heat stress thresholds is mixed, likely because thresholds differ between individuals. Historically, a THI of 72 (equating to 25°C and 50% relative humidity) has been used to define the point at which heat stress occurs, based on a reduction in milk production.

However, more recent research suggests that lactating dairy cattle are more sensitive to environmental conditions than previously thought, possibly partly due to the genetic progress of milk production, which has led to a cow with increased metabolic heat production and therefore is more susceptible to heat stress. For example, a THI value of 62 (equates to 20°C at 0% humidity) has been suggested as a new threshold for Western European Holstein cows, below which milk yield declines by 0.16 kg/day/cow.

Cow showing signs of heat stress

In another study, negative effects on milk production traits and somatic cell counts were found when the average monthly THI was greater than 60 (less than 20°C at 0% humidity). In New Zealand, a reduction in milk yield in Holstein-Friesian cattle started to occur at THI of 64 (equivalent to 20°C and 40% humidity), whereas milksolids started to decline at a three-day average THI of 68 (equivalent to 21°C and 75% humidity).

Even though New Zealand dairy cattle produce less milk, the production thresholds seem to be similar to that of high producing Holsteins. This could possibly be due to higher levels of solar radiation in this country, and the internal heat load build up due to the distances New Zealand cows often walk to and from milking.

Breathing rate is a useful indicator of thermal challenge as it increases in response to increasing heat load. Panting behaviour (e.g. when the mouth is open and drool and a protruding tongue may be visible) is associated with high breathing rates and is a good indication of increasing body temperature and animals experiencing heat stress.

In a New Zealand study, dairy cattle benefited from cooling (reduced breathing rate and body temperature) with shade and sprinklers at THI ≥69 (equivalent to 22°C and 55% humidity). Access to shade on pasture lowered breathing rates at HLI of 65 (air temperature was 20-21°C). Cows with limited shade began to compete to gain access to shade, and cows without shade began to spend more time around a water trough when HLI was approximately 75 (air temperature was 19-25°C). These findings indicate that dairy cattle benefit from cooling at thresholds lower than previously thought.

Shade cooling

Access to shade in summer improves the production and welfare of cattle. Shaded cows have lower breathing rates and body temperature than unshaded animals. Access to shade increases feed intake and, consequently, milk production. It is clear that shade is an important resource for cows in summer that they are willing to compete to gain access to.

For shade to cool cows efficiently it needs to have certain features:

- First, it needs to protect cattle from solar radiation. Cows prefer and spend more time in shade if it provides greater blockage from solar radiation. Shade use is directly related to solar radiation levels and peak when these levels are highest
- Second, the shade needs to be large enough for all cows to use at the same time. Cows with access to 3.6 m^2 shade/cow had lower body temperature and produced more milk than unshaded animals. However, while the cows could physically fit under a shade with 3.6 m^2/cow, they did not use the shade simultaneously, likely due to social factors and competition.

Cooling benefits are greater if there is enough shade for all cows to use it simultaneously. For example, cows that had access to 9.6 m^2 shade/cow spent more than twice as much time in the shade compared to cows that had access to 2.4 m^2 shade/cow. Cows with the larger shade area also had lower breathing rates and fewer aggressive interactions than cows with 2.4 m^2 shade/cow. Cows with 9.6 m^2 shade/cow could use the shade simultaneously and could also rest under the shade, whereas those that had access to 2.4 m^2 shade were never seen using the shade at the same time.

Providing cows with more shade is likely beneficial in terms of reducing competition for the resource, as well as enabling more space between animals, thereby increasing the air flow around individuals and efficient cooling. Cows on pasture likely need at least 4-5 m^2 shade/cow for efficient cooling.

If shade cannot be provided at pasture, a shade cloth at the milking parlour may be a practical way to provide cooling after the afternoon walk to milking. For example, access to shade for 90 minutes in the holding pen before afternoon milking in the Waikato reduced breathing rate by 30% and lowered body temperature by 0.3°C compared to cows without shade. The cooling benefits of shade persisted after milking; body temperature remained lower for two to four hours after milking.

Water cooling at the milking shed

Compared to shade alone, cooling with water spray reduces body temperature, breathing rate and air temperature more efficiently. In the Waikato, cooling with sprinklers for 90 minutes before afternoon milking reduced breathing rate by 60% compared to non-cooled cows.

Compared to shade alone, sprinklers reduced body temperature more markedly, especially at THI ≥69 (equates to 23°C, 50% humidity), and the body temperature remained lower for more than four hours after milking. Cooling cows before afternoon milking could be a practical and efficient way to reduce the peak body temperature and breathing rate of cows in pastoral dairy systems.

However, cows that were under sprinklers for 90 minutes had *higher* body temperatures when THI was lower than 69 (air temperature was 23°C), suggesting that the cows were getting hypothermia and care needs to be taken not to use sprinklers for too long on cooler days. The study that investigated the effects of providing shade or sprinklers prior to milking was exposing the cows to the treatments for 90 minutes and the duration was based on an estimated common waiting time at the shed. More research is needed to make recommendations about appropriate shade and/or sprinkler use at the milking shed.

Sprinklers also provide other welfare benefits, such as reducing insect load. There is some evidence though that cows may find sprinklers aversive, possibly because they do not like parts of their head getting wet. Indeed, New Zealand dairy cattle preferred shade over sprinklers to cool down in summer when they were given a choice between the two resources. Others have demonstrated that cattle readily use water cooling and prefer feedbunks fitted with sprinklers over those without sprinklers.

Lactating cows used a 'cow shower' for, on average, three hours in every 24 hours in an experimental study at UC Davis in California; the shower use increased by 0.3 hour for every 1°C increase in air temperature. Differences between studies are likely due to weather conditions and the manner in which the water cooling was provided. For example, systems that produce fine droplets to cool the air by evaporation are not efficient in humid climates and can contribute to heat stress as humidity levels increase. For spray or sprinklers to be efficient, droplets need to be large enough to penetrate the coat and wet the skin (thereby causing evaporative cooling), drawing heat away from the body.

Heat stress in other ruminants

The Codes of Welfare for beef cattle, sheep and deer state that animals should be provided with the means to minimise the effects of heat stress. However, there is very little information available about the effects of warm weather on these livestock classes in New Zealand conditions. Increased heat load in all these species is associated with an increase in breathing rate and body temperature and shade-seeking behaviour.

Sheep and beef cattle, similar to dairy cows, also respond to heat load by an increase in water intake and a reduction in feed intake and production. Romney cross-bred ewes in New Zealand spent different amounts of time in the shade (43% and 67% of daytime observations, respectively), depending on whether conditions were:

- Warm and dry (Otago, where mean daily temperature was 18.5°C, relative humidity was 49%)
- Warm and humid (Waikato, where mean daily temperature was 22.0°C, relative humidity was 67%).

Sheep that had access to shade had a lower body temperature and breathing rates at both locations, and shade was efficient in reducing body temperature at air temperatures >20°C. Weather conditions and relative humidity levels seem to alter the behaviour of sheep. Increasing air temperature is associated with reduced grazing activities.

However, lying behaviour seems to be associated with relative humidity levels. Humid and warm conditions reduced time spent lying, whereas in more dry climates, lying activities increased. This is likely due to humid weather decreasing the effectiveness of evaporative cooling (breathing rate and sweating). The increase in upright behaviour (also seen in cattle) may be an attempt to increase the air flow around the body.

Breathing rate has been used as an indicator of heat stress in sheep where values between 80 to 120 breaths/min indicate high levels of heat stress, and more than 200 breaths/min indicate severe heat stress. Unshaded sheep in New Zealand had breathing rates of 121 breaths/min and 226 breaths/min in dry and humid conditions, respectively, which would put them into the category of high to severe levels of heat stress.

Behavioural responses of deer to warm weather include seeking shade or other favourable microclimates. For example, if given the opportunity deer wallow, but it is unclear about any potential benefits in terms of cooling effects. The few studies that have investigated the shade and shelter use of deer have shown that fawns use shelters more in warm weather and choose bed sites with lower ambient temperature than the surrounding area at air temperatures >24°C.

Conclusion

Warm weather affects the welfare and production of farm animals. Shade is a valuable resource for dairy cattle in summer and access to shade (or cooling with water) improves production and welfare. Shade is also a valuable resource for beef cattle, sheep and deer, and more research is needed to study the effects of warm weather on the welfare and productivity of these species.

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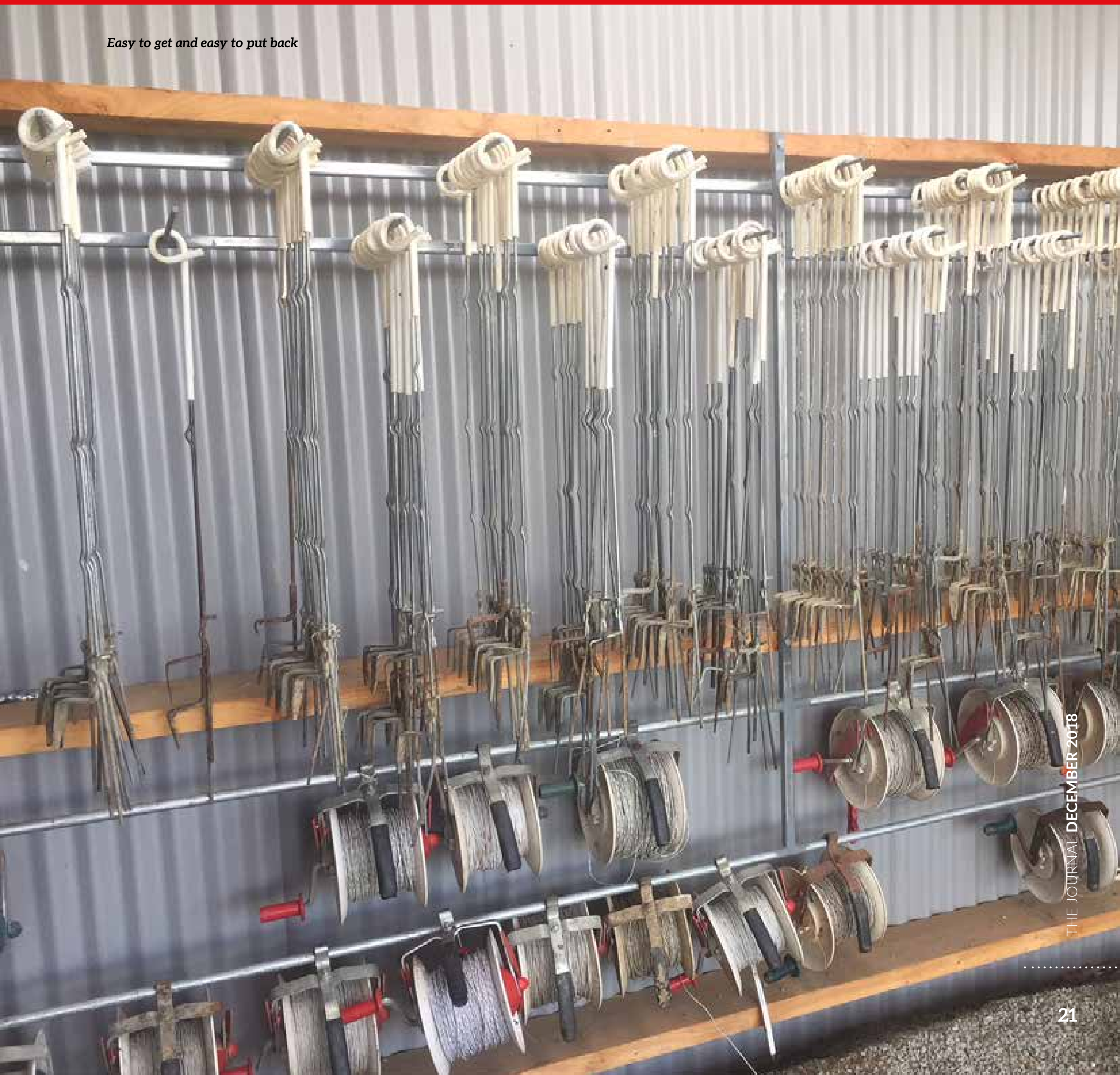
SARAH WATSON

LEAN MANAGEMENT IN FARMING

This article outlines the concept of lean thinking, how to create the right culture for this to thrive in, and describes some lean tools and myths. It also takes a brief look at lean thinking in the dairy sector and its usefulness to small and large-scale primary producers.

Easy to get and easy to put back



The core principle of lean is creating more value by eliminating waste using the concept of continuous improvement.

What is lean thinking?

Lean thinking is often referred to as 'lean manufacturing' or 'lean management'. Many associate lean with manufacturing, where tightly controlled processes and cost reduction are key. However, lean has been successfully applied in many environments globally. Increasingly, farming businesses are also adopting the principles that make up lean thinking and seeing the benefits these can bring on-farm.

Europe and the US are leading the use of lean thinking in the primary industries. Lean can deliver measurable results to any business, especially where there are processes that include variation between operators.

Core principle of lean

The core principle of lean is creating more value by eliminating waste using the concept of continuous improvement. The Japanese call this Kaizen (good change). The simple concept of continuous improvement can result in huge improvements in productivity, efficiency and engagement. These improvements are achieved through empowering everyone in the business to take responsibility for eliminating waste and providing value to customers. The key is to lock these improvements in.

Successfully implementing lean in any business requires a change in thinking right through the business, particularly from business leadership and management. Lean is not without its challenges. It requires discipline, focus and energy to embed a culture of continuous improvement.

Creating the right culture

Lean focuses on the people doing the work and its core premise is that these people are best placed to identify opportunities for improvement and engineer solutions which work. To be successful, these people must be engaged in the lean process, understand the concept of continuous improvement and feel safe to contribute.

Typically, the most common reason for a lack of successful lean implementation is not a problem with the workforce, but with a lack of the right kind of leadership to take the workforce through the culture change that will sustain workforce-led continuous improvements.

Lean thinking is creating a culture where the focus is on:

- The physical day-to-day processes that occur in the business
- Making small incremental changes to improve these processes by identifying and eliminating waste
- Ensuring it is simpler and safer for people in the business to work efficiently.

Lean tools

Some of the most commonly recognised lean tools include:

- **7 wastes:** Understanding the 7 wastes helps businesses to identify opportunities for improvement. If you can see it (waste), you can eliminate it. The aim of the 7 wastes is to help you 'see' the waste in the business. Waste is defined as any activity in the process which does not add value in the eyes of the customer. The 7 wastes are:
  1. Waiting waste: waiting for products, information, people and animals before you can proceed, e.g. half done jobs are waiting
  2. Motion waste: unnecessary searching or movement, e.g. searching for a tool or an email
  3. Transportation waste: transporting information or goods too far or too often, e.g. constant trips to town for supplies
  4. Storage waste: too much stored goods or information, e.g. ordering extra drench because it is on special but not using it all and it going out of date
  5. Defect waste: products or information that cannot be used because of a defect, e.g. antibiotic milk or feed that goes bad
  6. Over/under-processing waste: having to re-do a job because it was not done properly the first time, or having extra steps in a process 'just in case', e.g. doing an 'extra' hot wash of the vat
  7. Over-production waste: producing too much, too soon, e.g. rearing half recorded heifers and not being able to sell them.
- **5 whys:** This is a powerful tool for finding the root cause of simple or moderately difficult problems, simply by asking 'why?' at least five times. It is most successful when the answers come from people who have first-hand experience of the problem and the process. Once the root cause is identified it is possible to find the right 'counter-measure' to prevent the problem arising again.
- **5S:** This is the foundation of all improvements and is the key component of establishing a visual workplace. A 5S programme focuses on having visual order, organisation, cleanliness and standardisation. 5S represents the key steps in setting up your work environment for success: sort, set, shine, standardise, sustain.

Some lean myths

There are some common myths linked to implementing lean that need to be addressed before we can consider the value it can provide to primary producers:

A place for everything and everything in its place

Myth #1 – Lean is all about the tools

False: It is true that lean tools are important, but they will not lead to success on their own. More important is the structure and culture that sits around how any tools are used by people in the business.

Myth #2 – Once you implement lean you can stop thinking about it

False: Lean implementation is not a project with an end point. It is about changing how the business thinks and acts – about changing the 'culture' to continuously strive for improvements. By definition, continuous improvement will never be 'finished'.

Myth #3 – Lean is only about cost reduction

False: Lean is about value, a bigger and more inclusive concept than just cost. Cost reductions will follow when the long-term strategy is about constantly improving and changing for the better. People add value in a business when they are constantly striving for improvements. In this context people are not a cost, but a valuable resource that will help find ways to reduce cost.

Myth #4 – Lean is only used to get rid of waste

False: Lean is much more than *just* getting rid of waste – it is about capturing the power of the people in the business. Efficiency and productivity improves when people know how to recognise waste in everyday processes, understand the root cause, and identify effective solutions to remove it.

Myth #5 – Lean means doing more with less people

False: Lean is about reducing waste, not making people work harder or 'slimming down the workforce'. Lean is about capturing and challenging the power of people to identify opportunities for improvement, to learn how to work smarter not harder, and how to think and add value to the business.

Myth #6 – Lean stifles innovation and creates a workforce that cannot think for themselves

False: Lean thinking increases the opportunities for innovation. It works best when people are actively engaged on-farm and can suggest improvements in the way their work is carried out.

Lean application in dairy farming

Lean is well engrained in the processing part of the dairy sector. Some large-scale dairy farming businesses have been implementing lean thinking in New Zealand since 2012. In 2013, Venture Southland ran a project funded by the Ministry for Business Innovation and Employment (MBIE) and DairyNZ with the aim of evaluating:

- How well lean could be applied to smaller and medium-sized farming operations
- What support and resources would be required to scale-up the programme to spread the learnings and benefits to other farmers.

In 2014, the findings from the Venture Southland work lead to a DairyNZ funded project to develop a fit-for-purpose lean programme for New Zealand dairy farmers. The outcome was a programme that would train and support farmers to implement lean thinking in their businesses and that could be commercially delivered to farmers throughout the country.

Lean is well engrained in the processing part of the dairy sector. Some large-scale dairy farming businesses have been implementing lean thinking in New Zealand since 2012.

This programme is called FarmTune® and has been successfully delivered since 2015 to farms in Southland, Otago, Canterbury, Manawatu and Waikato. The programme is delivered by accredited FarmTune® providers across the country.

A Worksafe evaluation of the pilot programme demonstrated participating farmers had made improvements in efficiency and productivity. These efficiencies resulted in shorter workdays and improvements in communication and health and safety culture within the team. The impact of these improvements is:

- Active health and safety management on-farm, including daily discussions about this topic
- Better management of hazards on-farm
- Standard operating procedures with clear safety steps to manage risks
- Safety equipment located at the point of use
- Reduced work hours at key times of the year, resulting in less fatigue and less accidents
- Time saving in day-to-day activities, resulting in more time spent on maintenance and less breakages and breakdowns
- Clearer rules and systems, making it easier to do things the right way on-farm
- Clear visual controls leading to more effective training
- The whole team taking responsibility for reporting hazards and sharing with the rest of the team.

Feedback from farmers about the impact of lean gives an insight into how it can add value on-farm. Examples of improvements include:

- Increasing the six-week in-calf rate from 60% to 78% in two years by implementing lean thinking
- Milking times reduced by an hour a day on a farm that had above average milking times
- Eliminating frustration for the owner, manager and team
- Team able to take two hours for lunch during calving because of better communication, organisation and clearer processes meant jobs were done more efficiently
- New employees easier to train because the systems are better – they also get 'up to speed' quicker
- The whole team taking responsibility for how things happen on-farm, making it easier for the manager to delegate
- Development of maintenance schedules and time to implement these, resulting in less breakdowns and savings on repairs and maintenance.

Lean implementation on-farm in New Zealand is still relatively new and the full financial benefits will take two to three years to flow through. However, there is clear evidence that lean significantly improves the work environment on-farm, resulting in a more engaged and efficient team.

Lean thinking and small to large-scale primary producers

Increasing expectations around product quality, environmental management, animal husbandry and welfare, biosecurity, health, safety and wellbeing have changed the skills required on-farm. Farmers are under increasing pressure to maintain a team of people who are competent and skilled enough to manage the increasing complexity of operating a farm.

There is greater reliance on everyone in the team to know and understand how things need to be done, and less room for error. At the same time, it is increasingly difficult to find suitably experienced and skilled people, so farmers need to develop systems and processes that make it easier to get new or inexperienced people up to speed.

Not only are our systems more complex, but we are facing ongoing challenges and requirements linked to how we farm. Farmers need to be operating efficient and productive operations to be able to 'front foot' changes and challenges.

Add to this the challenge of attracting quality people into the sector. Part of the solution to this will be improving the work environment, particularly in relation to hours of work and rosters. To achieve this the sector needs to do things differently.

Lean thinking provides a framework for assisting farmers to set up robust systems and processes that can guide the team – one that can improve employee training, competence, confidence, engagement and productivity. Lean thinking is the framework farmers and advisors can use to identify the critical points in the system where improvements need to be made, and a process to manage their implementation.

Lean management in farming is the opportunity to add value and reduce waste in all areas of the business. This helps businesses position themselves to maximise value, manage change positively, attract and retain quality people, and counter rising production costs.

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SUZIE GREENHALGH, ADAM DAIGNEAULT AND OSHADHI SAMARASINGHE

ALLOCATION – THE DILEMMA AT THE HEART OF SETTING WATER QUALITY LIMITS

Allocating nutrient discharge limits to farmers as part of regional council water limit setting processes is not easy, and often hotly debated. This article shows why there is no universal 'best' approach to allocate nutrients to farmers, explains why it is so challenging, and offers a process to navigate these choices.

The tenor of the allocation debate is often contentious when setting nutrient reduction limits.

Background

The National Policy Statement for Freshwater Management (NPS-FM) provides a framework that directs how councils are to set objectives, policies and rules about freshwater in their regional plans. They must do this by establishing freshwater management units across their regions and identifying the values (e.g. irrigation, mahinga kai, swimming etc) that communities hold for the water in those areas to set limits.

As part of the limit-setting process, a total catchment load (i.e. a cap on nutrients) may be set and this cap may be allocated between resource users, including diffuse sources such as agriculture and forestry. This can be done by allocating individual nutrient discharge amounts (NDAs) to farmers. Where this happens we want to know how best to allocate these limited resources between resource users.

The tenor of the allocation debate is often contentious when setting nutrient reduction limits. Catchment caps or targets set at existing (or even slightly higher) discharge levels have implications for potential new entrants and future growth, and for potentially maintaining the longer-term financial viability of farmers as costs increase, but their ability to intensify to maintain profitability is limited. A more stringent cap that requires a reduction from existing discharge levels has immediate financial implications and may endanger the viability of some impacted operations. Therefore, where 'clawback' or a lower cap is set the allocation debate is likely more controversial.

With diffuse sources, the debate becomes even more challenging as soil characteristics, rainfall, topography and how the land is managed plays a large role in the amount of nutrients that reach a waterbody. This means nutrient losses need to be estimated on an individual farm basis, and there is frequently wide variability in discharge levels from farms across a catchment.

Setting policy

There are two common aims when setting policy, including freshwater policy. One is that policy is implemented at least cost or minimum loss to society (i.e. the policy is efficient as it maximises total net benefits). The other relates to the distribution of an economy's resources (i.e. the policy's impacts are perceived to be equitable by all stakeholders involved).

Equity is particularly challenging as the definitions of equity are subjective and involve value judgements that can vary between people. Defining principles for what stakeholders wish to achieve through the policy can help equity judgements. One consideration for many stakeholders when judging equity is where the cost burden of the policy lies.

Both efficiency and equity are important (but not the only) considerations when developing policy, and the design of an optimal policy may involve a trade-off between efficiency and equity objectives. This is often the case with a regulatory approach that involves the allocation of a catchment cap between sources, as typically there is no 'right' allocation approach that maximises both objectives for all affected stakeholders. Rather it is a decision on how to weight questions of efficiency and equity and how equity is being judged. The debate on the appropriate allocation approach to use is often heated, with stakeholders arguing about who loses the most today and who loses the most in the future (i.e. about questions of equity).

Approach

In this article we show why the allocation question is so challenging. To do this we use economic analysis to draw some general conclusions about the efficiency and equity implications of a number of water quality allocation approaches being discussed around the country. The most efficient allocation approach has the lowest overall financial burden (i.e. impact on net farm revenue in the catchment), while equity implications are considered in terms of how costs are distributed under different allocation approaches. For the policy-maker there could also be other aspects to consider, but these are two of the more common concerns.

We compared two Canterbury catchments – Hinds and Selwyn (*Figure 1*) – using the New Zealand Forest and Agriculture Regional Model (NZFARM) to demonstrate why allocation related to water quality is so challenging. NZFARM is an agro-economic model designed to test policy scenarios, including those related to the environment. Six approaches to allocate non-point source nutrient discharges under three nitrogen (N) reduction scenarios are assessed – four are based on existing land use and two on land characteristics (see *Table 1* but this is not an exhaustive list of possible allocation approaches).

Each allocation approach has implications for efficiency and equity. With the exception of grandparenting, allocation approaches tend to involve some immediate transfer of wealth, which incurs a cost for some individuals and benefits others. Grandparenting, which maintains the status quo, will have cost implications for individuals whose future opportunities are restricted when land receives a low NDA, e.g. forested land that could profitably be used for higher leaching activities. The interplay between the overall efficiency of the allocation approach and the subsequent impact on equity is where the challenge lies.

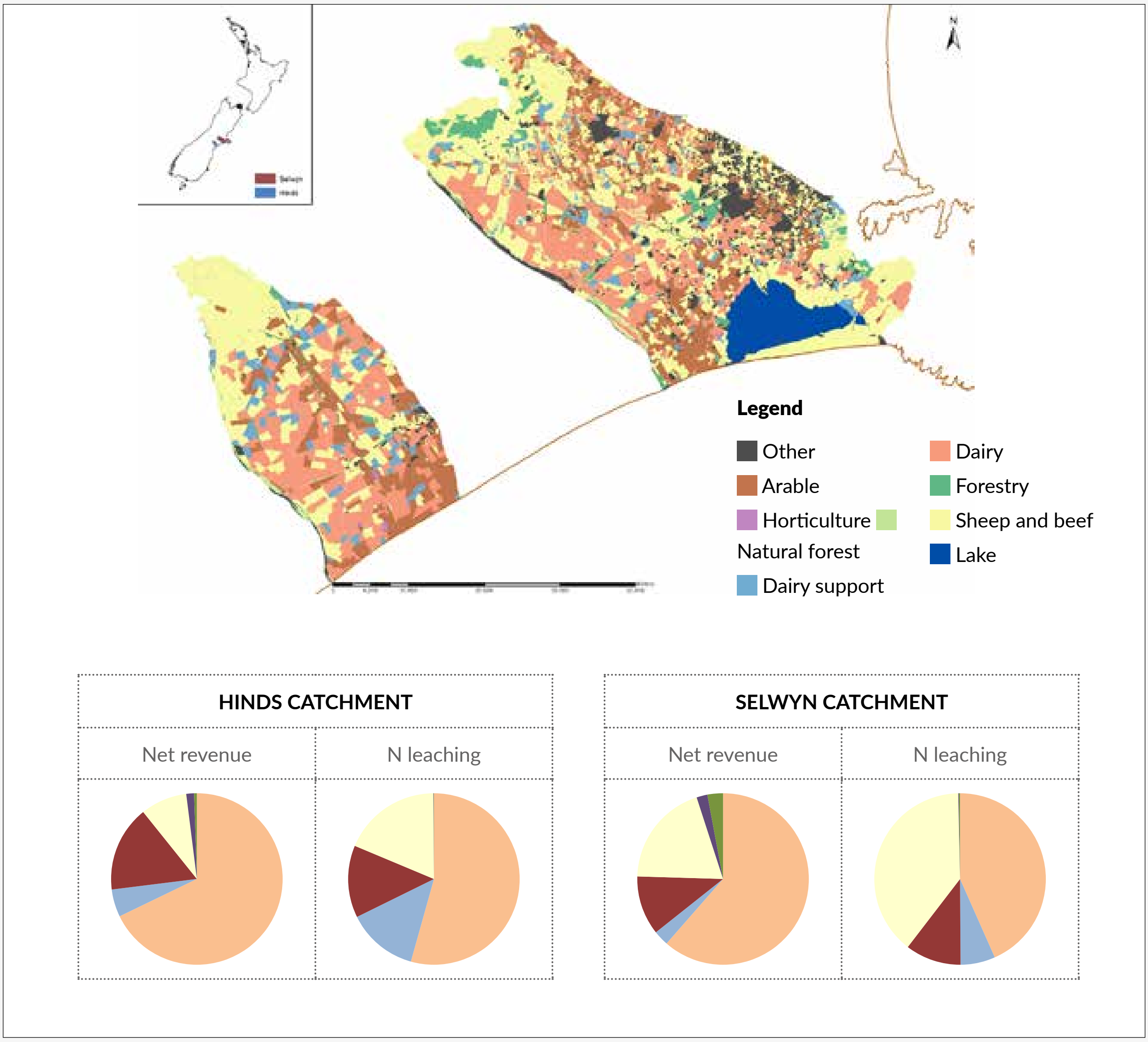

Figure 1: Hinds and Selwyn catchments – baseline land use, net farm revenue and N leaching distribution

Table 1: Modelled allocation approaches

ALLOCATION	DESCRIPTION
Grandparent	NDA based on N leaching rates during a baseline or benchmarking period and proportional to reduction target
Natural capital	NDAs are allocated based the physical quality of the land, soil and environment. Land use capability (LUC) is used as a proxy for natural capital, and more NDAs are allocated to higher class land
Catchment average	All farmers are given the same NDA regardless of land use and this is the average of total N discharge from land-based sources.
Land cover average	Farmers managing a specific land cover (e.g. pasture, forest, arable) are given the same NDA
Sector average	Farmers within the same sector (e.g. dairy, sheep and beef) are given the same NDA
Nutrient vulnerability	NDAs allocated based on the nutrient leaching capacity of the soil. More NDA would be allocated to land with lower 'vulnerability'

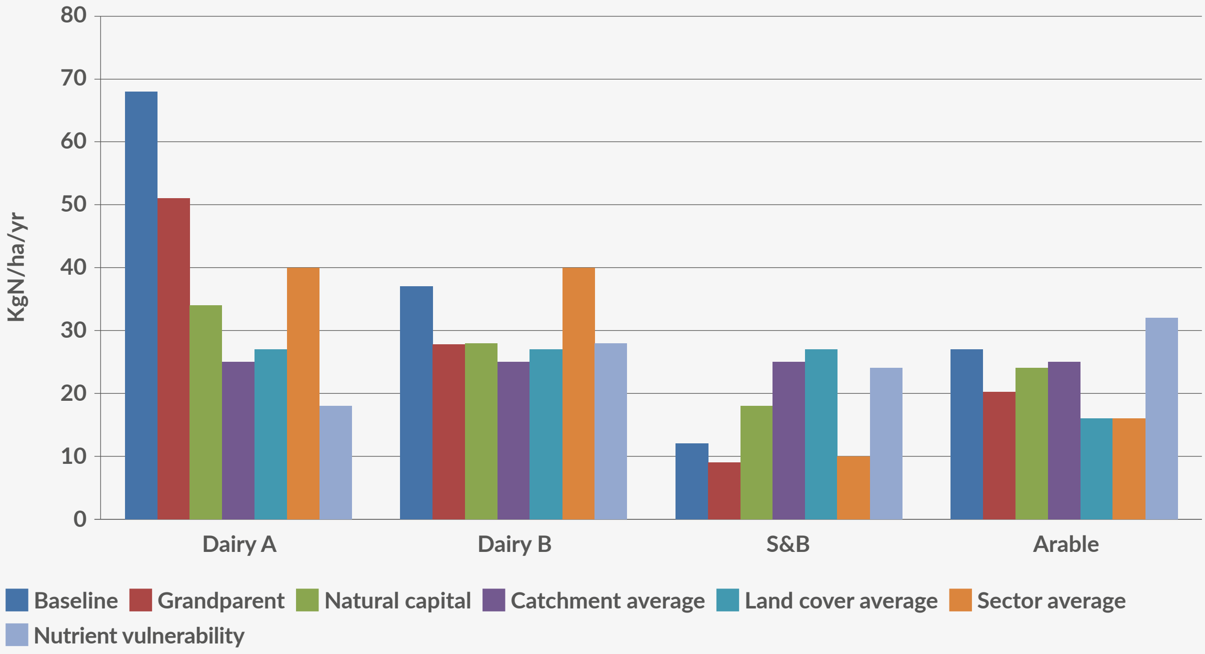

Figure 2: Illustrative distribution of allocated N leaching rates for baseline leaching and 25% N reduction target

Each allocation approach has implications for efficiency and equity. With the exception of grandparenting, allocation approaches tend to involve some immediate transfer of wealth, which incurs a cost for some individuals and benefits others.

For our comparison of allocation approaches farmers can:

- Implement nutrient reduction practices
- Continue to operate as long as they are within their allocated NDA
- Change land use as long as they stay within their allocated NDA.

A least cost option is included to demonstrate the most efficient outcome for the catchment. This can be interpreted as a catchment having a single farmer who is making the optimal economic decisions for the whole catchment. There was also no trading of allocated NDAs allowed. However, should trading be allowed it is likely to provide greater flexibility for farmers and reduce the costs of complying with the limits.

Illustrating the allocation dilemma

To illustrate how the different allocation approaches work we outline a stylised example of a catchment with four farms:

- Two are irrigated 160 ha dairy farms with net returns of about $4,000/ha/yr. Dairy farm A is located on LUC Class I land with predominantly very light soils that currently leach 68 kgN/ha/yr
- Dairy farm B is located on LUC Class III land with predominantly medium soils that leach 37 kgN/ha/yr
- The third farm is a 250 ha dryland sheep and beef (S&B) enterprise on LUC Class VI land with light soils that leaches 12 kgN/ha/yr and returns $500/ha/yr
- The fourth farm is a 120 ha mixed arable cropping system on LUC Class IV land that leaches 27 kgN/ha/yr and nets $1800/ha/yr.

As all four farms are located on different soil types and LUC their discharge amounts differ with the allocation approach (*Figure 2*).

Farm profitability is a primary concern for farmers. If we assume that higher discharge amounts more likely provide higher farm profits, then farmers are likely to prefer the approach with the lowest (or no) financial impacts. From *Figure 2* the sheep and beef farmer is likely to prefer land cover or catchment averaging approaches because they provide an opportunity to expand their operation, while the arable farmer would prefer nutrient vulnerability.

The preferred allocation approach varies for the two dairy farmers. Dairy A would prefer the grandparenting approach as it requires the least reduction in their N leaching, while Dairy B would prefer the sector averaging. Given that many catchments in New Zealand contain hundreds of farmers, this illustrates why allocation decisions can be contentious and complex.

Implications of different allocation approaches in two catchments

Now consider a more complex set of policy scenarios where farmers in the Hinds and Selwyn catchments must cumulatively reduce their N discharges by 10%, 25% or 50% below the no-policy baseline. For context, the average baseline N leaching is 32 kgN/ha in Hinds and 18 kgN/ha in Selwyn. As with the stylised example, the catchment-level assessment shows that the preferred allocation approach for each sector differs between catchments and across stringency levels when you look at policy efficiency and the distribution of costs (a component of equity), and the challenges involved in these decisions become evident.

Efficiency

The efficiency of different allocation approaches can be judged by comparing the impact on net revenue. The lowest reduction in net revenue for a given N reduction target is the most efficient. From ***Table 2***, the allocation approach in Hinds whose change in net farm revenue is closest to the least cost option is grandparenting for the 10% and 25% targets and natural capital for the 50% target. For the Selwyn, sector averaging is the most efficient allocation option regardless of the N reduction target. However, natural capital for the 50% N reduction target has similar efficiency as sector averaging.

Table 2: Estimated impacts of N reduction policy scenarios

SCENARIO/ALLOCATION APPROACH	NET REVENUE (M$)	N LEACHING (TONNES)	NET REVENUE (M$)	N LEACHING (TONNES)
	HINDS CATCHMENT		SELWYN CATCHMENT	
Baseline	$246.1	4,443	$294.6	4,266
10% reduction target				
Least cost	–1%	–10%	0%	–10%
Grandparent	–2%	–10%	–2%	–10%
Natural capital	–7%	–27%	–11%	–38%
Catchment average	–9%	–35%	–10%	–36%
Land cover average	–9%	–34%	–9%	–35%
Sector average	–5%	–21%	–1%	–10%
Nutrient vulnerability	–10%	–36%	–9%	–34%
25% reduction target				
Least cost	–4%	–25%	–3%	–25%
Grandparent	–4%	–25%	–7%	–25%
Natural capital	–9%	–32%	–13%	–42%
Catchment average	–12%	–41%	–13%	–42%
Land cover average	–12%	–40%	–11%	–39%
Sector average	–9%	–31%	–4%	–25%
Nutrient vulnerability	–13%	–43%	–12%	–39%
50% reduction target				
Least cost	–14%	–50%	–14%	–50%
Grandparent	–19%	–50%	–24%	–50%
Natural capital	–17%	–50%	–15%	–51%
Catchment average	–21%	–56%	–20%	–54%
Land cover average	–21%	–56%	–19%	–52%
Sector average	–21%	–50%	–15%	–50%
Nutrient vulnerability	–24%	–60%	–24%	–58%

For the Hinds catchment, the nutrient vulnerability approach is estimated to be the least efficient. It allocates a high proportion of NDAs to farms on low vulnerability soils (i.e. low baseline N), thereby requiring many farmers on high vulnerability soils to make changes that significantly impact their profitability. In Selwyn, natural capital is the least efficient for the 10% N reduction target, natural capital and catchment average are least efficient for the 25% target, and for the 50% target it is nutrient vulnerability. These findings indicate there is no most or least preferred allocation approach based on efficiency criteria across reduction targets and catchments.

For many allocation approaches, the aggregate reduction in N leached is higher than the reduction target. This is because some farmers are allocated more than they currently leach. Therefore, they can maintain their current operations and still have NDAs in reserve to use at a later date. This is one situation where a market-based flexibility mechanism such as trading has benefits.

With trading, farmers could sell their excess NDAs to other farmers in the catchment who might find it more profitable to leach more than their initial allocated amount. This enables those farmers to increase their discharges while others decrease their discharges by an equivalent amount. Therefore, efficiency improves as the overall cost of meeting or managing within a limit is reduced.

Equity

The relative fairness or equity of each approach was also assessed. Provided the N reduction target is set at a level that achieves societal goals, we assume that the benefits of the policy to the wider community are accounted for. Regardless of how equity is defined, the distribution of benefits and costs across affected parties should be understood. We do this by disaggregating the catchment net revenue impacts to the various sectors. The impacts of the 25% N reduction target as shown in *Figure 3* (acknowledging there are within-sector distributional impacts that are not shown) illustrate that the distribution of costs varies between sectors and allocation approaches.

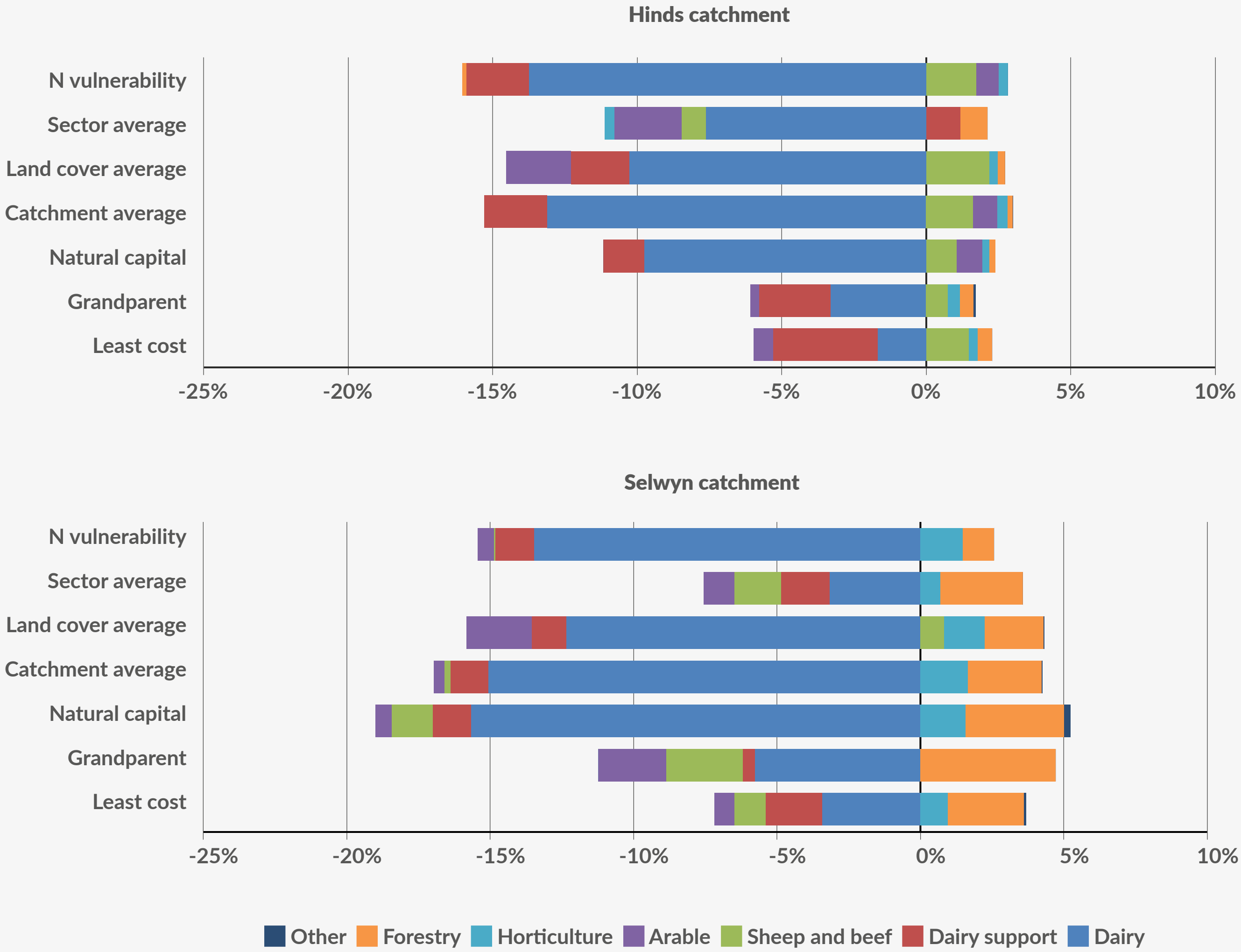

Figure 3: Estimated catchment net revenue change from baseline (% change from baseline total), by enterprise, 25% N reduction target

For many allocation approaches, the aggregate reduction in N leached is higher than the reduction target. This is because some farmers are allocated more than they currently leach.

The financial impacts can vary widely and are not consistent across the two catchments, even for the same reduction target or allocation approach. For nearly all allocation approaches, there are greater impacts on sector net revenue in Selwyn than in Hinds. This is influenced by Selwyn's larger catchment size and the distribution of existing land uses, which results in a lower mean N leaching rate for that catchment. Forest and horticulture revenues and area are generally estimated to expand more in Selwyn relative to Hinds because the Selwyn catchment already has some infrastructure for those sectors and can more easily support sector expansion.

There are some key observations across the different allocation approaches. For example, the relative and directional impact on arable profits changes significantly depending on the allocation approach, especially in Hinds. Generally, arable farmers stand to lose more under land cover and sector averaging approaches because they have higher leaching rates relative to other enterprises in the catchment (with the possible exception of some dairy and dairy support that have more cost-effective mitigation approaches available), and thus must mitigate a higher amount of N.

Dairy stands to lose the largest net revenue in nearly all cases. This is to be expected because dairy is by far the highest earning enterprise and contributor to N losses in each catchment (*Figure 1*). However, despite dairy having a relatively high baseline leaching rate it has a range of feasible mitigation approaches available for farmers to meet their individual limits.

Key findings

Our findings demonstrate the challenges that confront decisions to allocate NDAs to farmers. There are instances where the most efficient allocation approach also aligns with a sector's likely preferred approach in terms of lowest sector losses. For example, for the 25% reduction target in Hinds the most efficient modelled allocation approach is grandparenting, which has the lowest impact on dairy and horticulture revenues. However, dairy support has the largest revenue reduction with grandparenting making it a potentially contentious approach for some farmers.

The process and logic to decide which approach to apply when allocating a catchment water quality cap between resource users may therefore involve:

- Stakeholders agreeing on criteria and principles to choose between allocation approaches, including for equity. The principles should be agreed before allocation approaches are compared to facilitate a more objective discussion on the approaches based on these criteria/principles
- Identifying allocation approaches to consider

- Estimating the catchment revenue impacts of each allocation approach to compare the relative efficiency of each one
- Evaluating the distributional impacts of each approach on different sectors considering the other criteria and/or principles agreed by stakeholders
- Identifying appropriate policy mechanisms or design. This could, for instance, be focused on improving efficiency (e.g. through trading or some other flexibility mechanism) and/or compensating those who face the highest costs or have the least options to mitigate.

The key findings are:

- There is no universal 'best' approach to allocate nutrients to farmers. In an analysis that compares different allocation approaches in two catchment settings we find that the efficiency and equity implications of the various approaches differ based on existing land use, land characteristics, and the stringency of the regulation
- To move past the current impasses and debates on allocation, policy-makers should recognise that different stakeholders are likely to prefer diverse approaches. The *a priori* identification of criteria and principles to compare allocation approaches is needed to focus discussions. Efficiency and equity in these dialogues will be important as these relate to the size of the costs and benefits and who bears the costs. Policy can be designed to improve efficiency and to compensate, where necessary, those most affected.

Conclusions

In conclusion, clean freshwater is at risk in this country and national policy directions are being defined to maintain or improve the overall quality of freshwater across New Zealand.

One response to address declining water quality is to regulate the loss of nutrients coming from diffuse sources. This is when the quandary of how to allocate an overall

catchment cap (or nutrient load limit) to individual farmers arises and there has been some debate on how to define a common approach across the country.

Our analysis, however, shows that the most efficient allocation approach and the cross-sector distribution of costs when limiting nutrient discharges differs between catchments due to different existing land use and land characteristics, and stringency of regulation. In other words, there is no universal 'best' allocation approach.

While it seems that at lower reduction targets the approaches related to existing land use appear more efficient this does not hold at higher stringency levels. Therefore, debates should focus on which approach to choose for a catchment considering the agreed criteria and/or principles including, among other things, efficiency and equity. Policy can then be designed to, for example, improve efficiency and/or compensate those most affected.

Compensation could take many forms such as direct compensation for losses or extending compliance periods. Therefore, it is the purview of policy-makers to decide which approach, and potential compensation and flexibility mechanism, is best suited to the land uses and land characteristics in any given catchment and for the people within it.

Acknowledgements

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MELANIE BROOKS

IRRIGATION IN NEW ZEALAND – AN UPDATE

Is there a change in perception of water given its perceived scarcity, and of irrigation being bad for the environment? Where there is water there is food and social benefit. This article looks at some of the issues and trends in the irrigation space in New Zealand.

Viewing platform at MHV Water scheme storage ponds at Carew

Our water isn't always in the right places at the right times, and that is where storage, distribution and application infrastructure are important to complete the picture.

Irrigation not the culprit

Irrigation is the life force that has spawned prosperity – it has enabled us to grow consistent, reliable and profitable crops on land that once grew little more than tussock.

New Zealand is the envy of the world; we have excellent soils, security of supply chain (how our supply chain for water and food is safe), and water. Our water isn't always in the right places at the right times, and that is where storage, distribution and application infrastructure are important to complete the picture. However, this also raises questions about environmental sustainability and cultural awareness.

Irrigation does not cause pollution or degradation to our waterways. Poor practice and intensification beyond what the land can handle are the issues. Profiteering off the back of unsustainable practices is no longer something that is tolerated within the agricultural sector or by the wider public. Improvements to on-farm infrastructure and further advances to practices are required, and farmers now know that we are on the path of continuous improvement for better environmental outcomes.

Kai tiaki guardianship

We are all guardians of the land, and kai tiaki is alive and well within the farming community. Current generations have the opportunity to leave our land in a better place, both from an environmental and economic perspective. Within the irrigation industry we face many challenges and opportunities as kai tiaki and these are discussed below.

Environmental sustainability and public perception

One of the main challenges that we are facing in New Zealand is the gap between the perception and reality of what our farmers are doing. We are one of the most urbanised countries in the world; 86% of the population lives in urban environments. How do we bridge the divide and foster understanding and empathy between our rural and urban environments?

The agricultural sector has made substantial progress as we have recognised and owned the issues, made initial changes to address poor practice, are continuing to make changes to improve practice, and are investing in research and technology to find further improvements. Being open and transparent about our behaviour and how we farm is important too. The negativity and anger at farmers was amplified when, as a sector, we were defensive and seemingly in denial.

MHV Water education day

Storage infrastructure improves supply resilience and enhances improved environmental outcomes, because it reduces use, improves reliability, and enables the growth of high-value crops.

It was an important step when our farmers and the sector came out and effectively said, 'Yes, we unknowingly contributed to degradation of the waterways, we didn't know, but now we do and we are going to make a change.' It may seem like a small thing, but it was significant. By acknowledging there is a problem you can then isolate the issues and start on the path of continuous improvement.

Now we have identified what are known as good management practices (GMPs) and these will continue to evolve. They are different from what we did five or 10 years ago, and they will be different again in five years' time. This is a good thing, as we need to keep improving as our knowledge improves.

The public perception of New Zealand farming practices, especially within the dairy industry, is less than ideal but how do we change it? When we take a step back, we all want the same thing. We want a thriving environment and society where our children can swim in the rivers we did when we were young, and we want biodiversity and safe recreation in this country. Agreeing that we want the same outcomes is the start of the answer.

Collaboration important

Given we want similar things we need to collaborate more, getting people from different sectors and backgrounds sitting around the table and listening to one another, instead of talking at each other. That may sound simple, but it can make a huge difference. If we can each understand a little more about 'the other side', their concerns and what success looks like for them, then surely we can also find a common path.

When we listen and focus on solutions we communicate that we care. If we are defensive and enter these discussions with anger, resentment or bitterness it will not work and we will further alienate each other, and the distance grows. With so much at stake it is worth the effort to take the time to listen.

For instance, Te Runanga o Arowhenua (our local Runanga) are passionate about what they want to achieve. While we do not always agree (mainly about shorter-term actions), we are mostly aligned in the longer term and I am positive that together we can achieve these long-term objectives.

Infrastructure resilience and development

Infrastructure resilience is another key pillar and we need to ensure we are maintaining a long-term view when we are building and maintaining these multi-generational assets. With our water infrastructure being mainly funded by users, as opposed to central government, there is a concern that our investment outlook is too short term.

Major infrastructure projects may have a 50 to 80 year life, but as irrigation schemes the need for our farmer-shareholders to fully fund our investments themselves makes it hard for us to have a sufficiently long-term view. Even though it is much cheaper to build upfront, it is difficult for us to build in surplus capacity (overbuild) that may not be required for another 10 years or more, because the benefit of that surplus is for future users but the burden of financing it falls on existing users. This challenge, and misdirected public perception around irrigation, has seen three key irrigation scheme proposals fall over in recent times and they represent lost opportunities to build more resilience into our economy and in some instances domestic water supply.

We know that the prosperity in Mid-Canterbury is a direct result of the investment by the then Labour Government back in the 1930s who decided to stimulate the economy and invest in large-scale water delivery infrastructure. Not only did it help the economy and get people working after the Great Depression, it has stimulated the economy for generations to come.

How is the current government supporting large-scale infrastructure investments? The Crown irrigation fund was lending, at commercial rates, to pay for overbuild or to cover shortfalls in short-term uptake. It also supported feasibility studies to investigate opportunities to expand/build new infrastructure and to incorporate environmental flows. This support enabled progress that might have otherwise failed, and showed goodwill from the government, a willingness to support large agricultural infrastructure projects, and it recognised the wider community and national benefits.

This country undoubtedly benefits from the increase in GDP from these projects, but there are serious concerns that the inaccurate perception that irrigation is polluting our environment has derailed an investment fund that was helping to grow New Zealand Inc, and especially grow a healthier regional New Zealand. Infrastructure is not just about the delivery of water, but also about capturing the water when it is plentiful and distributing it in times of need.

Moving away from 'just in case' irrigation

Storage infrastructure means that we can continue to evolve from 'just in case' irrigation to 'just in time' irrigation to 'just enough' irrigation. For instance, our MHV Water scheme storage ponds at Carew, which hold about

In the past irrigation schemes were solely about delivering water, but now we need to balance environmental and economic sustainability to achieve improved water quality outcomes.

five days of water at peak demand, have increased farmer confidence in our water reliability, allowing them to move away from 'just in case' irrigation and reduce water use.

Storage infrastructure improves supply resilience and enhances improved environmental outcomes, because it reduces use, improves reliability, and enables the growth of high-value crops. As a country we are in an excellent position because we are 'change ready'. We recognise our environmental and cultural requirements, and while it is problematic to make generalisations, on the whole there is willingness to continue to evolve. The capacity to change is the challenge. Some farmers are highly geared, and while they are willing, they are restricted to operating a system that will generate sufficient cashflow to cover their costs.

Science, technology and collaboration

During a recent Irrigation NZ Study Tour to Colorado and Nebraska one of the many highlights for me was how farmers were using the irrigator as an applicator, not just for water, but also for fertiliser and chemicals. With variable rate irrigation (VRI), which was developed in New Zealand, they were able to cater for different requirements for crops at different stages underneath the pivot. They were applying fertiliser and/or their chemicals little and often to align with the plant requirements, to reduce unwanted leaching and with a high degree of accuracy. This is undoubtedly an opportunity in New Zealand as we continue to strive to lead the world in environmental sustainability.

We should also not understate the scale of investment in agri-tech, science and research both here and internationally – it is phenomenal and we need more. One example is the Water for Food Institute in Nebraska, which is world leading. Through research and policy development, education and communication the Institute is enhancing knowledge, fostering future water and food security leaders, and developing effective techniques to sustainably manage water and increase food security.

There are hundreds of other New Zealand organisations showcasing and leading agriculturally-focused research and development. Blinc Innovation, based in Lincoln, Canterbury (which has one of the highest concentrations of agri-scientists in the southern hemisphere) are focused on improving collaboration within agriculture to increase the rate and delivery of usable innovation. They are collaborating across historic silos and building opportunities for businesses in New Zealand to reach the world.

It would be helpful to see how the Regional Growth Fund could support research into future food and fibre options for our farmers and recognise the benefit of a resilient infrastructure network. Questions that need asking are:

- What can we grow?
- Is it sustainable environmentally and economically?
- Do we have a competitive advantage?
- Is there a market and is it accessible?

The opportunities will fall out of that and enable positive change. The growth in focus on food production and food security looks set to continue and we need to find ways to foster more interest in working in the agricultural sector. We need more scientists, entrepreneurs, inventors and generalists who want to be involved in this exciting and growing industry for the benefit of New Zealand Inc.

A brighter future

There are a number of key challenges and opportunities for irrigation in New Zealand in the future. Ultimately, irrigation schemes need to deliver sustainable solutions for their farmer-shareholders and their communities. In the past irrigation schemes were solely about delivering water, but now we need to balance environmental and economic sustainability to achieve improved water quality outcomes.

We know that there is further work required to share the progress we are making on water quality. Progress on improvements may not always be linear, and we need to have confidence that with a focus on GMPs and striving for kai tiaki we will achieve success.

Rural professionals showing leadership

As rural professionals we must show leadership with our farmers and help guide them on the journey to improved environmental performance. While it is easy to criticise the performance of farmers, the challenges being thrown at farming are substantial. We have a role to help bring balance to the discussion, by helping urban New Zealand see the progress that is being made and encouraging our farmers to get on board.

Having improved water quality outcomes is a goal for all New Zealanders to solve and aspire to. None of us should stand in our glasshouse throwing stones. Instead, let's each look at what we can change in our lives or businesses and then look for the next opportunity to change and then continue to repeat the process for a better tomorrow.

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TERRY PARMINTER

MEASURING SYSTEM INTENSITY ON SHEEP AND BEEF FARMS

Farming intensity is a concept often talked about, especially in relation to system change and environmental footprints. An objective measure of intensity is proposed for the sheep and beef industry to sit alongside the one that is already available to the dairy industry.

Wairarapa hill country, which suits intensive sheep and beef farming and if managed appropriately has minimal environmental damage

Farm systems modelling

Farm consultants are often evaluating farming systems and farming performance across farms and for the same farms across a number of years. Farm system modelling can be used for within-farm comparisons at detailed levels and to dynamically reflect management changes.

To illustrate the most salient changes, the results of system modelling are often standardised and reported per unit area and/or per stock unit. However, these can be misleading when applied across a range of farming systems and farm contexts. The limitations of using stock units for this purpose has been previously described by Warren Parker in 1998, where he considered that a number of adjustments were needed before standards based on livestock units could account for the underlying differences between farm topographies, seasonality of feed demand, resources and policies. The proposed measure of livestock intensity for sheep and beef systems can address some of these.

Measure of system intensity

Having a measure of system intensity available can assist with strategic issues that apply across a number of farms or when there are system changes being made within a farm. It provides a useful way of understanding the interactions between farm management and off-farm effects, as well as being a useful tool for explaining the fit of new technologies and practices to farmers and other professional groups. For me, system intensity is that part of system productivity directly related to human inputs and activities. According to that definition, farming systems that require greater inputs and more complex decision-making are going to be more intensive than farming systems where the converse applies.

For example, as shown in *Table 1*, in most regions a relatively highly stocked sheep and beef farm selling store stock is going to have a better fit with seasonal pasture growth patterns than a lower stocked farm finishing all its lambs over the winter and into early spring. The higher stocked farm that matches feed demand to pasture supply may actually be the lower intensity farm.

In this example, if we are thinking about nutrient contamination of waterways and unless suitable mitigations are in place, it is likely that the lower stocked farm will need to make greater use of inputs over the winter. It will also have the potential for greater waterway contamination. The example shows it is unhelpful to use measures of stocking rate as a shorthand for farm system intensity. Doing so can result in pressure on farmers to reduce stocking rates when a change in the farming system might be more useful, and vice-versa.

Differentiating between the two terms in this way enables us to support farmers who have highly stocked farms with high pasture utilisation in a different way to farms that may still be highly stocked, but have a high amount of feed derived from forage crops and/or imported into the farm. Both of these farm systems have the potential to be similarly profitable, but they will need to do so in quite different ways.

Dairy industry implications

Being able to respond to farm system differences has also been important in the dairy industry. Early research papers lamented that the increasing variety in dairy systems meant that researchers were not able to develop a consistent set of key performance indicators and best management practices. In response, they developed a framework for describing dairy systems based on their

Table 1: Comparison between actual sheep and beef farms in the Wairarapa in the Ruamāhanga River catchment

Source: Parminter & Grinter, 2016

FARM ATTRIBUTE		
Farm system	**Sheep and beef breeding**	**Sheep and beef finishing**
Lambing percentage (weaning)	130%	140%
Proportion of store lambs	63%	100%
Sheep to cattle ratio	75:25	70:30
Pasture utilisation	85%	82%
Proportion of feed imported	2%	15%
Stocking rate (winter stocking rate)	9 su/ha	8 su/ha
Nitrogen loss to water (kgN/ha)	8 kgN/ha	17 kgN/ha
Operational profit	$345/ha	$400/ha

The higher stocked farm that matches feed demand to pasture supply may actually be the lower intensity farm.

resource use intensity without using stocking rate. One of the advantages of their measure of system intensity is that it is independent of production or farm profit and can be used to underpin possible ways of improving these.

For those unfamiliar with the measure of system intensity used by the dairy industry, the following has been extracted from the DairyNZ 'Facts and Figures' report (2017, p. 24):

- System 1 – all grass self-contained, 100% homegrown feed with all adult stock on the dairy platform. No feed imported. No supplement fed to the herd except supplement harvested off the effective milking area and dry cows not grazed off the effective milking area
- System 2 – 90-99% of total feed is homegrown feed. 1-10% of feed is imported, either as supplement or grazing off [farm] for wintering dry cows
- System 3 – 80-89% of total feed is homegrown feed. 11-20% of total feed imported to extend lactation (typically autumn feed) and for wintering dry cows
- System 4 – 70-79% of total feed is homegrown feed. 21-30% of feed imported and used at both ends of lactation and for wintering dry cows
- System 5 – 50-69% of total feed is home grown feed. More than 31% of feed imported and used throughout lactation. Feed imported could be greater than 50%.

The dairy farm system descriptors are commonly used to establish industry standards of, for example, farm profitability, feed utilisation and nutrient losses. They have also been used to examine the impacts of policy interventions by regional and central government.

From a farming systems perspective, the key attributes about these descriptors are the sources of feed and how they are used to generate production. For example, compared to System 3 farms, System 2 farms are managed in order to use their imported feed for supplementing dry cows between drying off and calving. The System 3 farms do that and also supplement their cows to extend their lactation by another few weeks in the autumn. At similar stocking rates it is possible to say that the System 3 farms are more resource intensive than System 2 farms, although they may still be able to achieve similar levels of profitability.

By addressing issues of resource use through an understanding of dairy farming systems and system intensities, a study carried out provided advice to Manawatu Wanganui Regional Council on the impact of their policies on the dairy industry. That study highlighted that Systems 1 and 2 dairy farms had little flexibility to achieve catchment limits without reducing both stocking rates and profitability. In the same study, Systems 4 and 5 farms had more flexibility about how they could be managed to achieve catchment limits.

The dairy industry has provided a farm system typology, but nothing similar has been available for people working with sheep and beef farmers. If we consider sheep and beef systems, amongst other things there are variations due to:

- The ratio of cattle to sheep and/or other livestock
- The ratio of breeding animals to replacements, store stock and finishing stock
- The ratio of animals purchased and/or sold within a season to those animals carried over between seasons
- The amount of pasture grown and its distribution
- The amount of forage crops grown and its feed distribution
- The amount of feed imported
- The types of land typography, their ratios and their accessibility
- Farm infrastructure.

Ruamāhanga River catchment

In 2016-2017, Greater Wellington Regional Council and the Ministry for Primary Industries (MPI) undertook an economic analysis of the impact of possible policy options for the Ruamāhanga River catchment. That study involved selecting suitable farms to represent farming within the catchment and then applying the results across the whole of the catchment.

The farms to be selected varied in terms of land use (arable, drystock and dairy), stocking rate (8-12 su/ha) and farming intensity. To select the farms, the dairy industry's established intensity scale (described earlier) was used but nothing was available for sheep and beef farming. Up until now the sheep and beef industry have relied on a system of farm classes to describe the different production systems to be found across New Zealand. The North Island is described as having three classes – 'hard hill', 'hill' and 'intensive' – and each class is described in terms of its topography and stocking rate.

Possibly the lack of interest by the industry in developing a scale of management intensity reflects that: from a national perspective, and within each class, the farms were considered to be very homogeneous; and the industry has not had to address environmental policies at a catchment scale in the same way as the dairy industry.

In order to develop a scale of farming intensity suitable for this project, staff at Beef + Lamb NZ helped to

Being able to respond to farm system differences has been important in the dairy industry.

identify a possible typology of intensity that could be used alongside the existing dairy industry typology. Like the dairy system typology, the sheep and beef typology initially needed to compare farming systems based on their fit with the expected feed-flow from pasture. At higher levels of intensity a higher proportion of animals are traded and greater use is made of imported feed.

The typology was independent of farm profitability, and although associated with stocking rates, each farm system could be developed to suit a range of stocking rates. In the typology, each sheep and beef system is not directly comparable with the equivalent dairy system, but the range of system types encompasses the range of systems found in the industry in a similar way to the distribution of dairy systems.

The sheep and beef farming systems that we developed were:

- System 1 – A sheep enterprise that is breeding its own replacements (wethers and ewes) and where the main output is wool. The cattle enterprise may not exist, or be self-replacing breeding cows producing weaner calves, or be store cattle between 12-40 months of age. There is generally no bought in feed, no forage cropping (except for pasture renewal) and no nitrogen fertiliser used
- System 2 – A sheep enterprise with breeding ewes selling the majority of lambs store (less than 15 months of age). A cattle enterprise of breeding cows selling some surplus calves and possibly some cattle at less than 30 months of age. At least 55% of the stock units wintered are sheep. Forage cropping may be used specifically to winter breeding animals and up to 10% of cattle supplement may be imported
- System 3 – A sheep enterprise with a flock of breeding ewes for replacements and finished lambs. Hoggets may be mated and/or additional lambs bought in and finished. No breeding cows but bought in cattle are kept at least nine months and finished at less than 30 months of age. Forage cropping may be used specifically to finish lambs and up to 10% of cattle supplement may be imported. Irrigation may be used
- System 4 – No breeding ewes but lambs are bought and finished on the property. No breeding cows, but cattle are bought and finished on the property at less than 30

Wairarapa cropping (plantain)

By understanding the intensity of sheep and beef systems, farmers are better able to match their own stocking rate and farming inputs to the most economically efficient benchmark farm for their level of intensity.

months of age. Forage crops and imported supplement used for finishing animals in summer and autumn. Irrigation may be used

- System 5 – No breeding stock and beef finishing at less than 18 months of age. Between 10-20% supplement bought in and irrigation may be used.

The farming systems that were developed were used alongside those from the dairy industry and different arable industry systems to select representative farms for the Ruamāhanga River catchment. The system intensity measures enabled comparisons to be made within and across livestock industries about their impact on water quality and regional gross domestic product. [This report is available on the MPI website: MPI Information Report No: 2016/22.]

Benchmarking

Farmers using benchmarking with other farms as part of their strategy to improve their profitability want to be able to compare themselves with farming businesses that have similar potentials to their own. By understanding the intensity of sheep and beef systems, farmers are better able to match their own stocking rate and farming inputs to the most economically efficient benchmark farm for their level of intensity. Management practices and new technologies that can affect pasture utilisation and feed use will influence the results from farming intensity. When they can take these into account farmers are able to improve their uptake of new technologies and management practices.

In the future, as the sheep and beef industry and individual farmers consider their off-farm impacts on water quality and climate change, they will need to consider the effects of farming intensity without it automatically meaning they have to adjust livestock numbers and/or profitability. By accounting for farming intensity separately from other farm system measures, discussions with officials and industry leaders will be able to take place in an objective and scientifically informed manner.

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HAYDEN ROBINSON

This profile looks at the career of Canterbury Branch Chair Hayden Robinson and his involvement with NZIPIM.

Ag education

Hayden was brought up in Methven, coming from a fourth generation arable and livestock finishing farming family, and they still farm there today. He took a keen interest in the farm growing up and spent many weekends and school holidays helping out. It was through the late 1980s and early 1990s that he gained essential skills around cost management combined with productivity. Cost management and a resourcefulness focus picked up from his family from those years are still with him today.

Despite not being encouraged by his teachers to further his study in agriculture, following high school Hayden went to Lincoln University, enrolling in a BCom majoring in accounting. Mid-way through the first year he realised that his passion was with agriculture, being more at home on field trips and analysing farm systems than doing accounting, so he enrolled in a BComAg.

North Otago experience

After graduating from Lincoln in 2002 Hayden moved to Oamaru for a role in rural finance working for Pyne Gould Guinness, which later merged with Wrightson to become PGG Wrightson Limited, under mentor Neville Langrish. Neville had previously worked at the Rural Bank before becoming the Managing Director of Stringer and Co, a subsidiary of Reid Farmers. Hayden saw the role as a great start to his professional career and learned many skills, both business and interpersonal, from Neville. He also met many people in the rural community while playing for the Valley Rugby Club and through his involvement with the Five Forks Young Farmers Club.

Agriculture was changing at that time in North Otago. The first stage of the North Otago Irrigation Company Limited irrigation scheme was being implemented, which changed the farming landscape in the region. It made for interesting times in the finance sector, assessing credit applications for those farmers who were supporting the dairy industry, which although is common practice now was almost unheard of in 2005 in North Otago. It was also a time for great development in the region, which resulted in the Oamaru branch having the largest loan portfolio for PGG Wrightson in New Zealand. The branch was able to retain client loyalty despite competition from the major trading banks.

Agriculture was diverse in North Otago and he had clients ranging from sheep and goat milking farmers (an area just gaining momentum at the time), South Island high country merino farmers who were beginning to supply Merino NZ, dairy farmers and mixed arable farmers, to traditional downlands sheep and beef farmers.

At a recent NZIPIM event it was stressed to the audience that Germany is renowned for its automotive industry, but it wasn't central or local government in that country which drove this, but the success of each individual car maker who created the outcome. Hayden feels that as producers in New Zealand we need more companies prepared to take a leading market role.

London and the GFC

Hayden took a working holiday to London in 2007 and while there worked at Barclays Capital. In the UK he experienced first hand the prelude to the global financial crisis, and he and his colleagues were encouraged to close out as many unopened deals as fast as possible. A year later in New Zealand the Deposit Guarantee Scheme was implemented, providing guarantees to depositors, and it maintained liquidity for the stronger finance companies.

Back in New Zealand in 2009, Hayden was promoted to the Head of Credit at PGG Wrightson Finance Limited. Again he was dealing first hand with the tightening credit squeeze and general liquidity issues facing many farming businesses.

Lauriston Farm Improvement Club

However, Hayden was interested in a broader role rather than focusing solely on rural finance and in 2010 joined the Lauriston Farm Improvement Club as a Farm Advisor, his current role. On joining the LFIC he worked alongside John Kinvig, Barry Croucher and Ross Polson, who combined had over 100 years of farm advising experience and knowledge. His clients include mixed arable, dairy support and dairy. On any given day he can be assisting clients with farm systems, agronomy, livestock integration, finance and succession planning.

New irrigation schemes, upgrades and extensions to existing schemes have provided him with rewarding work. Water has enabled better efficiencies, as well as improved viability and the opportunity to grow new crops and livestock. He believes that in most cases the environmental footprint of a farm business has improved.

Hayden finds working with young farmers particularly satisfying as they grow their businesses. He enjoys helping his clients identify oppourtunities and implement strategies. He also likes to ensure they do not become all consumed with their business and that they take time out to review it, and explore other strategies and research markets.

For him the challenge is ensuring the next generation have the oppourtunity to create their 'own vision' and, importantly, be successful in implementing it. He says a good succession plan needs the next generation to be better than the last.

NZIPIM involvement and benefits

He has found being involved with the Canterbury Branch Committee enormously satisfying, in particular his role as Branch Chair, and enjoys the networking through organising and participating at events. Hayden says the opportunities to attend courses promoted by NZIPIM, such as the Leadership Development Forum, play an important role that complements the on-the-job training provided by the LFIC.

All the Farm Advisors in the LFIC consider themselves generalists, so the wider networks provided by NZIPIM enable good access to specialists in different fields such as nutrient experts and valuers when required. Hayden notes that the challenge we face as an industry body is managing the expectations from a huge diversity of agricultural professionals.

In his view the primary producer has a number of calls on capital, which can include succession planning, debt repayment and asset replacement, all previously seen as a priority in the past. He suggests it may be that investment in new market development is a better use of capital going forward.

He recalls that at a recent NZIPIM event it was stressed to the audience that Germany is renowned for its automotive industry, but it wasn't central or local government in that country which drove this, but the success of each individual car maker who created the outcome. Hayden feels that as producers in New Zealand we need more companies prepared to take a leading market role, and whether that can directly include the grower remains to be seen.

Positive future for primary industry

In spite of recent environmental reforms and a clamp-down on foreign investment, he believes there is still much to be positive about. He is encouraged by new research, for example, forages for reduced nitrate leaching, breeding characteristics of cattle and general industry lead innovation.

Hayden says, 'The agricultural industry needs to continue to take the initiative to promote research and development for both on-farm practices and for importantly identifying and developing new markets. The key to this being successful is partnering with the primary producer and demonstrating to them the potential improved viability of their business.'

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