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

HEALTH AND SAFETY OBLIGATIONS RISK AND RESILIENCE ON LIVESTOCK FARMS
MENTAL AND PHYSICAL WELLBEING ON-FARM **PASTURE YIELD MAPPING**
FARM SYSTEMS ANALYSIS

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Building the capability and capacity of Rural Professionals

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STEPHEN MACAULAY CEO

CEO's comment

Opportunities abound in technology and information-based systems – but are we ready?

During this year's conference we brought together a great selection of speakers covering a diverse range of topics from across the primary industry, which made the event a stand out for the Institute. In reflecting on the conference over the last few weeks, I have been thinking about the opportunities for rural professionals in the use of technology and information-based systems.

Over the past few years we have seen an increasing array of technology and information-based systems become available to the farming community to help improve on-farm efficiency and productivity. The speed of change in the development of technology and information-based systems is likely to accelerate in the years to come.

There is an increasing sense that the individual has greater choice and flexibility in the technology platforms they choose to use. Collier Isaacs of FarmIQ reinforced this during his presentation at the conference when he advised that when selecting and deciding upon any technology or information-based system, it is important that farmers and rural professionals drive what they want out of the system, rather than being constrained by the limitations of a system's architecture.

With the increasing use of cloud-based information systems there are greater opportunities for farmers and their advisers to integrate and share information between multiple sources, including accounting packages, farm decision tools, regulatory information, livestock data, risk management information, etc. Combined with new technologies for monitoring and collecting data, we are headed to a future where the cost of inputting, analysing and reporting data will reduce and the parameters that we measure and the granularity with which we measure them will increase. We will have the data to manage farms with the level of monitoring similar to that available to factories and processing plants. The challenge will be how this data is turned into information that can be used to make better strategic and operational decisions.

Expanding upon this further, it is predicted that engineering intelligent software systems will emerge that can process large data sets using unstructured commands and subtle judgments with the ability to learn 'on the fly', which will be a significant step towards 'automation of knowledge work'. In May 2013, the McKinsey Global Institute identified automation of knowledge work as one of 12 disruptive technologies that have the greatest potential to drive substantial economic impact by 2025.

> **In the face of new and potentially disruptive technology, rural professionals may need to consider their service offering beyond the provision of information and knowledge.**

With better use of cloud-based information and the potential development of knowledge-based intelligent software systems in the future, what are the opportunities for the rural profession in servicing an increasingly sophisticated farming clientele?

During the conference Collier noted that 'it's wisdom we are after' in maximising value within information systems, while Andrew Gibbs of Deloitte described it as 'wisdom and insights' at the end of a decision-making process as the target to strive for.

In the face of new and potentially disruptive technology, rural professionals may need to consider their service offering beyond the provision of information and knowledge. This could be on how rural professionals use the information available to work with their farming clients, both at a high level in areas such as developing strategies to meet the objectives and aspirations of the farming business, and then evaluating the implementation and ongoing business outcomes against those strategies and business constraints.

I believe that the skills, expertise and insight of the rural professional in effectively using technology and information-based systems, underpinned by the integrity and professionalism of that individual, have the potential to extend their position as an integral and highly-valued part of the farming business in the future.

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We would also like to thank our principal sponsor and partnering sponsors for their generous support of the conference.

The towing vehicle must match the load – here the coupling has sheared

NEIL PERCIVAL

Coming changes to workplace health and safety

There is evidence from other industries that businesses with good health and safety outcomes are more profitable. Good outcomes are a benefit, not a cost. There is much concern, however, about how the impending changes in health and safety legislation will affect farming.

Given that agriculture never really came to grips with the current legislation, it is understandable there is concern that the new rules will be too restrictive. Consultants and advisors will need to be very clear about how the new legislation will affect clients. Good advice is always based on good understanding and knowledge – and health and safety is no different.

High cost of workplace deaths, injuries and illnesses

As a nation our performance in workplace health and safety is much poorer than our neighbours across the Tasman and in the United Kingdom. As an

As an industry agriculture still has an appalling number of deaths and injuries – the cost to ACC is about $80 million per annum.

industry agriculture still has an appalling number of deaths and injuries – the cost to ACC is about $80 million per annum. This does not take into account the cost of lost economic contribution or the human cost; collectively these will raise the treatment and injury costs about seven-fold.

The deaths tend to be associated with machinery and transport, while the highest injury cost is from contact with cattle and sheep. Simple things like trips, falls and musculoskeletal injuries are also major contributors. The consequence is that ACC levies are higher for agriculture than for most other industries and this is a significant cost to the sector. None of these statistics take into account the costs of illnesses arising from farming such as hearing loss, emphysema, asbestosis or severe allergic reactions.

Key changes in new legislation

New PCBU definition

The concept that every business must have a PCBU (Person Conducting a Business or Undertaking) will make all farmers more directly responsible for ensuring that contractors work in a 'safe manner'. There is no way of opting out of this responsibility by signing disclaimers etc. At present most farmers leave their contractors to sort out their own safety standards, but that will no longer apply. So if a silage contractor rolls a tractor and the driver is injured or killed, expect to be part of the investigation by WorkSafe NZ.

Director's liability

The concept of 'director's liability' is there in the present legislation, but not as explicitly as the new Bill. This was one of the identified factors in the Pike River Royal Commission report. In a practical sense, it means that dairy farm owners with a sharemilker must provide resources that are safe to use. Similarly, the trustees of the big Maori farming incorporations must ensure likewise for the manager and staff.

Reasonably practicable test

The test for controlling safety hazards is moved away from taking 'all practicable steps to control significant safety hazards' to doing what is 'reasonably practicable' to control safety risks. There is a perception that this will simplify the control of high safety risks. 'Reasonably practicable' means what is, or was, reasonably able to be done at a particular time to ensure health and safety, taking into account and weighing up all the relevant matters. The test of 'reasonably practicable' brings New Zealand into step with most of the western world.

More safety guides

WorkSafe NZ have already greatly expanded the number of safety guides for farming. While these are not as prescriptive as approved codes of practice or regulations, you must have a very good reason not to follow them. For instance, the infringement notices being issued for quad bike 'misuse' are based on the *Quad Bike Guidance* document.

Quad bike roll-over – after the event. Preventable? Totally. The best prevention is using another type of vehicle

Embedded low safety standards in NZ agriculture

Most farm accidents are primarily caused by the person who gets injured. Sometimes there are factors such as fatigue, inexperience or incompetence involved, especially with young people, those new to the industry, or where those recently arrived in New Zealand do not understand our culture or the risks in farming.

There are often significant risk-taking behaviours involved in accidents. The question then arises, 'Why would anyone knowingly put themselves at risk of injury in their job?' Answer this and the battle is half won. Some people are risk-takers and others are risk-averse. As a nation we are habitual risk-takers – look at our recreational activities such as tramping, whitewater rafting, bungy jumping and mountain biking.

A significant factor in our poor safety record on farms is that unsafe ways of working become normal methods of working, as most of the time we get away with it.

A significant factor in our poor safety record on farms is that unsafe ways of working become normal methods of working, as most of the time we get away with it. This definitely does not make it right. Take the resistance to using helmets on farm bikes and quads. Will the farmers who refuse to wear these helmets drive to town without a seatbelt fastened in their vehicle? It's not likely, so why would they resist a simple measure to reduce injury risk? There is a simple explanation that risky behaviours become normalised. Somehow we have to break this cycle and education is much more effective than enforcement.

Most accidents with stock occur in the yards, shearing or cowsheds – the facilities must be fit for purpose

Sourcing reliable health and safety information for agriculture

The question also arises, 'How far should consultants go on health and safety advice?' If you wouldn't ask a bank teller about taxation issues then consider if you have the skills and knowledge to advise on safety issues with clients. Health and safety is a specialised area, so be very cautious in giving advice.

Always question the formal qualifications of anyone working as a health and safety consultant – they should have at least a diploma level qualification.

The government is promoting a register of competent health and safety professionals named the Health and Safety Professionals Alliance (HSaPA). Until this is operational it is still possible for anyone to practice as a health and safety consultant, qualified or not, competent or not. A new organisation has been formed to administer this – the Health and Safety Association of New Zealand (HASANZ). The members are the various professional bodies representing the sector. Each body will set their standards and accredit people in the same manner that happens with engineers, accountants or farm management consultants.

The new HSaPA register will at least give you a chance to assess the ability of someone to help your clients and should come on-stream in 2016-17. In the meantime, always question the formal qualifications of anyone working as a health and safety consultant – they should have at least a diploma level qualification.

In many instances the farming industry has not been well served by those offering health and safety training, where after a half-day or one-day course you are classed as trained and competent, which you clearly are not. Many of these so-called 'trainers' have a very rudimentary understanding of safe systems of work and, in some cases, regard the embedded risk-taking behaviour as normal. Training must be effective, getting at attitudes as well as skills.

The agricultural industry is also beset by so-called experts selling health and safety systems. It is recommended that in considering such a service always check their credentials. It is very important that the initial risk assessment is specific to the farm and that there are clear recommendations for necessary actions. The Health and Safety Plan must be easily understood and as far as possible be written in plain language.

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NEELS BOTHA

Staying mentally safe on-farm

This article looks at depression in farming communities and farmer suicide. Initiatives such as the recently launched Farmstrong website are discussed, and risk factors outlined, as part of the solution to help farmers stay mentally safe on-farm.

What is wellbeing?

Wellbeing is a complex combination of a person's physical, mental, emotional and social health factors and is strongly linked to happiness and life satisfaction. How you feel about yourself and your life is an easy-to-use and, for all practical purposes, a close enough measure of your wellbeing. Researchers investigating happiness have compiled a list of 15 interrelated factors that enhance a person's wellbeing. Jobs like consultancy or farming, for instance, provide not just money but also purpose, goals, friendship and a sense of belonging.

Some factors also make up for the lack of others, for example, a good marriage can compensate for a lack of friendships, while religious beliefs may help a person come to terms with physical illness. Money is linked to wellbeing, because having enough improves living conditions and increases social status. However, happiness may increase with income but only to a point. Many people mistakenly believe that increased wealth is associated with increased happiness.

Image courtesy of Farmstrong

Various international studies have shown that it is the quality of our personal relationships, not the size of our bank balance, which has the greatest effect on our state of wellbeing. Believing that money is the key to happiness can actually harm a person's wellbeing. For example, a farmer who chooses to work very long hours misses out on time with family, friends and leisure pursuits. The added stress of long working hours may also reduce a person's life satisfaction. Research shows that people who pursue 'extrinsic' goals such as money and fame are more anxious, depressed and dissatisfied than those who value 'intrinsic' goals like close relationships with loved ones.

The research showed that signs of depression played a key role, both in farmers' mental and physical health, and were strongly associated with anxiety, burnout, pain and physical illness.

Survey results

Wellbeing is important, but not easily realised. The 2012 New Zealand general social survey has shown that 23% of New Zealanders thought they did not have enough contact with family they did not live with. Looking back over the four-week period before the survey, 42% felt they had not had enough free time, 31% reported having felt lonely and 15% felt they did not have enough money to live on.

An American study into mental health found that while one in four respondents was depressed, only one in five was happy – the majority fell somewhere between, neither happy nor depressed. Measuring wellbeing in any population is difficult because its interpretation is so subjective – how you feel about your life largely depends on the way you see it.

Moreover, survey results tend to differ depending on what aspect of wellbeing is measured. For example, an Australian survey of young people found that eight in every 10 reported feeling satisfied with their lives including how they felt about their work, studies, income and relationships. However, this positive picture was contradicted by another survey, which found that about half of all young Australians were grappling with a difficult problem such as depression or alcohol abuse. Wellbeing is a nebulous concept that is hard to pin down with graphs, charts and statistics.

Depression in farming communities

Despite the challenges associated with measuring wellbeing, it is still worthwhile investigating because it does increase our understanding of how well or how badly things are going for people by providing trends and insights into the interactions between different aspects of wellbeing. Also, keeping track of the nation's or farmers' mental wellbeing is important, as evidenced by the World Health Organization who have indicated how mental illness accounts for 15% of the total burden of disease in the developed world, with depression set to become the second leading cause of disability in the world by 2020.

Understanding what is happening in our farming communities in terms of depression is therefore important. This is not only because it can lead to disability in a sector that is of strategic importance to the New Zealand economy, but also because people like us who work in and are dependent on the industry actually care about the wellbeing of farmers and the industry.

Farmstrong

Farmstrong was recently launched and its website (www.farmstrong.co.nz) highlights the unique set of challenges that farmers face. It indicates that many of these challenges are hard to predict or control, and that farming is also a business with particular demands that challenge farmers' resilience. Our own DairyNZ funded research in the dairy sector has shown that most dairy farmers take good care of their stock, farms, equipment and so on, but not of themselves – they neglect aspects of their own personal wellbeing.

We found no evidence that depression and/or anxiety levels among dairy farmers are worse than the national population. However, the research showed that signs of depression played a key role, both in farmers' mental and physical health, and were strongly associated with anxiety, burnout, pain and physical illness. We also found that young males who were employed on dairy farms tended to smoke more than other people on these farms. Males on New Zealand dairy farms also tended to have more pain-causing conditions than females on dairy farms, and more of the males also had high blood pressure and were more overweight than females. Males on New Zealand dairy farms also tended to not avoid the development of dangerous skin conditions by using sunscreen and wearing sunhats. Gender is certainly important in this regard.

Our research has also shown that, when asked, most farmers said things were going well, but when they were screened for mental and physical wellbeing things looked a bit different for some. This is not unexpected and can partly be explained by the way in which the question was asked and the setting in which the interviews took place – at dairy farmer health pit-stops held at field-days and other events. This finding is comparable to Irish research that has shown that almost one in three members of farming communities do not tell anyone about their personal problems and difficulties.

Farmer suicide

Suicide is an outcome that is linked to poor mental wellbeing and is particularly concerning, because it has been repeatedly shown to be higher amongst farmers than many other occupations in New Zealand. This is not unique, as studies conducted in the United States, Japan, England and Wales, Australia, China, Scotland and Spain have also shown farmers to be at higher risk of suicide than some other occupational groups. Disturbingly, research has shown that the over-representation of tradesworkers and farmers in New Zealand suicide rates has not changed over the last three decades. This is something that researchers in this country agree upon, but they disagree on other aspects related to suicide.

As in other countries, accurately measuring suicide rates in New Zealand is particularly difficult because of the ways in which data is collected, coded, reported on, analysed and the assumptions that are used in the analyses. Moreover, there are differences between the Ministry's official statistical publication *Suicide Facts* and the Chief Coroner's provisional suicide data, which can cause analytical discrepancies and confusion.

International comparisons

How do New Zealand's farmer suicide rates compare internationally? The Ministry of Health says it is difficult to compare suicide rates from different countries because of the different standards that each uses to determine whether a death is suicide. The level of proof required for a death to be classified as suicide can vary between countries, which means that comparing suicide rates between them may not be comparing like with like. Bearing this in mind it is still interesting and useful to do this, even if it is not 100% accurate.

Using numbers that indicate the rates of suicide in an occupation (profession) compared to those in the general population to compare suicide rates between different occupations in the same, and even between, countries provides a picture of what is happening. It can provide a comparable number that indicates the odds that a death is by suicide for a given occupation. For example, a number of 1.5 means that those in that particular profession die from suicide as a cause of death at a rate that is 1.5 times the 'norm', i.e. the death rate by suicide for the general population. This number has also been called the 'odds' of a person in an occupation dying from suicide compared to the general population.

Such lists of odds do in fact exist and can be found on the internet. For example, based on information released by the National Institute for Occupational Safety & Health (NIOSH) in the United States, calculations have shown that medical doctors are approximately 1.87 times as likely to commit suicide as those working in other occupations. Doctors were followed by dentists (1.67), police officers (1.54) and veterinarians (1.54), and ninth on the list were farmers (1.32).

In 2011, another list was compiled for the United States and consisted of causes of death from 1984 to 1998 for white males (since there is a greater demographical representation of this group) with occupations that had over 1,000 deaths. The rank order was different to the first list mentioned here, with medical doctors second (1.87) on the list, followed by dentists (1.67). Farm managers (1.32) – were 14th on the list.

Suicide has been repeatedly shown to be higher amongst farmers than many other occupations in New Zealand.

Interestingly, if we use data from a recent New Zealand report, the odds may be calculated as 1.34 (at a rate of 19.53 suicides per 100,000). This score is quite comparable to both the American lists that scored farmers at 1.32.

There is little information about rates of suicide based on occupations in European countries. A group of French researchers have found that farmers did not have any more suicide attempts than average, but had the highest rate of mortality if suicide was attempted. A British study attempted to compare suicide rates for all possible occupations there, and farmers were not on the list of high-risk occupations. The researchers concluded that socio-economic factors played a significant role in the influence of suicide rates throughout Britain.

The exact causes of suicide can be different for each individual case of every occupation; three farmers may commit suicide for completely different reasons. One may have been battling a mental illness, another may have been as a result of high stress, long hours and a relationship breakdown, while for another the struggle with unserviceable debt may have become too much to bear. It is also important to remember that most farmers are actually less likely than average to die through suicide. In the United States, for example, it was estimated that over 95% of medical doctors have a higher quality of life and greater individual mental and physical health than average. So just because suicide rates for an occupation are high, most individuals in that field could actually be at less risk than the average population.

Risk factors

There are factors that may increase suicide risk. Perhaps the most obvious is that certain professions like medical doctors, dentists and vets have ready access to pharmaceutical drugs with knowledge of lethal dosing. Farmers similarly have access to specialist equipment, which may increase the risk for them.

Instability caused by international markets and climate obviously impact farmers, but not all of them experience or 'feel' these factors in the same way and it is important not to generalise. There are other factors as well, and another research report has cited reasons for high suicide rates among farmers as including:

- Geographic isolation
- Poor access to health care
- An interaction between socio-economic and geographic factors
- Sudden shifts in economic status
- The depressive effect of chronic pesticide exposure
- Social isolation
- A working culture based on stamina
- Lack of separation between home and work – little work-life balance
- Dependence on major events beyond their control such as weather and economic fluctuations.

Geographic and social isolation

Note that geographic and social isolation are mentioned separately because they are different. Loneliness and social isolation are very important issues because research has shown that these factors are generally associated with wellbeing through a range of health issues including increased mortality, depression, high blood pressure and dementia. Social isolation has also been identified as a factor in the development of suicide behaviours and is recognised in the New Zealand Suicide Prevention Strategy 2006-2016, as well as the New Zealand Settlement Strategy.

With respect to the difference between isolation and loneliness, isolation is about being separated from social or familial contact, community involvement or access to services. Loneliness is an individual's personal, subjective sense of lacking social or familial contact, community involvement, or access to services to such an extent that these things are wanted or needed. This means that a farmer or farm worker can be isolated without being lonely, or a farmer could feel lonely but not isolated. Many farmers I have interviewed have said to me that they do not feel isolated at all, despite living far away from a town or services. They actually choose the isolation – it is part of their lifestyle.

More research and resources

In 2014 Andrew Solomon wrote a commentary in *The New Yorker* titled 'Suicide, a crime of loneliness' about the suicide of actor and comedian Robin Williams. He said: 'When the mass media report suicide stories they almost always provide a "reason", which seems to bring logic to the illogic of self-termination.' It is natural and common

We need to develop a better understanding of why the statistics for farmer suicides in New Zealand tell such a sad story.

for people to seek some logic, or a reason(s), for farmer suicides. Unfortunately there are generally speaking more opinions than facts in these conversations. We need to develop a better understanding of why the statistics for farmer suicides in New Zealand tell such a sad story. We simply need more research so that we can design evidence-based intervention and prevention strategies that will help turn the tide. Among others, loneliness and social isolation are topics that are under-researched and often misunderstood.

Of course more resources, particularly money, can be put into this area, but in my experience the amount of resources is only one of the issues. There is a plethora of non-governmental, semi-governmental and state organisations (each with their own resources) that are still often working (often in isolation from each other) towards the same goal, i.e. better outcomes. Coordination and collaboration between organisations that have, or should have, an interest in farmer welfare specifically, and a mandate to actually do something about it, has improved over the last few years.

The current financial woes of the dairy industry will be testing the resilience of farmers and the whole system that is linked to farming. In this industry there will be sharp rise in stress levels, and it is possible to expect a decline in mental wellbeing, and perhaps more suicides, during and even after this tough period of time has passed. I am certainly not trivialising and minimising the impact of hard times on farmers and farming communities, but have to say that many farmers are resilient and do take care of their wellbeing. Most will weather the downturn. Others will find it more difficult and may require support, and then there will also be those who will really struggle to make ends meet financially and/or otherwise. There has been a groundswell of interest in, and investment into, farmer wellbeing over the last six or more years, and I believe that it will have helped the cause of preparing farmers for hard times and supporting them when things become difficult.

People first

People are the core of the agricultural industry and deserve to be taken care of – we should never forget that. The wellbeing of farmers is just as important and, dare I say, more important than making money.

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BRONWYN MUIR

Health and safety – education and risk assessment

Compliance inside the farm gate, whether it be environmental, employment, health and safety, or quality assurance for product supply, is currently our leading challenge for the collective rural industry – farmers and their service providers.

Pressure of compliance on farm businesses

The mounting pressure that all farm business owners now face is constant. They need to understand the applicable science, legislation, good practice codes, guidelines and regulatory rules to effectively manage the associated tasks and compliance risks and not fall foul of regulatory standards. Industry perception, and the fact that much of this pressure is coming from paper-based statistics, does not sit well with our industry either. Farmers, owners and managers alike fear that they are not going to be able to provide enough written evidence to cover their business, just in case a mistake is made and it results in an accident.

The risk of not meeting all these compliance standards places risks on the farming business, potentially resulting in fines or prosecutions, causing financial and reputational damage as individuals and collectively as an industry. What we hear anecdotally is that because of these risks, the conversations that farmers have with the inspectorate teams assigned to assess or audit business compliance are often highly charged.

This comes across as industry negativity or excuses as to why farmers should not 'have' to comply. The compliance pressure consequences can also have far-reaching effects. Our whole rural industry mood is already on watch as we face not only this pressure but other problems such as climate issues (drought, flood and serious slip damage) and the downturn in the dairy pay-out.

Role of advisors

So how can our service and consultancy industry assist? It's all about education. The farming community and other industries are coming to terms with the increased oversight under the Health and Safety Act 1992. At OnFarmSafety NZ we have assessed that there could be a minimum of 40 governing codes, legislative acts, guidelines, local body regulations and industry good practice standards that we must 'tick the box' on to meet compliance standards.

In our business we encourage farming enterprises to have a set of best practice processes, policies and

Farmers, owners and managers alike fear that they are not going to be able to provide enough written evidence to cover their business, just in case a mistake is made and it results in an accident.

procedures for internal use or to use those that have been developed by their industry associations to work through large amounts of industry regulations. No wonder farmers are still unclear and struggling with 'grey areas' as to what they must do to achieve compliance. We find it is not that they don't want to do it. Rather it is that in a paper-adverse, time-poor industry, where there is real pressure to manage all the elements of running a profitable system, the last thing they have time to do is sit down and run through the fine print to ensure they do not 'miss' any details that may put them in breach of compliance standards.

The New Zealand rural Industry needs to raise its best practice for hazardous substances

Cross-section/industry discussions are required about health and safety regarding shearing

Effective health and safety advisory businesses must ensure that clients know it is not just about the sign on the gate, the folder on the shelf or the wearing of helmets. It is about working on a positive health and safety culture.

Effective health and safety advisory businesses must ensure that clients know it is not just about the sign on the gate, the folder on the shelf or the wearing of helmets. It is about working on a positive health and safety culture. Even when this is achieved most farm workplaces cannot prove it or provide evidence to support this culture. We are finding that the glaring holes and grey areas in what is occurring on-farm are mostly related to communication, whether this is between owners, directors, boards, managers, sharemilkers and/or staff. It is important to get the relevant people to sit down and discuss their respective responsibilities, obligations and expectations. Lack of understanding about these areas, and unclear or non-existent job descriptions, are quite common – leading to lapses.

Employment contracts or agreements are often the founding relationship document between farmers and staff. For example, the Federated Farmers agreements are widely utilised in our farming industry, but not so thoroughly understood. Taking the time to go through clauses line by line and get advice on any areas they do not understand is key to setting up a good base for an ongoing working relationship. Health and safety responsibilities in both contractual employment agreements and job descriptions are vital for clarity for individuals and within farm teams.

Regular assessment of that relationship in performance reviews is also advisable, but very rarely done as an industry practice. The documented evidence base that we require as an industry is to be compliant with the Act, but the messaging on regulatory requirements can vary. As a case in point, recent advice from WorkSafe NZ suggests that minimal documentation is required around hazard notification. We know that this will not be sufficient evidence if there is an investigation. Any health and safety advisory business must implement a system that ensures complete risk management for their farm business clients.

Impracticality and blurred boundaries

When we dig deeper as an industry into the fine print we find that many of the regulatory rules have been based on manufacturers' guidelines and good practice recommendations. These tend to be designed to protect the manufacturer more than the end user, and when applied, for instance, to our machine use purpose they can be impractical. Also we need to factor in that the farm is a workplace, but also a home for farmers and their employees, families, children, pets etc. When the day's work is done, it often becomes a place of recreation and fun. Where and how do the workplace boundaries get applied? When is a workplace not a workplace? How does this fit into the 'rule book'?

Quad bikes

Carrying passengers on quad bikes is a real sticking point because it is an integral part of the way the business of farming is carried out. In taking the farm consultant, vet, bank manager or fertiliser consultant to the back paddock, if the quad bike is the most suitable vehicle for the job (alternative vehicle options having been eliminated due to access and egress safety) then this should be accepted as having taken all practicable steps to ensure safety.

Under the current rules many contractors and organisations have created a policy that states that no employees can ride pillion on a quad bike and they are now equipping staff with trailers and their own machines, which then applies pressure on the farm business representative – the Person Conducting a Business or Undertaking (PCBU). They must now assess the competency of the rural professional to be able to competently ride the bike over the farm terrain presented.

The problem is that the rural professional is a specialist in their field of expertise and not necessarily a competent quad bike/4WD rider (or horse rider), and this places the farm principal in a tough decision spot. If that PCBU is a manager, then they have the responsibility of making the call on behalf of a farm owner or a board. Also the rural professional often comes with an hourly rate price

Dairy Industry health and safety compliance often involves a review of industry and multi-business policies, best practice and standards

There is certainly more discussion to be had before we get a health and safety system that works for the entire agricultural industry.

tag attached, so the longer they are there the bigger the invoice will be. Their diary is also probably full of clients to cover and time management on each property is critical. Adding a few hours on to walk the job is not an option for either party.

Other industry effects

Farm field-days are another issue for our industry. It is important to have a meaningful discussion with the regulator WorkSafe NZ, given the role that field-days have in effecting the uptake of technical information and developments within the farming community.

Combined industry health and safety is also challenging. Each area of our service industry has its own set of codes and best practice policies they need to abide by, such as agricultural aircraft. Those who fly fixed-wing planes and helicopters are struggling to simplify the required documented evidence needed for their clients – land or strip owners, fertiliser companies and trucking firms. As a combined industry we need to come up with a combined solution to this problem. Strip owners are legally very vulnerable in this situation, but the last thing we need as an industry is for the landowner to shut the gate on strip use because the risk is too high to their business if something goes wrong and a plane goes down. This leads to productive issues and increased on-farm costs of fertiliser, resulting in increased tonnage rates.

The industry push-back on the impracticalities of how this is going to work is fully understandable and requires a meaningful discussion around setting the rules. Federated Farmers have developed health and safety systems that meet our own industry risk assessment needs, but there does not seem to be any flexibility in regulation for self-mitigation and making our own risk assessment.

WorkSafe NZ has been invited by Federated Farmers to come to the table with an open mind about how we can come up with rules that fit our combined industry workload. To make meaningful progress in this area, regulators and the farming community need to work together to educate farmers and achieve practical outcomes in meeting health and safety regulations.

Benefits of a workable system

If done well, and to maintain a workable system for the farming community, the benefits are:

- Increased individual and industry understanding of health and safety – peace of mind and a better working environment
- Less deaths and accident rates – no farmer wants to injure their workers or have a fatality at work
- The practice of regular reviews and internal auditing ensures engagement
- Evidence the business is taking all practicable steps to minimise health and safety risks – compliance in accordance with the legislation
- Staff/family engagement and involvement – improvements in this area
- Government financial support – economic business backing and reward or merit for doing a job really well – NZ Trade and Enterprise already operates in this space
- ACC levy reduction – reduced employer levy fees – Workplace Safety Management Practices (WSMP) and Workplace Safety Discount (WSD)
- Risk assessment for financial/insurance partners – provision of all the relevant business risk management systems and paperwork required to reassure business stakeholders that risk is managed and there is opportunity to reduce premiums and increase incentives
- Raising the farm business bar – lifting business best practice
- Industry-led good practice – raising expectations and standards.

There is certainly more discussion to be had before we get a health and safety system that works for the entire agricultural industry. However, if we look at this proactively we will be able to achieve the desired goal for individual farmers, the industry and the regulator. In the end, less farm workplace injuries and deaths can only be a good thing.

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TONY BYWATER

Risk and resilience on livestock farms

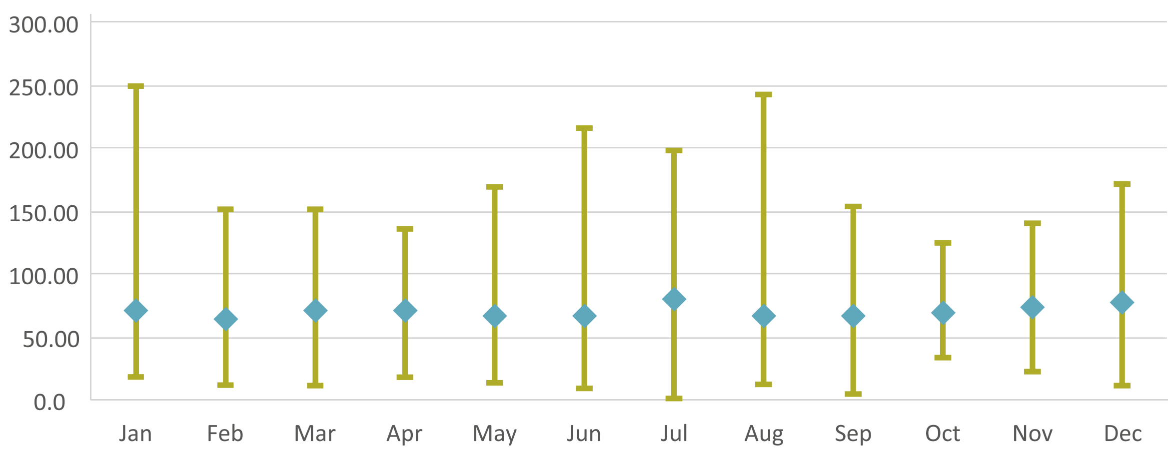
Resilience is about consistent performance in the face of variability in the operating environment. With sheep and beef stock units increasingly confined to traditional breeding areas, farmers face greater risk from variability in feed supply. Resilience in this context requires high animal growth rates from high quality pastures, the flexibility to adjust stock numbers quickly without major loss in profit, and environmental monitors that trigger adjustments in a systematic way. Farmers should be stocked to 'better than average' conditions; farming for the average or below average year simply won't do it.

On their sheep and beef farm in Marlborough, the Averys of Bonavaree near Blenheim have characterised their year into the return period, the risk period and the recovery period. The return period is between August and some time around November when pasture growth is usually sufficient to support high lamb growth rates, i.e. mean pasture growth is higher than the range in growth between years. This is the window of opportunity during which production and revenue for the year are determined. During the risk period, which generally lasts through to February, the variability in pasture growth (range) is higher than the mean, with the implication that growth can cease at any time. From March until winter the mean exceeds the range again, so pastures usually grow and the system recovers before heading into winter, ready to start again the next spring.

This pattern is typical of dryland livestock farms on the east coast of both islands, with some regional differences in timing and growth rates. Interestingly, mean rainfall does not vary much from one month to the next – it is the variability in rainfall which is the main issue. **Figure 1** shows 20 years of rainfall data (1991-2010) for Horarata in mid-Canterbury from NIWA. Average monthly rainfall is between 60 and 80 mm in all months of the year, but the range in values is much greater in January and between June and August than it is in April and October/November. Without moisture, pastures cease to grow and during summer quality deteriorates quickly. The biggest risk for dryland livestock farmers is therefore whether, and if so when, conditions will dry out in late spring/summer.

The traditional response to this is to maintain a low stocking rate, so that if and when it gets dry there are

Figure 1: Mean and range in monthly rainfall over 20 years at Hororata in mid-Canterbury from the NIWA Virtual Climate Station Network



fewer capital stock to feed. The stocking rate for the MPI Canterbury Marlborough Sheep and Beef Breeding Monitor Farm was around 8.5-10 SU/ha leading up to 2012. The downside of that is that if it does not get dry, pasture mass gets out of control and quality deteriorates because there are not sufficient stock to maintain it in an actively growing state. Low quality feed means low lamb growth rates, almost guaranteeing poor performance in good years as well as bad.

Farmers usually have a range of contingencies in place to cope with dry periods – a proportion of flexible stock such as cattle, a store of hay, baleage or grain, selling store lambs or buying in stock if conditions are good and so on. The problem is of course that in good years everyone wants to buy stock and in poor years everyone wants to get rid of stock and/or buy feed, with inevitable consequences in terms of price.

The situation is a little different in summer-safe environments, but the patterns are not totally dissimilar. The main differences are that autumn growth is more predictable, and while summer growth may be low there is generally less chance that it will cease altogether. As a consequence, stocking rates are higher than in dryland environments and management imperatives are different.

With dairy farming and dairy support increasingly taking over better or irrigable land, traditional finishing land is diminishing and sheep and beef are being confined to more variable country in terms of feed supply. Sheep numbers continue to decline and the processing sector struggles to maintain viability with diminishing and less certain supply, the opposite of what it needs to prosper. So how can production and profitability not only be increased on livestock farms but become more consistent and predictable in the face of increasing variability of feed supply? In other words, how can we develop more resilient livestock systems which consistently perform at a high level, whether it is a dry year or a wet year? Farming for the average, or less than average, year is simply not going to do it.

There have been a number of reports over more than a decade of research trials and commercial experience which all tell a similar story. The key features of productive and consistent livestock farming systems in dryland environments are high lamb growth rates and flexibility to change stocking rates quickly, particularly during the 'risk' period, without major loss in revenue. High lamb growth rates require high feed quality, which coincidentally will also promote high lambing percentages if available to ewes as well. So the question becomes how to provide high feed quality consistently when it is required, despite variability in growing conditions. Also, 'without major loss in revenue' means that destocking must be part of the system, not a knee-jerk reaction to the fact that it has become dry and there is no feed.

High lamb growth rates are important because, as Colin Brown pointed out to the Grasslands conference 25 years ago, lambs growing at 100 g/day take 300 days to gain 30 kg from birth to drafting, whereas lambs growing at 300 g/day take 100 days. Lambs born weighing 4 kg in mid-August will reach an acceptable drafting weight of 34 kg by the last week in November growing at 300 g/day. It would take to the middle of June the following year if they only grow at 100 g/day.

With dairy farming and dairy support increasingly taking over better or irrigable land, traditional finishing land is diminishing and sheep and beef are being confined to more variable country in terms of feed supply.

The point is that fast-growing lambs are able to be drafted sooner meaning that they are off the farm before the risk of dry conditions gets too high. Slow-growing lambs are more likely to still be on the farm if and when it gets dry and pasture growth and quality decline. This just leads to even slower lamb growth, later sales, and more chance they will start to compete with ewes in autumn for feed needed for flushing, which threatens next year's lambing percentage. So high-performing resilient livestock systems in dryland environments need:

- High-quality feed supply systems
- Flexibility to change stock numbers quickly, and
- Either a planned destocking regime or a pre-determined trigger to begin destocking.

In the Silverwood sheep systems trials, we used soil moisture in the top 20 cm of soil, monitored weekly with relatively inexpensive probes, and started destocking when the moisture level reached 10%.

High feed quality can be achieved in a number of ways. At Bonavaree the Averys' system is based on lucerne, with Omaka forage barley and annual ryegrass as winter feed and transition feed respectively, and rolling hills providing maintenance feed for ewes and cattle. Pre-weaning lamb growth rates are 350-400 g/day and 80% of the lambs are drafted before the end of December. Decisions on the purchase or sale of store lambs and cattle are made in mid-October, so the farm is not understocked in good years or trying to finish lambs during dry summers.

Tom Fraser and colleagues at Winchmore compared improved forages, including chicory, red and white clover, and tall fescue with conventional ryegrass/white clover pastures. They achieved slightly, but significantly higher, pre-weaning lamb growth rates on the improved pastures

(300 vs 284 and 312 vs 289 g/day in years 1 and 2) and much higher post-weaning growth rates (292 vs 150 and 298 vs 133 g/day). On the improved farmlets in years 1 and 2, an average of 92% and 97% of lambs were drafted by the first week in January, when all remaining lambs were sold as store, with only 53% and 58% drafted on the conventional system. Ewe liveweights in late summer were 6 kg and 4 kg heavier on the improved farmlets, but no differences in lambing percent were reported since ewes were re-allocated to farmlets prior to mating.

The ability to respond rapidly to changing growing conditions can reduce year-to-year variability in farm financial results, i.e. reduce risk and improve resilience.

At Tempello in the Awatere Valley, the Griggs employed a variety of strategies to increase subterranean clover in the pastures, including application of fertiliser and lime, subdivision, spring seed head management to allow the clover to seed, restricted grazing of seedlings in autumn, and spelling for two months before set stocking for lambing. Over a seven-year period, sub-clover content increased to between 40% and 60% of the pasture, lamb growth increased from an average of 258 to 350 g/day, and lambing percentages increased from 108% to 140%, mainly due to higher ewe weights at weaning.

In the Silverwood trials, we looked at a sheep-only system based on a mix of high nutritive value and conventional pastures, and a sheep and cattle system based on conventional ryegrass/white clover pastures with a high stocking rate of 14 SU/ha. The stocking rate was intended to match 'better than average' conditions, designed to provide sufficient grazing pressure to keep pastures in an actively growing state, with flexibility to retreat from that stocking rate if and when it started to get dry. Both systems included kale, barley for silage, back into perennial pasture, and a summer or autumn brassica (pasja or rape) under-sown with perennial pasture.

The high nutritive value pastures included lucerne and 'switch' pastures (annual/perennial clovers over-sown in late summer with annual ryegrass). Over-sowing annual ryegrass into pastures designated for renewal the following spring provided early spring feed on both systems. Flexibility was provided with a mob of older ewes destined to be culled and mated either three or four weeks before the main mob (first cycle ewes), plus R2 cattle on the grass system. Once the soil moisture level reached the trigger point, cattle and first cycle ewes were sold as soon as possible and an assessment was made of the lambs that could be finished on the feed on hand at the time. The remainder were sold as stores.

There was no significant difference between the two systems in terms of lamb growth rates. Pre-weaning growth rates for singles were between 350-365 g/day, with twins between 295-315 g/day for both the first cycle and main mobs. The average growth rate of all lambs from birth to sale on both systems was 296 g/day. Pasture ME values averaged 11.6 and 11.5 MJ ME/kg DM on the grass and legume units from April to October in the first year when soils dried out in the first week of November, and 11.6 and 11.4 MJ ME/kg DM from April to January in the second year when soil moisture stayed above 20% throughout the season.

These results combined show that high feed quality systems with lamb growth rates of 300+ g/day can include high nutritive value species, such as legumes or herbs, or they can be based on conventional grass-based pastures at high stocking rates to keep the pastures in an actively growing state. The advantages of grass-based pasture systems are that they are generally much less complicated to manage and less costly to maintain. This was the case at both Winchmore and Silverwood in comparison with the improved pasture/high nutritive value systems. The disadvantages are that in order to maintain high pasture quality, grass-based systems have to be stocked at high levels. This increases the financial risk if conditions turn dry and in turn increases the need for flexibility, and in very hot and dry environments ryegrass/white clover swards do not survive well.

Having the flexibility to respond in a pre-determined way to the onset of dry conditions will not remove all variability associated with uncertain weather conditions, but it can reduce it significantly. **Table 1** shows selected performance indicators for the grass unit at Silverwood and the MPI Canterbury/Marlborough Breeding Sheep and Beef Monitor Farm for 2008-2009 and 2009-2010. Despite the much higher stocking rate on the trial unit, the lambing percentage to sale is similar to that on the monitor farm in both years. Net income, gross margin and surplus after overheads per hectare are significantly higher on the trial unit. Although net income per SU is higher on the monitor farm, as might be expected with a much lower stocking rate, with higher direct costs per SU, gross margin and surplus per SU are slightly higher on the trial unit than the monitor farm.

More importantly, the difference between years in all financial indicators except overhead charges is much smaller on the trial unit than on the monitor farm. This suggests that the ability to respond rapidly to changing growing conditions can reduce year-to-year variability in farm financial results, i.e. reduce risk and improve resilience.

Given that a range of feed options will provide high quality feed, each with different costs and risk-return characteristics, and that there are different stock policies to provide flexibility, is there an optimum combination which will increase productivity and profitability and reduce variability in returns? Following the Silverwood trial, we undertook a simulation analysis, based on the trial results, using the computer model LincFarm to investigate the returns (average gross margin or GM) against risks (standard deviation of GM). There were seven different stock and pasture combinations, at four stocking rates, with either no response to soil moisture conditions (a set marketing policy) or three different soil moisture trigger levels, all simulated for 19 years with the first four years discarded. The risk-return profiles over 15 years to 2010 for all 112 runs of the model are shown in **Figure 2**.

The first point to make is that the set marketing policy options (no adjustment for soil moisture level), shown in black in **Figure 2**, are completely dominated by all situations where a soil moisture response is included. The returns are lower and the risks are higher. Farmers obviously do respond to current conditions, so to assume there is no response is unrealistic, but it does reinforce the fact that responding in a systematic way to (in this case) soil moisture levels not only increases returns but reduces their variability.

The second point is that the response is systematic. As soon as the trigger soil moisture level is reached, the simulation starts destocking. It does so in an 'optimised' way. There is a priority list of stock classes, which may change during the season, and the rate of destocking depends on the severity of the situation at the time. This is assessed as a combination of the current stock and feed on hand (days of grazing) and the probability of rain in the next 28 days, each characterised as low, medium or high.

The third point is that the boundary line on the results identifies the risk efficient frontier. This set of policy-response combinations dominates all other combinations, because for the others higher returns can be achieved for the same risk by moving vertically to the frontier, or the same returns can be achieved with lower risk by moving horizontally to the frontier. The risk efficient set provides a range of options that farmers can select depending on their risk preference. For farmers preferring less risk with lower returns, the options at the lower left end of the frontier are appropriate, but those willing to take greater risks for higher returns should select options from the top right.

So what are the options? Policies 1-4 (the first digit in the bracket) are all based on grass-based pastures, and 5-7 include high nutritive value pastures. Within each there are different combinations of sheep and cattle, including a self-replacing flock either alone or with a first cycle mob of older ewes and/or R2 cattle. The second digit refers to the stocking rate (10, 12, 14 or 16 SU per ha), and the third digit refers to the soil moisture level which triggers destocking; a trigger level of 15% is more conservative (earlier destocking) than one of 10%. So combination (7, 10, 15) is policy 7 (highest proportion of high nutritive value pastures) at a stocking rate of 10 SU/ha and destocking when soil moisture reaches 15%. Combination

Table 1: Comparison of key financial indicators on the grass unit at Silverwood with the MPI Canterbury/Marlborough Monitor Farm

	GRASS UNIT			MPI MONITOR FARM		
Effective area (ha)	87.8			469		
	2008-09	2009-10	Diff %	2008-09	2009-10	Diff %
Total stock units	1231	1172	-4.8	4096	4125	0.7
SU/ha^{-1}	14.0	13.3	-4.8	8.7	8.8	0.7
Lambing % to sale	126.5	139.3	10.1	125.0	138.0	10.4
	$	$		$	$	
Net income[1]/ha^{-1}/SU^{-1}	1,211 86.34	1,170 87.65	-3.3 1.5	866 99.13	965 109.77	11.5 10.7
Direct costs[2]/ha^{-1}/SU^{-1}	351 25.07	357 26.74	1.6 6.7	375 46.80	436 49.56	16.2 5.9
Gross margin/ha^{-1}/SU^{-1}	859 61.27	813 60.91	-5.4 -0.6	491 52.32	530 60.20	7.9 15.1
Overheads[3]/ha^{-1}	72	61	-14.7	80	72.44	-9.1
Surplus[4]/ha^{-1}/SU^{-1}	787 55.51	752 56.33	-4.5 1.5	411 42.38	457 51.97	11.2 22.6

[1] Includes sale of culls and wool and cost of replacements.

[2] Does not include labour.

[3] Farm overheads pro-rated ha^{-1} for the grass and legume units; does not include interest costs.

[4] Does not include labour, wages of management or interest charges.

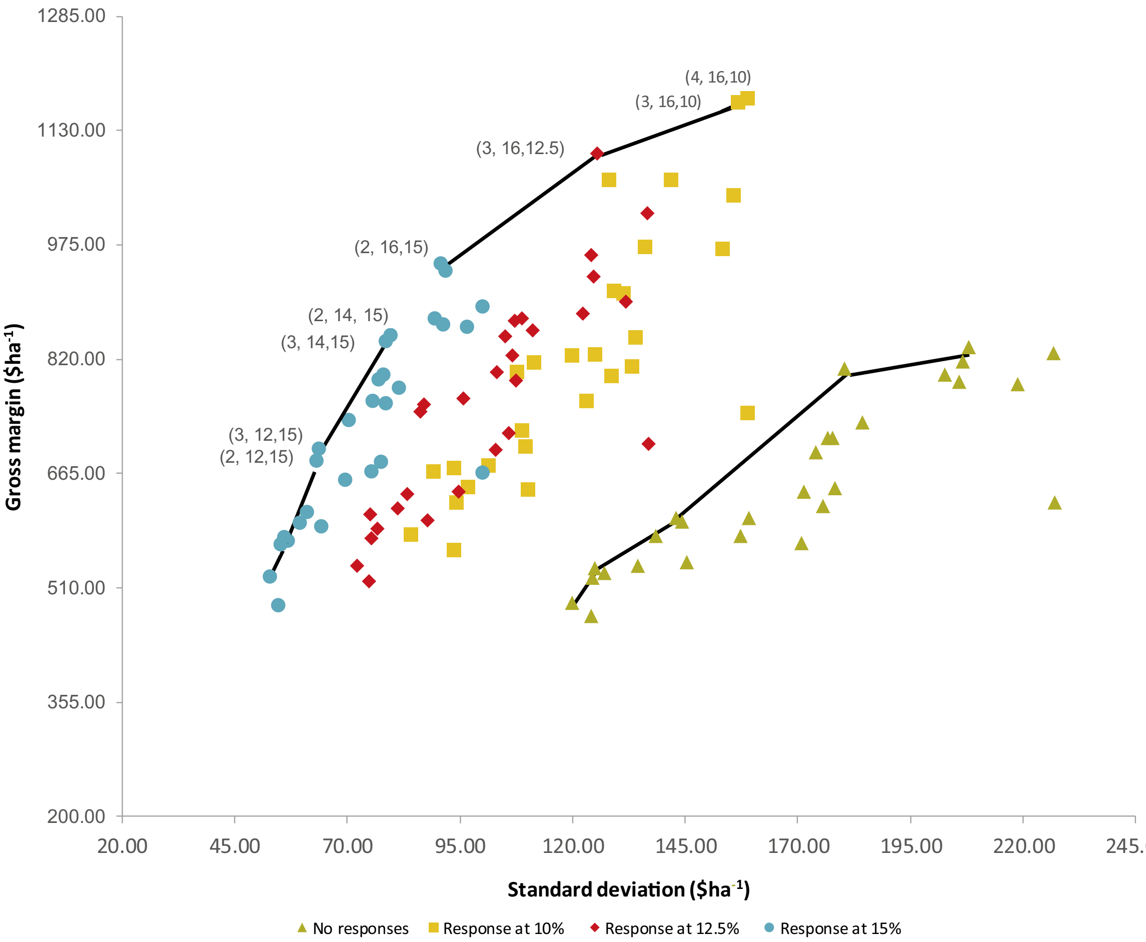
(4, 16, 10) is conventional pastures with both a first cycle mob and cattle, at 16 SU/ha, responding at 10% soil moisture.

The policy options do not include a lucerne-based system such as that at Bonavaree, nor do they include the option to purchase store lambs, and the simulation is based on the weather records for Silverwood at Hororata. Although the results are limited to these circumstances, they provide some interesting conclusions. All of the risk efficient combinations include cattle, whereas with the set marketing options none of the risk efficient alternatives do. Cattle simply exacerbate the situation if they are farmed under a set marketing policy, but improve the resilience of the system if used to add flexibility as well as stock units.

The low risk, low return options are at lower stocking rates with higher soil moisture triggers, i.e. they are more conservative on both stocking rate and when to respond to drying conditions. The stocking rate is in fact the average for the Canterbury/Marlborough breeding farm model, but note that the optimum soil moisture level to start quitting stock is well before the point where pastures start to wilt and cease to grow (around 10% moisture). If you are going to farm at the average stocking rate, you are better off responding earlier rather than later when it gets dry. The high risk, high return options all include both high stocking rates and low soil moisture triggers, i.e. they are more aggressive on both counts. Remember that in all cases, once the trigger point is reached the simulation starts a systematic destocking of the farm.

All of the high risk, high return options are based on conventional pastures, whereas inclusion of high nutritive value species is better in lower risk, low return options. If you are really going to push the system, do it with conventional pastures. Another way to look at it is that in order to perform well, the stocking rate has to be high enough to maintain pasture quality and take advantage of good growth years with conventional pastures. These will lose quality to a greater extent than high nutritive value pastures if they get out of control and the mass gets high. The corollary is that the higher nutritive value species will maintain their quality in better growth years even at lower stocking rates. As noted, this analysis is based on weather data from Hororata in mid-Canterbury. In more

Figure 2: Expected (mean) gross margin vs standard deviation of gross margin over 15 years for seven policy combinations at four stocking rates with four responses to climate variability (from the PhD thesis of Mathew Gicheha at Lincoln University)



severe environments, such as coastal Marlborough where ryegrass/white clover may not survive hot dry summers, the results would likely be different.

These results are not about having contingencies in place for dry years. In fact, contingencies such as stored feed were not included in the simulations and if they had been may well have pushed the risk efficient frontier higher and further to the left. These results are about flexibility and systematic responses to environmental triggers, in this case soil moisture. It may well be that in any given year responding to the pre-determined trigger may result in lower income than not responding because it happens to rain and the situation improves. That's gambling, not risk management – responding to the trigger every time gives better results over many years than not responding.

The 2014-2015 season was particularly dry over a longer than usual period. There are drought years in the climate sequence used in the simulation and the farm did not do well in those years. So even resilient systems will not handle extreme conditions, although it is worth noting that farmers who had most of their lambs away by mid-December this season were in a much better position than those who still had most left on the property in the middle of January. This reinforces the need for contingencies and the importance of consistent high quality feed.

If all farmers adopted what is advocated here and started selling stock as soon as their trigger is reached this could create problems getting space in the works and could affect store stock prices. However, not all farmers would adopt the same trigger point, implying that the sale of stock may be spread a little more than is currently the case in dry years. But what if farmers did not need to sell their stock at the trigger point, just get them off their dryland breeding unit? An irrigated finishing block would allow farmers to transfer stock in a planned way and finish them reliably in all but the most dry years. The problem is that the opportunity cost of irrigated land is too high in comparison with dairy and dairy support. Or is it?

It is not what you produce on the irrigated land that matters; it is what the irrigated land allows you to do on the dryland breeding unit that makes the difference. Our preliminary assessment suggests that with an irrigated area approximately 1/10th the size of a dryland breeding farm, removing all sale stock and replacement hoggets to the finishing unit as soon as they are weaned at say 25 kg allows the stocking rate on the dryland to be increased to around 17 or 18 SU/ha. If the average at the moment is around 10 SU/ha, and assuming a GM of about $50 per SU, an extra seven or eight stock units would increase total gross margin on the breeding unit by $350 to $400/ha. On a 10:1 ratio, that is an additional return of $3,500/ha to $4,000/ha to the irrigated land on top of a finishing margin of say $2,000/ha, assuming stock are transferred at store prices and sold at export prices. $5,500/ha to $6,000/ha with about a third of the capital cost of converting to a dairy farm makes an irrigated finishing block look a little more attractive.

It is not what you produce on the irrigated land that matters; it is what the irrigated land allows you to do on the dryland breeding unit that makes the difference.

We have not yet done the same analysis for summer-safe environments. As noted, the variability in pasture production is less compared to dryland, particularly over summer, and stocking rates are generally higher and feed supply and demand curves are usually better matched so there is perhaps not the opportunity for the same level of improvement. However, we cannot see any reason why the same principles of resilience should not apply in these circumstances. Pasture quality needs to be maintained at high levels (11.5 MJME/kgDM+), so that lamb growth rates are high (300g/day + birth to sale). This can be achieved with high nutritive value species such as legumes and herbs (higher cost) or with high stocking rates on grass-based pastures (higher risk). Either way, stocking rates should be matched to better than average pasture production with the flexibility (stock classes) to retreat rapidly from that when conditions dictate. There needs to be some monitor of environmental conditions, such as soil moisture on dryland, and a pre-determined trigger value to begin destocking and that should be an integral part of the system.

All of the above is designed to increase resilience from a productivity point of view, but it will not overcome the price volatility of recent years. There are other ways of dealing with price risk, but it is worth noting that the Meat + Wool/Beef + Lamb Economics Service has consistently found that top farmers from a production perspective also get better prices for their stock. This is not a coincidence as fast-growing stock give the flexibility to choose which stock to market, when it suits the farmer, and to capitalise on market opportunities.

Experience would suggest that more intensive stock systems lead to greater environmental impacts. While data are not as available for intensive livestock systems as they are for intensive dairy systems, this is clearly something that will need to be considered with the current regulations.

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SAMUEL DENNIS, ROBYN DYNES, ANNA TAYLOR, KARREN O'NEILL, CHIKAKO VAN KOTEN AND NEIL COX

Potential for pasture yield mapping as a management tool

Soils, topography, pastures, irrigation systems, fertility – all are highly variable and can result in pasture yields differing from one area of a paddock to another. Arable farmers are able to map crop yields, use this to identify poor performing areas, correct them and improve average yields. Is it possible to do the same with pastures? Pastures are more complex to measure, as they are harvested multiple times through the year by animals. However, it is possible to use readily available tools to map pasture yields. Protocols for this will be released during 2015.

Pasture yields can vary markedly between different areas of the same paddock, even on well-managed dairy farms.

Within-paddock variability

Variable physical resources

Pasture yields can vary markedly between different areas of the same paddock, even on well-managed dairy farms. The major causes of this yield variation are generally readily able to be understood. This new information may open the door to many new ways of improving on-farm profitability.

The physical resources a farmer has to work with are highly variable, as farmers have observed for thousands of years. The situation faced by the hand-sower in former times is the same as for the large-scale farmer of today. Some areas of a paddock have the potential to be far more productive than other areas, for a range of reasons, so production varies across the paddock and farm. The reasons for this differing production fall into two categories:

- Factors the farmer can change – fertility, irrigation, compaction, weeds
- Factors the farmer cannot readily change but must work with – soil physical properties (texture, depth, water-holding capacity), topography.

Value of a yield map

A map of current yield will indicate which areas currently have high yields (these may have the potential to yield even more) and those that have poor yields. Areas with poor yields can be investigated to determine why the yield is poor. Often this may be obvious, e.g. shallow soil, but other times it may require further investigation such as soil testing. The farmer can then choose what to do about this – whether the factor can be corrected, improved or just managed. One way to improve average yields is to find and correct the lower-yielding areas of the paddock.

It is possible to map some of the individual factors affecting production – soil water-holding capacity, fertility and so on. However, yield is the ultimate result of all of these factors. If there is an issue seriously limiting production it should be visible in a yield map. In the same way, if something is not affecting yields enough to be visible on a yield map it is not a serious problem.

Furthermore, yield directly contributes to profitability so pasture has a definable economic value in c/kgDM. By mapping pasture yield, defining any maps of variable costs if these exist (e.g. fertilisers or irrigation systems that vary across the farm) and combining these with the existing overall farm budget, it is theoretically possible to map gross margin across the farm in order to estimate the relative profitability of different areas of the farm. This may identify any areas that are actually a net cost to the farm under current management, and indicate areas where management could be altered to improve profitability. Some arable farmers already do this.

Technology is now available that can map pasture covers, e.g. the C-Dax Pasture Meter. However, to measure the economic value of yield we need to know total annual consumed pasture. To measure this directly with pasture cover maps would require mapping pre-grazing and post-grazing, every grazing for an entire year, subtracting the post-grazing from the pre-grazing maps to obtain maps of intake, and then adding up all the intake maps to determine annual yield. This is complex and impractical. For pasture yield maps to be practical we need to be able to map once, or a very small number of times, at strategic times of the year. This can allow us to estimate the relative annual yield across a paddock.

Research undertaken

Several tools are available that could theoretically be used to map pasture covers. We used the C-Dax pasture meter for this work, as we have done this for a number of years, and with its independently developed calibration equations we are confident about the tool. The ideal overall measure of pasture production is annual pasture intake. It is pasture intake that contributes to animal production and therefore profit. A map of annual pasture intake would tell a farmer the economic value of the production from every area of a paddock. However, annual pasture intake is difficult to measure directly.

We selected six paddocks at the Lincoln University Dairy Farm (LUDF) and mapped pasture cover pre-grazing and post-grazing, every grazing, for two seasons. This database of several hundred maps allowed us to map actual annual pasture intake on these six paddocks. We then compared the actual annual pasture intake to the individual maps to find when during the year we could map pre-grazing pasture mass to get an indication of the variation in total annual yield.

Work at LUDF has also looked into the practicality of mapping, the pattern to drive in the paddock, how far pre-grazing is suitable to map and so on. We have also obtained detailed soil available water-holding capacity (AWHC), topography and fertility maps, to determine the causes of yield variation. At the same time we have collected a number of other yield maps from eight commercial dairy farms in Canterbury and the West Coast, with a range of soil types and irrigation systems, including no irrigation. We are using this information to assess the applicability of our results at LUDF to other farms in the region.

Findings

How much variation exists?

The LUDF is a very well-managed and highly scrutinised property, being a best-practice demonstration farm. Nevertheless, even on this property substantial variation in pasture yield was found within paddocks. The farm management believed these paddocks to be reasonably uniform, and the fact that large variation existed was unknown until the mapping was conducted.

Figure 1 shows the total pasture intake for most of the 2012-13 season on paddock N6 at LUDF (actual annual production would be slightly higher than this as a few grazings were not measured). The total production within the paddock ranged from 8-18 tDM/ha, with substantial areas yielding from 13-17 tDM/ha.

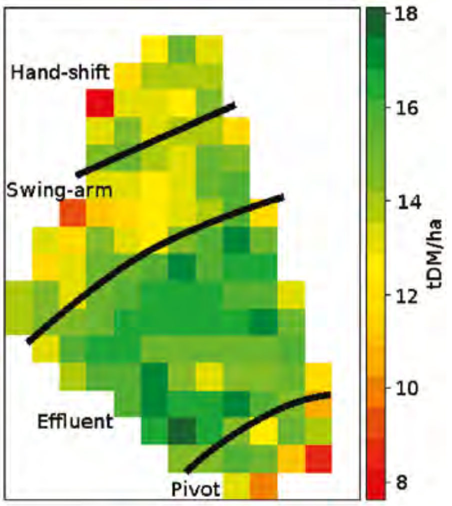


Figure 1: 2012-13 pasture intake – paddock N6 at LUDF

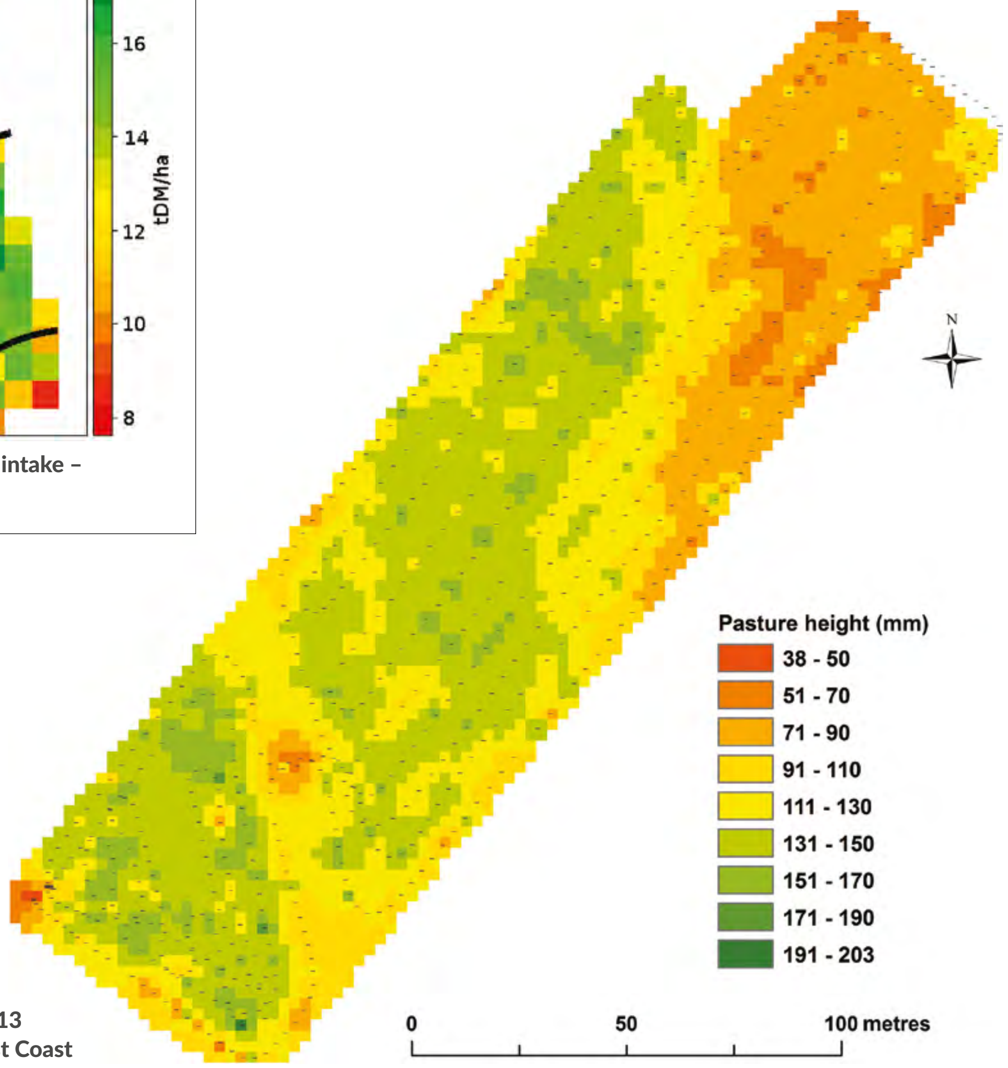


Figure 2: October 2013 pasture height – West Coast

The southernmost end of the paddock (bottom of the image) is irrigated by a centrepivot, the next section receives effluent as well from sprinklers mounted on the pivot, the next section is irrigated by the pivot swingarm, and the outer section is irrigated using hand-shift sprinklers. The major differences in production clearly correspond to irrigation and effluent application differences.

On other farms, even more variation was observed. **Figure 2** shows the pasture height recorded pre-grazing on an unirrigated paddock on the West Coast in October 2013. Large differences in pasture cover are clearly visible. In this case, it is the lower-lying and more waterlogged areas of the paddock that have the lowest yields, with the higher and better drained areas that yield well.

Is it practical to measure?

It takes approximately 20 to 40 minutes to map an 8 ha paddock using the C-Dax Pasture Meter, depending on how closely the operator drives, plus time to download and process the data. The equipment works well, and the data collection requires no specialist knowledge. This time requirement means it would be impractical to map every grazing, but mapping once or a limited number of times per year is entirely achievable.

Higher-yielding areas appear to have higher growth rates from immediately following grazing, so covers begin to differentiate between high-yielding and low-yielding areas rapidly after each grazing. It is possible to map any time in the second half of the regrowth period before the next grazing and obtain a reasonable indication of which areas are highest versus lowest yielding. Obviously the actual cover at grazing will not be known until just before grazing, but if the intent is simply to define areas of the paddock to investigate further the absolute yield of these areas is not necessary.

Results were presented at the International Conference on Precision Agriculture held in Sacramento, California in 2014 that showed from one year's data that it is possible to take a single map of pre-grazing pasture cover in summer and identify the areas of high and low total annual yield. In other words, the areas with a high pasture cover in summer tend to have the highest annual yields, and those with the lowest pasture cover in summer to have the lowest annual yields. This means that it is possible to use a single map of pasture cover to identify areas of different performance within the paddock for further investigation in order to find areas that may be able to be managed differently to improve yields. Further analysis is currently being completed and will be released over the next few months to provide more precise recommendations about when to map.

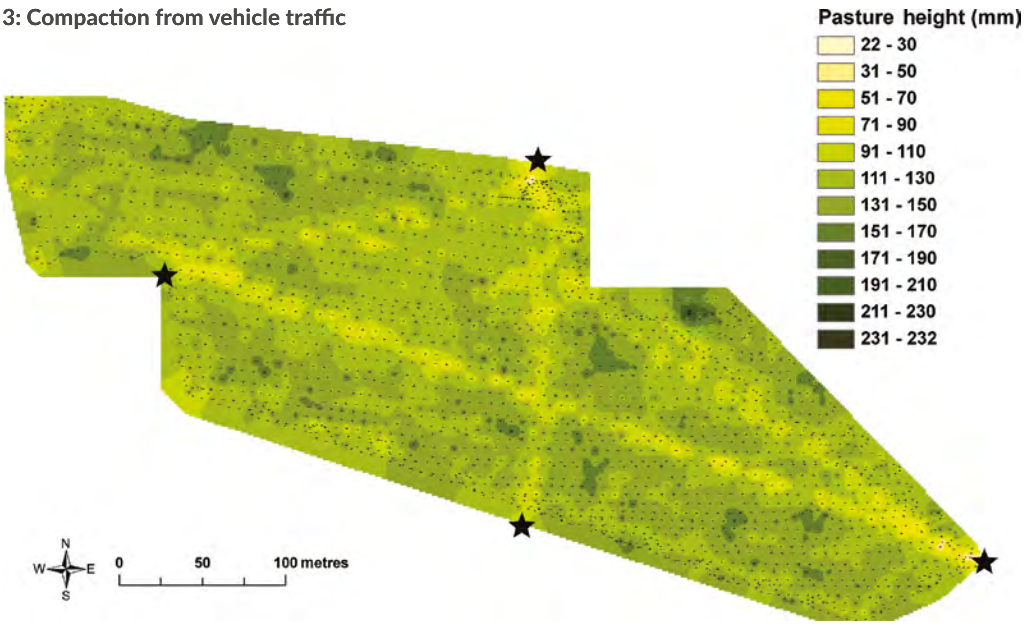
Protocols will be published soon to allow such maps to be used to estimate how total annual pasture yield varies across a farm.

Can we understand what is causing the variation?

In many cases, the major reasons for the variation are obvious. For the irrigated properties in most of this study pasture yield was primarily related to irrigation. At LUDF (see **Figure 1**), the centre pivot irrigator resulted in consistently higher yields than the hand-shift corner irrigation system. Within the centre pivot, the area that also received effluent was higher yielding again. In other cases, major areas of differing yield tended to correspond to areas of different soil types or topography (see **Figure 2**).

In some cases, very narrow man-made and readily correctable features may be visible on the maps. **Figure 3** shows pasture height in spring on a paddock at LUDF, with

Figure 3: Compaction from vehicle traffic



each gateway marked with a star. Between each gateway is a clear line of lower pasture yield. This paddock has gates into the baleage storage area (west), the main track (east), the road (north) and the neighbouring paddock (south), so it receives an exceptionally high amount of traffic. Much of this traffic could be avoided due to the presence of laneways and the road, but the paddock is driven through for convenience. In other cases, irrigation has such a strong effect on pasture yield that a single blocked sprinkler on a centre pivot can show up as a narrow ring of lower yield. This means yield maps can highlight the potential economic cost of such apparently minor issues, and may encourage staff to correct such issues earlier.

On the farms studied to date, fertility has not been well correlated with yield. This is because the well-managed farms studied, such as LUDF, have been carefully soil sampled and fertilised in the past, so although there is fertility variation within paddocks no areas are so low as to be obviously restricting yield. Were there any fertility issues serious enough to impact yields, these should become visible in a yield map.

Can we use the maps to improve management?

Provided the primary causes of variation do not change, the pattern of yield is reasonably consistent from one season to the next. This means that a yield map produced in one season can be used to guide management decisions for the following season. There are very many potential uses for this new information such as:

- Awareness of the seriousness of human-induced and avoidable problems – faulty irrigators, compaction and so on
- Contributing to gross margin maps, identifying any areas that are unprofitable for correction, or areas where there may be potential for higher profits
- Pasture renewal – paddocks are often renewed because either the paddock average yield has declined or the farmer believes the pasture has become 'run-out' or patchy. However, paddock average yield is driven by variation – it is dragged down by low areas and raised by high areas. Also, if a paddock has patchy or variable production this must be caused by something. Yield mapping allows the problem areas of the paddock to be identified, so causes for the poor production can be identified and corrected in order that the same issues do not simply reoccur in the new pasture
- Irrigation investment decisions – knowing the relative production between different irrigation systems will greatly benefit cost-benefit calculations on irrigation improvements. Assess effect of technology such as variable rate irrigation
- Zoning based on yield for fertiliser and other management – areas with yield differences that cannot be corrected, e.g. from soil type, will have different nutrient uptake and therefore different maintenance fertiliser requirements. Where large differences in yield are present these may allow improved fertiliser plans, saving money by reducing fertiliser to areas that will be unable to fully utilise it
- Identifying representative paddock transects for soil sampling, regular yield monitoring and so on
- It is a simple tool to assess the benefits of shelter, effluent application, drainage systems, aeration or other factors that could potentially affect pasture yield.

The purpose of our work is to develop standard protocols for how to map yields, and demonstrate the variation in yield that can exist on-farm. The potential uses of yield maps are wide-ranging and will differ on every property. However, in general the causes of a large portion of the variation are readily determined, and in many cases are manageable, which opens up many opportunities for improved management.

Conclusion

It is possible to map pasture covers, using a limited number of maps, and relate this to total annual yield variation using a tool that is already commercially available and in wide use in New Zealand. Even on well-managed dairy farms, pasture yields can vary markedly within paddocks. The reasons for the major patterns of variation are generally readily understandable, allowing farmers and their advisers to assess what the potential may be to improve production and profitability as a result of this information. This information has many potential uses:

- Demonstrating the effect of decisions, to drive better management
- Calculating gross margin maps, so any areas that are not performing to their full potential can be identified and corrected, and to inform investment decisions
- Assessing the result of investments, whether they actually improved yields or not
- Identifying paddocks for pasture renewal
- Dividing the farm into zones for precision management.

Detailed standard protocols for industry use of pasture yield mapping will be released during 2015.

Acknowledgements

This project was funded by the Ministry for Primary Industries through the Sustainable Farming Fund, New Zealand dairy farmers through DairyNZ, and by Ravensdown. The project team is grateful for extensive support from the South Island Dairy Development Centre, the Lincoln University Dairy Farm, and all farmers who participated in the study.

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PHIL JOURNEAUX AND MATTHEW NEWMAN

Economic and environmental analysis of New Zealand dairy farms with barns

Cow housing and off-paddock infrastructure have become the latest trend in intensification of New Zealand dairy farms.

The reasons for this investment are varied, but are not often driven by or informed well by financial or environmental analysis. The purpose of this DairyNZ funded study was to investigate the financial, environmental and farm system impacts of incorporating cow housing facilities (barns) on 14 case study farms.

Removing cows from pasture or crop, in autumn and/or winter, is one option to reduce nutrient losses. To do this effectively infrastructure is required, such as a stand-off pad or some sort of cow housing facility. These can require considerable capital investment, and as a result farms usually intensify (additional cows and/or feed) in order to justify the investment.

Methodology

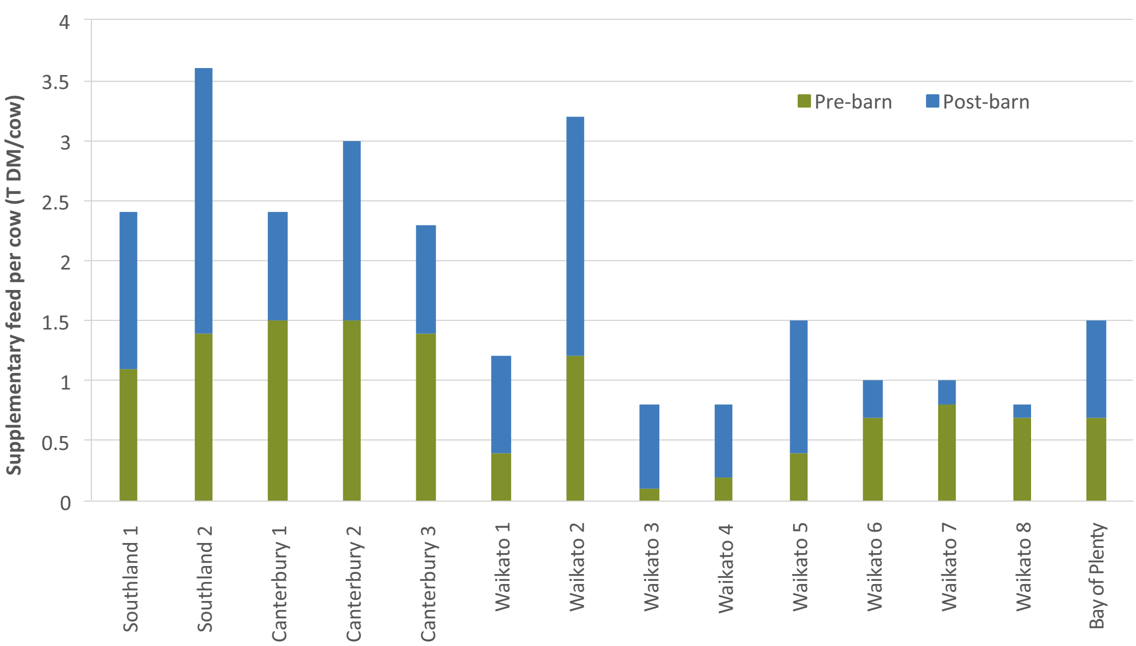
The study utilised an investment cost-benefit analysis approach to analyse financial impacts, while OVERSEER® (version 6.2) was used to measure nutrient loss and greenhouse gas emissions. Farms were selected by DairyNZ and were considered not to be extreme in terms of production system, but were thought to be reasonably efficient. The 14 farms studied across the country were:

- Two freestall barns in Southland
- Three freestall barns in Canterbury
- Five Herd Homes® in Waikato
- Three Redpath® barns in Waikato
- One loose house/compost barn in the Bay of Plenty.

The process involved two visits to each farm to collect pre-barn and post-barn information and to discuss the reasons for the barn and any farm system changes. The analysis used a discounted cashflow analysis over a 20-year period. This included the capital costs involved, the marginal increase in production and operating costs, and any benefits experienced directly from the barn. The government recommended discount rate of 8% real was applied, and a standardised methodology was used, with a base milk price of $6.50/kg of milksolids (five-year average to 2013-14).

For all farms, the advent of the barn resulted in increased levels of supplementary feeding, particularly for the South Island freestall barns (**Figure 1**) which resulted in higher milksolids production. The freestall barns tended to increase supplementary feed by around 1 tonne DM/cow to over 2 tonne, while the increase tended to be less on the North Island farms to become around 1 to 1.5

Figure 1: Change in supplementary feeding levels



tonne DM/cow post-barn. Half the farms also recorded an increase in cow numbers (**Table 1**).

Reasons for building a barn

The reasons provided by the farmers for incorporating barns into their farm systems were:

- Reduced pugging, particularly over winter
- Improved utilisation of supplementary feed
- Provides an alternative option for managing cows in winter (control)
- Quicker pasture recovery after drought
- Shelter for stock during adverse weather, including hot summer weather
- Better working conditions.

All the farmers expected the barn to be profitable, and while a financial return was important it ranked well down on the list of reasons to build one. A reduction in the farm's environmental footprint was not mentioned unless prompted, although there was a general expectation that the barn could future-proof their farm system in terms of environmental requirements. Overall, the farmers put a high intangible value on the barn, which was not costed in the analysis, and all case study farmers felt the barn had achieved their desired objectives.

Economic results

The cost of similar barns varied significantly, as did the type of barn built and how it was used. For many of the farms there was a significant capital cost beyond the barn itself, for example, further spending on other farm infrastructure such as effluent systems, and additional concrete (silage bunkers and raceways) and machinery. The total cost of the barn (and all associated capital changes including additional cows and milk company shares) ranged from $952 to $6,744 per cow, with an average of $3,093. On a square metre basis the total costs ranged from $136 to $791, with an average of $493.

All the farmers expected the barn to be profitable, and while a financial return was important it ranked well down on the list of reasons to build one.

Milk production increased by 6% to 38%, with most North Island farms producing over 400 kg milksolids and South Island farms over 550 kg per cow post-barn. The increased operating expenses per increased kg milksolids (marginal cost) varied considerably, but were generally lower on North Island farms. The majority of these additional costs were due to increased supplementary feed. The marginal cost, along with the capital costs, had a very good correlation to the investment returns (IRR). Those farms with relatively low capital, and/or operating costs, recorded the highest returns.

The results of the economic analysis (**Table 2**) showed that all but two case studies were profitable in the sense of having a positive IRR, and seven had a return greater than the discount rate of 8%, i.e. positive NPV.

Table 1: Summary of changes

	Barn cost ($/cow)^	Total capital cost ($/cow)^	Total capital cost/kg increased MS	Peak cows*	Kg MS/ cow*	Increased operating cost/ kg increased MS	Increased operating + capital allowance/ kg increased MS
Southland 1	$2,102	$3,160	$25.25	852 (+52)	568 (+11%)	$5.87	$8.08
Southland 2	$2,573	$4,181	$22.93	572 (+21)	559 (+20%)	$8.19	$10.84
Canterbury 1	$2,994	$3,733	$26.19	1,150 (0)	565 (+6%)	$9.45	$14.73
Canterbury 2	$3,302	$4,731	$27.59	540 (+40)	661 (+12%)	$7.31	$10.66
Canterbury 3	$4,000	$6,744	$22.41	950 (+100)	463 (+22%)	$9.56	$13.74
Waikato 1	$1,440	$2,161	$25.28	450 (0)	447 (+30%)	$4.94	$7.76
Waikato 2	$1,120	$3,145	$35.19	210 (-2)	495 (+38%)	$6.61	$8.88
Waikato 3	$2,080	$2,524	$25.37	250 (0)	526 (+25%)	$5.09	$7.02
Waikato 4	$1,486	$2,449	$24.08	350 (+60)	362 (+13%)	$2.96	$4.98
Waikato 5	$1,500	$2,241	$33.05	355 (+20)	428 (+28%)	$5.26	$7.05
Waikato 6	$1,600	$2,214	$28.38	214 (-9)	489 (+29%)	$3.50	$5.15
Waikato 7	$455	$952	$65.91	215 (0)	526 (+8%)	$4.30	$6.35
Waikato 8	$1,071	$2,047	$41.88	280 (+10)	371 (+27%)	$4.01	$5.84
Bay of Plenty	$1,496	$3,024	$52.33	455 (+55)	451 (+24%)	$4.70	$6.73

^ Figures based on the cow capacity of barn

* In brackets = change from pre-barn situation

The NPV and IRR were particularly sensitive to three main factors:

- **Milk price** – the study indicated a 'break-even' milk price in the order of $6.50+/kg MS; at this price level most of the farms were returning a positive IRR. A milk price of $7.50+/kg MS was needed for the majority to achieve an IRR of 8% or better
- **Capital cost** – a 20% decrease in total capital costs resulted in the IRR improving by two to three percentage points
- **Supplementary feed costs** – a 20% reduction in feed costs resulted in a three to 13 percentage point improvement in the IRR. This reinforces the importance of marginal cost relative to milk price at high levels of supplementary feeding.

Environmental results

The environmental impact of the case study barns was measured using OVERSEER®, with the changes in nitrogen leaching varying based on how the farm system changed as a result of the barn. Changes in phosphorus loss and greenhouse gas emissions were also captured. Note that the farms in the study did not attempt to optimise nutrient losses from the farm, but rather recorded the changes occurring from pre-barn to post-barn.

Figure 2 shows that five of the farms recorded a significant increase (greater than 10%) in nitrogen leaching, six recorded essentially neutral nitrogen leaching results (varying from 3% to +7%), while only three farms recorded reduced nitrogen leaching post-barn. This general increase in nitrogen leaching

Table 2: Economic returns at 8% discount rate

	Barn type	NPV	IRR
Southland 1	Freestall	$378,072	10%
Southland 2	Freestall	-$633,236	4%
Canterbury 1	Freestall	-$809,121	3%
Canterbury 2	Freestall	-$2,480,644	-6%
Canterbury 3	Freestall	-$7,076,558	-10%
Waikato 1	Herd Home	-$17,401	8%
Waikato 2	Redpath	-$347,552	2%
Waikato 3	Herd Home	-$143,803	5%
Waikato 4	Herd Home	$559,489	15%
Waikato 5	Herd Home	$9,292	8%
Waikato 6	Herd Home	$292,114	15%
Waikato 7	Redpath	$117,434	15%
Waikato 8	Redpath	$316,938	14%
Bay of Plenty	Compost	-$240,244	6%

NPV = Net present value is the value of the cashflow over 20 years discounted to today's dollars

IRR = Internal rate of return indicates the return the project provides as an investment

Five of the case study farms recorded a reduction in tonnes of CO_2 equivalents per hectare, with the largest reducing by 22%.

Figure 2: Changes in nitrogen leaching

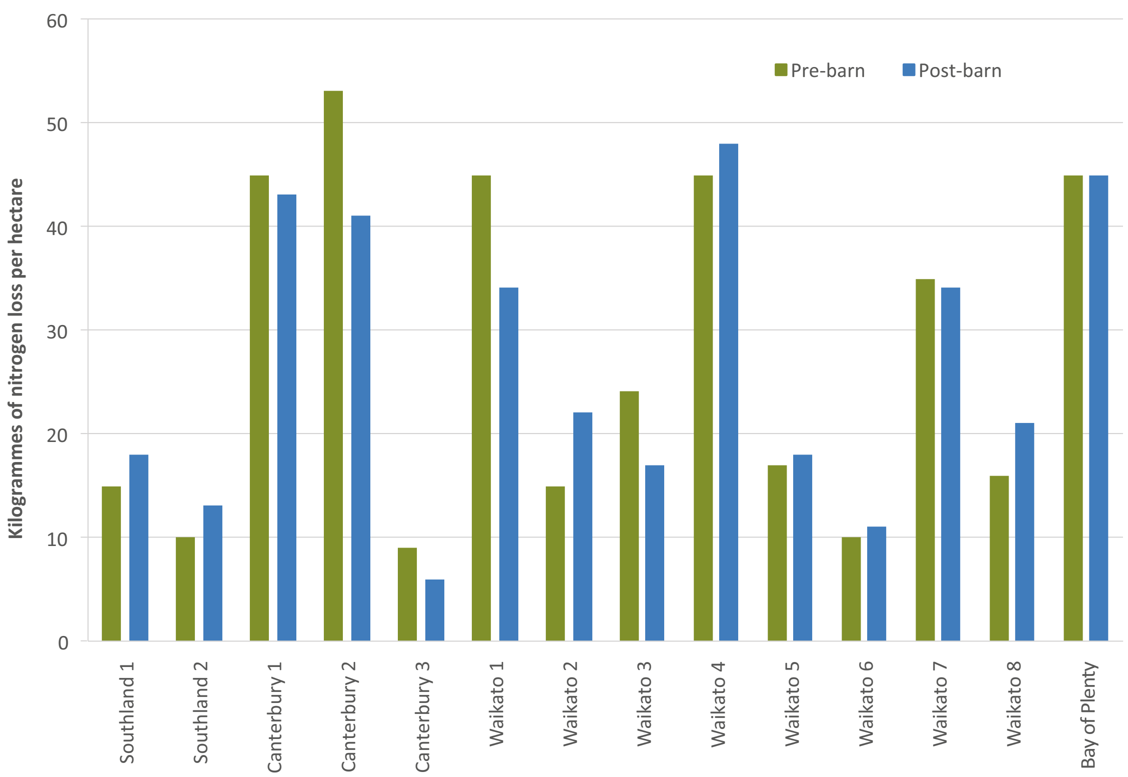
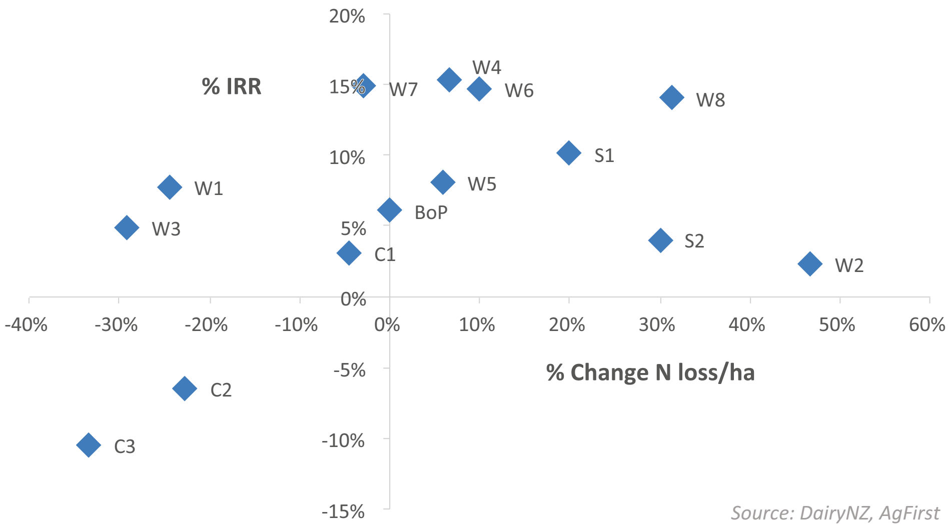


Figure 3: Summary of IRR and change in nitrogen leaching



Source: DairyNZ, AgFirst

is largely attributed to the intensification of the farm system as a result of the barn, which included increased cow numbers and/or supplementary feeding, coupled with (on several farms) an increase in cropping area. Changes in wintering practices and effluent management also had an impact.

The relationship between the IRR's calculated (vertical axis) and the changed nitrogen leaching level (horizontal axis) is illustrated in **Figure 3**. Two farms show a positive IRR and reduced nitrogen leaching post-barn. Waikato 1 had a tightly integrated system where all effluent from the farm (barn + dairy shed) was collected, transported to the support block and applied to maize crops, which were then fed in the barn to the cows. The reduction in nitrogen leaching on Waikato 3 was largely due to an improved effluent system, which was installed at the same time the barn was built. With the exception of Waikato 7, no farms reached the desirable quadrant of greater than 8% IRR and more than 10% reduction in nitrogen leaching.

Phosphorous losses have generally risen following the advent of a barn, with this due to a combination of factors including increased effluent discharges (albeit more controlled) and increases in cropping areas.

There was a similar picture with changes in greenhouse gas emissions. Five of the case study farms recorded a reduction in tonnes of CO_2 equivalents per hectare, with the largest reducing by 22%. The rest increased, with the largest more than doubling. The analysis showed an increase in methane (more cows) and CO_2 (more supplementary feeding), while N2O either reduced due to less effluent deposition and less nitrogen fertiliser, or increased due to more cropping and composting.

Summary

The main reasons farmers invested in barns was for management purposes (such as prevention of pasture pugging or overgrazing, improved conditions for cows and staff, and reduced reliance on winter grazing contracts) and not necessarily for financial or environmental reasons.

In general, farms with barns are trading some of the climatic risks for financial risks, especially as all intensified their farming systems post-barn. Incorporating a barn tended to intensify the farm system with more feed typically imported and more detailed management required, particularly around nutrition and stock management. Many farmers reported taking two to three years to adjust the system to a level they felt was appropriate. The general pattern of results show:

- The inclusion of a barn without intensification of the farming system will result in a reduction in nitrogen losses, but at a (potentially significant) cost
- The investment in a barn can be profitable conditional on good management and intensifying the farming system (more cows/ more supplementary feed), but dependent on the milk price, feed costs and capital costs. This illustrates the importance of concentrating on additional capital and operating costs in relation to additional milk production (marginal costs) to ensure maximum returns
- Intensifying the farm system to make the barn profitable often erodes the environmental benefits.

Overall, the decision around a barn tends to be either/or: you make money out of it; or you reduce the environmental footprint of the farm. It is difficult to achieve both. However, the primary objectives of the farmers in building the barns were farm management-oriented and these objectives were largely achieved.

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ALEC MACKAY, ESTELLE DOMINATI AND JOHN RENDEL

Looking to the future of land evaluation and farm systems analysis

This article explores the merits of using an ecosystem service approach to advance land evaluation and resource management, shows how multi-functional land evaluation could be used for inclusion in farm plans, and briefly describes the possible future face of farm systems modelling and analysis.

Introduction

Land evaluation has a long history of describing and quantifying the differences between units of land. Land evaluation goes beyond the description and quantification of soil characteristics (i.e. stocks) to include an assessment of the 'fitness of a soil to function' under specific climate and management for sustained production. In New Zealand land use capability classification is the basis for assessing the suitability for sustained production taking into account the physical limitations the land may have.

With the increasing demands on the finite land resource in this country, the time is rapidly arriving when land evaluation must go beyond an assessment of just land suitability for primary production to include consideration of all the ecosystem services provided to humans by a combination of land type, climate, land use and management practices. In addition to food and fibre, landscapes provide a wide range of other services on which we depend including physical support, nutrient filtration, sources of clean fresh water, flood mitigation, greenhouse gas regulation, a safe place to build and live, aesthetics and for many their spiritual home (**Figure 1**).

Inclusion of suitability for a range of ecosystem services as part of the land evaluation processes would address one of the limitations of the current approach – the provision of indicators for all the benefits we obtain from a given landscape, and not just productivity. Other limitations of the current land evaluation approach include the qualitative nature of the assessment, the limited investigation of the impacts of the intensity of the uses and practices, and the lack of stakeholder participation in defining community expectations on practices and impacts on receiving environments.

Current land evaluation

The Level 2 and 3 farm plans described in the Land and Environment Planning (LEP) Toolkit of Beef + Lamb NZ and the 'whole farm plans' that are part of the Sustainable Land Use Initiative of Horizons Regional Council are good examples of the current approach to land evaluation and planning used in soil conservation and environmental plans. Land evaluation is formally defined as 'the assessment of land performance when used for a specified purpose'. Historically, the land evaluation procedure uses physical limiting factors arising from climate, hydrology, landforms, soils and vegetation as the basis for evaluation of sustainable yields, with critical values determining the boundaries of suitability.

Two new trends emerging from land evaluation frameworks globally are the recognition of the wider functions and services provided by landscapes and the need for greater stakeholder participation in exploring the balance between economic, environmental, social and cultural outcomes.

Two new trends emerging from land evaluation frameworks globally are the recognition of the wider functions and services provided by landscapes and the need for greater stakeholder participation in exploring the balance between economic, environmental, social and cultural outcomes (**Figure 2**). Decisions on-farm which impact beyond the farm boundary also need to be included in any integrated assessment frameworks. For example, the challenges we currently face with water quality demonstrate that soils have a finite capacity to retain nutrients and receiving environments have a finite capacity to assimilate nutrients.

Natural capital and ecosystem services

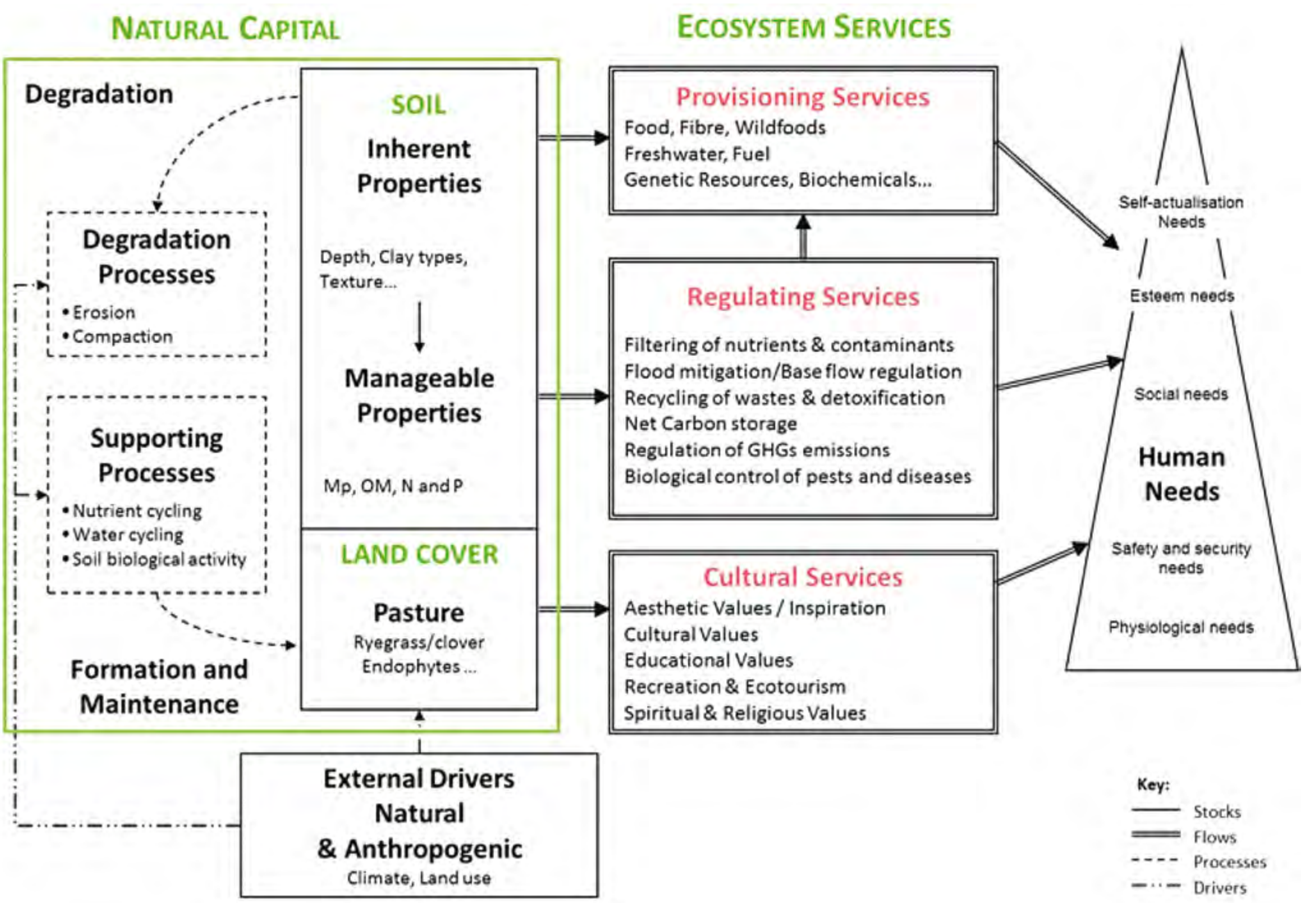
A rapidly emerging multi-disciplinary approach to assess the multi-functionality of natural resources is based on the concepts of natural capital and ecosystem services. Natural capital is defined as the 'stocks of natural assets that yield a flow of ecosystem goods or services into the future' (**Figure 1**). The notion of natural capital comes from trying to frame the contribution of natural resources alongside manufactured capital (factories, buildings, tools), human capital (labour, skills) and social capital (education, culture, knowledge) to the economy. Ecosystem services are defined as 'the benefits people obtain from ecosystems'.

The ecosystems approach has its origins in ecological economics, recognising that the economy is a subsystem of the ecological system and that sustainable economic activity needs to be performed within the biophysical limits of the natural environment. Natural resources scarcity, which includes the ability of the environment to assimilate the waste products of economic activity without deleterious feedbacks, such as CO_2 to the atmosphere, is nowadays the limiting factor/threat to economic development and wellbeing.

Farms are more often than not an assemblage of multiple landscapes that include a mix of topographies and a range of different soil types, both of which influence pasture and crop production.

Adding an ecosystem services approach to land evaluation enables the supply of ecosystem services to be directly linked to the performance of a combination of land type, land use and management intensity to deliver specific outcomes identified by stakeholders. This provides a more complete picture of the efficiency of use of the natural resources, assists in defining natural ecosystem boundaries and gives more quantitative information on the progress towards outcomes (i.e. economic, environmental, social and cultural) desired by the community from the use of land (**Figure 2**).

Figure 1: Natural capital (soil and land cover) contribution to ecosystem services provision in an agro-ecosystem



Future shape of farm systems analysis

Farms are more often than not an assemblage of multiple landscapes that include a mix of topographies and a range of different soil types, both of which influence pasture and crop production. Importantly, these land units show different responses to inputs and practices. Today's intensive agricultural systems are the product of successfully combining and using built capital, alongside the diversity of natural resources (e.g. land, water) in the production of food and fibre for profit. Into the future, analysis of the farm system will need to be extended to include the implication of decision-making on not just food and fibre production, but all the services that our farm systems provide. While not a formal process, it must be acknowledged that this already occurs tacitly to some extent in that farmers do recognise many of the other services and manage accordingly.

Building an ecosystem service approach into the land evaluation framework offers a way to recognise these other services and provides a basis for recording, quantifying and including them in the analysis. It also offers a method for separating out and assessing the contribution from the natural and built capital to the farm system and the delivery of the services. For example, the contribution of investments which build the farm's natural capital, such as soil conservation or riparian margins, or built infrastructure investments like irrigation, feed-pads or herd homes, to ecosystem services delivery beyond yields can be quantified separately and valued. This will create new insights into the impacts of on-farm investments on ecosystem services delivery and the performance of the farm system towards multiple outcomes.

An ecosystems approach also creates the ability to define 'ecological boundaries' within which resources should be managed to ensure the preservation of natural capital stocks and thereby the sustainable delivery of services from our landscapes. The concept of adding ecological boundaries, within which land use must operate,

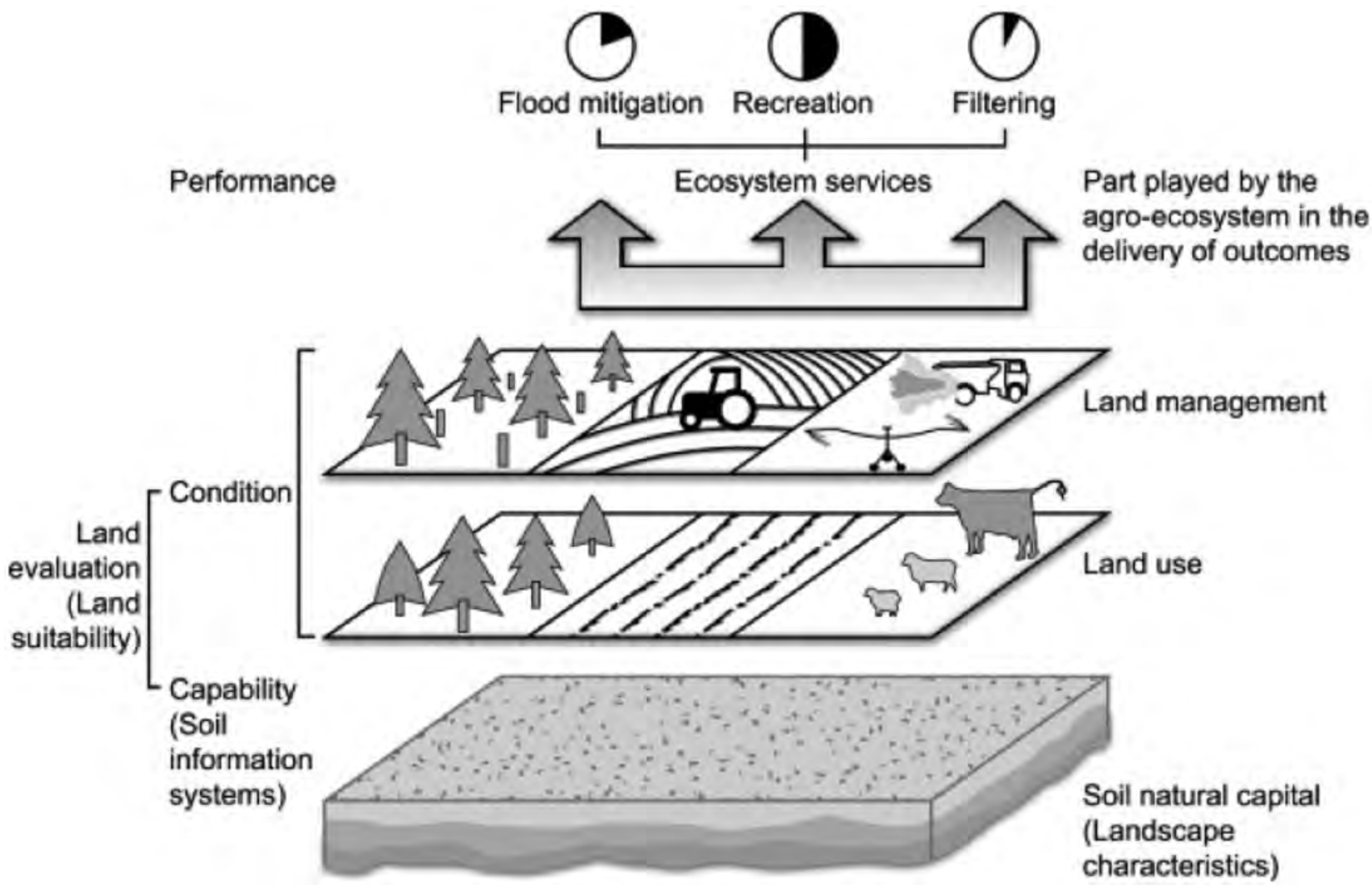


Figure 2: Combining land capability with resource condition under a use to quantify ecosystem services provision for multi-function land evaluation

The ability to define and include ecological boundaries within which resources should be managed will be a feature and capability that analytical farm system frameworks will require into the future.

moves the analysis from managing land to managing a landscape from which the community seeks multiple outcomes. While some of these boundaries will be defined by the landowner at the farm scale (related to sustaining the quality of natural capital stocks such as soil quality), some will be defined at the catchment scale and relate to desired community (thresholds on nutrient losses, sediment) and consumer (practice and produce quality) outcomes and some will be defined at the national scale (GHG emissions to air). The ability to define and include ecological boundaries within which resources should be managed will be a feature and capability that analytical farm system frameworks will require into the future.

New and emerging farm systems analytical capability

INFORM (Integrated Farm Optimisation and Resource Allocation Model) is a new generation farm systems model that advances the use of linear programming in farm systems modelling and decision-making by departing from the use of whole farm and average data, to integrate independently obtained biological data from each of the land management units within the farm system. Land management units are defined here as areas of the farm having similar natural resources and management practices. The optimisation routine uses the information from each land management unit to identify the mix of production enterprises and management regimes that maximise profit for the business. This enables the response to an input to be isolated to that area of the farm. This creates the capacity to estimate the expected returns from specific on-farm investments targeted at specific land management units for the whole farm business.

The ability within the modelling framework to also place constraints or boundaries on the use or emissions from each land management unit before optimising the farm system represents a step change over the current approach which first explores economic outcome (EBIDTA) and then mitigates for specific emissions (e.g. N, P, GHG). As indicated, some boundaries will be defined by the landowner at the farm scale (e.g. related to sustaining the quality of natural capital stocks or to specific farm performance objectives) and some informed from wider scales (e.g. thresholds on nutrient losses).

Future analysis

The use of an ecosystem service approach to advance land evaluation, in conjunction with farm systems models like INFORM that can optimise the use of natural and built capital within defined ecological boundaries, creates the capacity to: (1) separate out the contribution from built and natural capital to the provision of services; and (2) assess if the farm system is sustaining natural capital stocks (e.g. soils, water, vegetation) on which the business is based. This addresses the purpose (section 5) of the Resource Management Act (RMA) 1991:

> *The purpose of the RMA is to promote the sustainable management of natural and physical resources. In this Act, sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being and for their health and safety while – (a) sustaining the potential of natural and physical resources (excluding minerals) (Natural capital) to meet the reasonably foreseeable needs of future generations; and (b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems (Flow of services); and (c) avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

In that section of the RMA, 'sustaining resources' can be interpreted as natural capital stocks and 'life supporting capacity' as the ecosystem services.

This capacity also provides a basis for conducting a more complete analysis of the implication of adding built capital (e.g. irrigation, feed pad) or ecological infrastructure (soil conservation plantings, riparian margins) on the flow of services, the trade-offs between services, and on environmental outcomes. These metrics would also be useful in reporting to the consumer and market on the environmental performance of the farm operation from within the landscape where it is located.

Summary

The concept of using an ecosystem service approach to land evaluation is advanced and the future face of farm systems analysis is briefly explored in this article. The new generation farm systems models represent a step change over the current approach for isolating and examining the value of investments targeted at specific parts of the farm on the whole farm business. An analytical capability that can optimise the use of resources within defined boundaries is an emerging requirement by the pastoral industry.

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MIKE JOY

Water quality issues in New Zealand – monitoring methodology and approaches to improving quality

This is the second part of an article by Mike Joy on this topic. It looks at how water quality is monitored in both flowing water (rivers and streams) and in lake and groundwater. The article also discusses legislative and voluntary approaches to improving water quality.

Condition of New Zealand rivers and streams

Flowing waters in New Zealand have been regularly monitored since 1990 at a set of 77 river sites known as the National Water Quality Monitoring Network (NRWQN). Analysis of this data reveals the poor state of water quality in most lowland rivers, particularly in those measures related to diffuse nutrient and faecal pollution and sediment. However, the full extent of the decline has been masked by the reporting agencies averaging results over control and impact sites. When the water quality variables were compared with land use for pastoral and urban land, the correlations were almost all significantly positive, indicating that poorer water quality was associated with increasing urban or pastoral cover. However, it should be noted that urban catchments make up less than 1% of river length.

The commonly used biological measure of water quality/ecosystem health, the macroinvertebrate community index (MCI), is a measure of organic enrichment based on the response of the individual species to increasing nutrient levels. To give a national picture of the state of water quality, the national MCI scores measured at the sites shown as black dots in **Figure 1** were modelled by NIWA to fill in the gaps between and then colour coded. The red and dark orange river lines show areas that are severely (red) or moderately (dark orange) polluted. The predictive map shows clearly the areas with poor quality waterways nationally; these areas are mainly located in lowland New Zealand where intensive agriculture occurs. In contrast, the West Coast of the South Island, the East Coast around East Cape and the Coromandel Peninsular show that healthy waterways do still exist in lowlands without development.

Analysis of a larger dataset of more than 300 lowland waterways collected by local government, plus the NRWQN data, revealed that 96% of the sites in lowland pastoral catchments and all sites in urban catchments failed the pathogen standard considered safe for swimming and more than 80% exceeded nutrient guideline levels. Further analysis and modelling revealed that 62% of all waterways would currently fail the human health standard.

The human impact of these high levels of pathogen contamination is revealed from estimates by the Ministry of Health that 18,000 to 34,000 people annually contract waterborne diseases. While damning, these human health impacts occur despite the fact that many lowland waterways and estuaries have health warning signs, and these signs are now a common sight around much of lowland New Zealand.

62% of all waterways would currently fail the human health standard.

Temporal trends in water quality and biodiversity

Over the last two decades there were significant increases in nutrients levels at nearly all NRWQN sites (the worst were nitrogen and phosphate) and the only improvements were in water clarity. As with the state indicators, the strongest temporal patterns of deterioration were at sites with catchments in agricultural and urban land cover.

Trends in freshwater fish biodiversity, and therefore freshwater biological health in New Zealand, have been assessed using a measure of the integrity of fish communities commonly used internationally, the index of biotic integrity (IBI). This methodology was applied to 22,546 freshwater fish distribution records collected throughout New Zealand over the last 40 years. A comparison of these IBI scores in catchments with different land uses revealed significant differences. The scores were significantly lower at sites in tussock, pasture, urban and exotic forest catchments than in native forest and scrub sites. A temporal trend analysis of these IBI scores showed a clear and statistically significant decline in fish communities for all catchment land use types in New Zealand over the last 40 years, especially in the last decade. Notably, the strongest declines were at sites with catchments in agricultural and urban land cover.

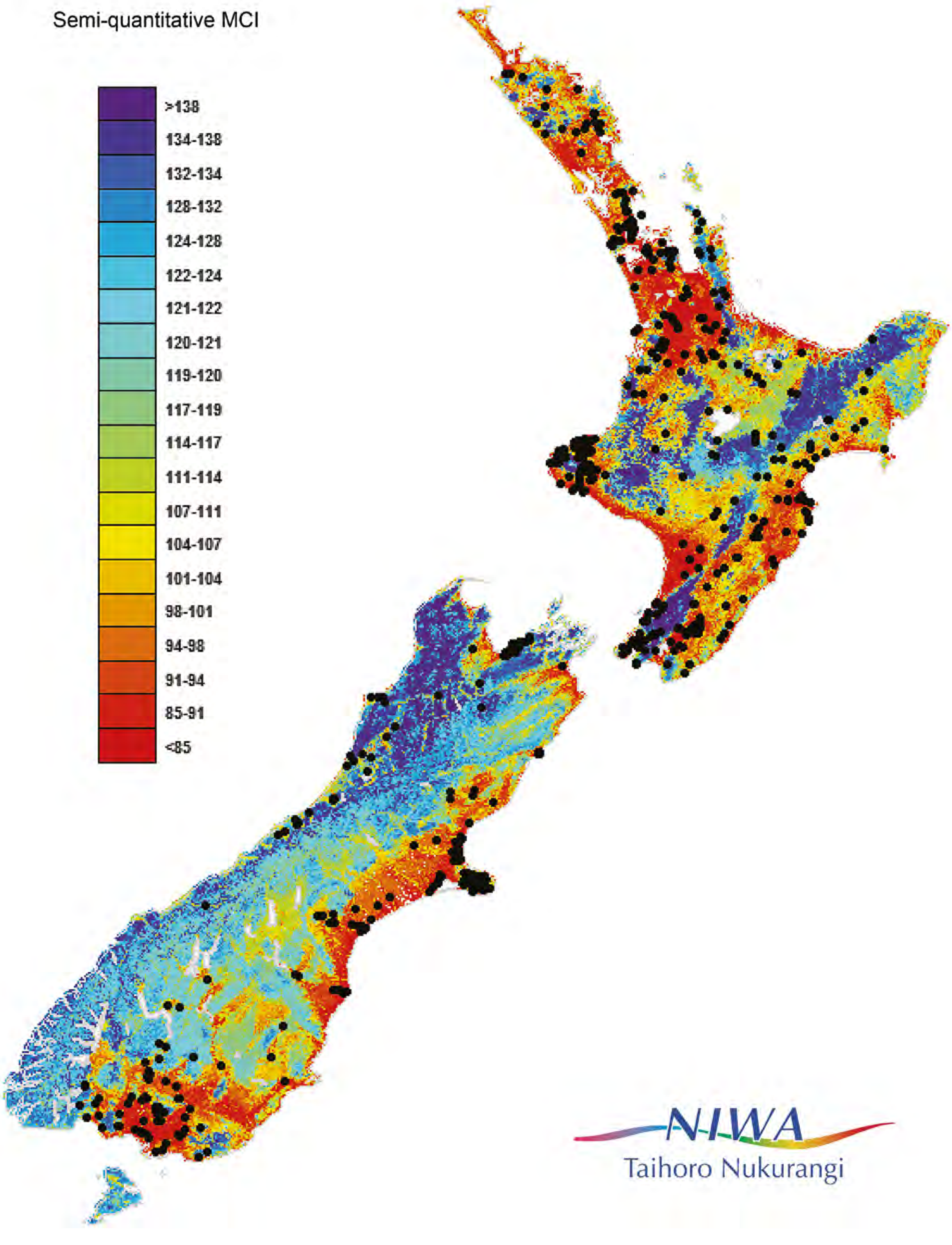

Figure 1: Modelled current state for the MCI. A score of <80 is severely polluted, 80-100 is moderately polluted, 100-120 is doubtful water quality and >120 is healthy. Accordingly, dark orange and red waterways are severely or moderately polluted. Source: Unwin, M.J. and Larned, S.T. (2013). ***Statistical Models, Indicators and Trend Analyses for Reporting National-Scale River Water Quality (NEMAR Phase 3)*****, NIWA**

Lakes and groundwater

Lakes and groundwaters show deterioration parallel to flowing waters, in that they suffer from excess nutrient inputs mainly from agricultural intensification, as well as urban waste and stormwater inputs. However, the difference for lakes and groundwater from flowing waters is that while they are more easily measured the impacts are longer lasting and harder to fix. The high level of nutrient inputs are revealed by the alarming statistic that 44% of monitored lakes in New Zealand are now classed as polluted, i.e. they are now eutrophic or worse, and most of these polluted lakes are in lowland areas and in agricultural or urban catchments. In groundwater, nitrate levels are rising at 39% of monitored sites and groundwater pathogen levels exceeded human drinking standards at 21% of monitored sites.

Freshwater biodiversity

Any changes in freshwater ecosystem health are ultimately and most comprehensively revealed by changes in freshwater biodiversity. Nationally, native freshwater fish abundance and diversity have been declining for at least the last century but the rate has accelerated over the last 40 years. Only one species, the grayling *Prototroctes oxyrhynchus*, has become extinct, but the range and abundance of almost all species has diminished. The declines are revealed by the increase in the number of species listed as threatened over the last 20 years, with the proviso that the criteria for threat rankings change over time and data for the listings inevitably lag behind actual declines. In 1992, the Department of Conservation recorded 10 species as threatened; by 2002 that number had risen to 16 species.

Three years later, in 2005, 24 species were listed as threatened. In 2007, a new threat classification scheme was established using a reduced set of categories but retaining the key threat descriptors from previous classifications. Under this new system 68% of all extant native taxa and 76% of all non-diadromous taxa were considered threatened or at risk. In 2013, a further analysis found that of the 54 resident native taxa, 40 (74%) were classed as threatened or at risk. This proportion of threatened fish species is one of the highest globally and gives a strong indication of the true extent of freshwater ecosystem decline in New Zealand.

These reductions in freshwater fish diversity have been paralleled by a decline in invertebrate diversity and distribution. The number of invertebrate taxa that might be considered at risk to some degree increased from 69 in 2002, to 139 in 2005, to 295 in 2010, and includes New Zealand's only freshwater crayfish and mussel species. Although some of this increase in invertebrates listed as declining reflects increasing knowledge of taxonomy and distribution, the number of nationally critical taxa has increased over the same time from four in 2002, to 11 in 2005, to 58 in 2010. However, even within this biodiversity assessment there are some clear anomalies with the two crayfish (*Paranephrops planifrons* and *P.zealandicus*) listed, but their commensal platyhelminth flatworm (*Temnohaswellia novaezelandiae*) is not listed.

The past

Legislative approaches

At the same time that the Resource Management Act 1991 legislation was passed into law, New Zealand committed internationally to halt the environmental decline at the United Nations Rio Earth Summit (the UN Conference on Environment and Development Rio de Janeiro held in Brazil in 1992). However, in the ensuing two decades there has been a comprehensive failure to achieve any of these commitments. The list of failures begins with Principle 16 which declared that 'authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments' and further that 'the polluter should bear the cost of pollution.'

To date there has been no fee applied, or any attempt to internalise the costs of the pollution of freshwaters in New Zealand. The only cost for 'out of pipe' (point-source) polluters is a one-off consent fee which is essentially an administration charge required by local government. The problem for freshwater health is that the biggest pollution source in New Zealand is not point-source, rather it is diffuse, and this form of freshwater contamination is not controlled at all. Diffuse pollution is the nutrient, urine and faecal contamination that makes it way into lakes and rivers through and over the soil mainly via cow urine patches and the washing overland of faeces in rain. The resulting additions of nutrients and microbial contaminants to lakes, rivers and streams has led to many ecological and human health impacts, outlined above, but these are not paid for by the polluters. To date, the Lake Taupo catchment is the only one in New Zealand where an effective attempt has been made to reduce diffuse pollution and protect this iconic lake from nutrient pollution through regulation using a nitrogen cap and trade system. Apart from the Lake Taupo example, local authorities have failed to use the capacity they have had under the Resource Management Act to control the obvious impacts of farming intensification on freshwaters. Instead they have chosen only to control the much less significant impact of dairy shed wastewater.

The main reason for local government (councils') failure to address the main impact on freshwater quality in New Zealand lies to a large extent in the failure of central government to implement a National Policy Statement (NPS) for freshwater management since the Resource Management Act. This was despite a legislative requirement to do so soon after the Act was passed.

This would undoubtedly have given guidance to regional councils and potentially given them the confidence that they would not be picked off individually as protective legislation was developed.

The only other response from central government around freshwater protection was to set up a stakeholder group known as the Land and Water Forum (LAWF). The forum was proposed and set up by central government as a collaborative approach to managing freshwaters into the future. In reality, the forum membership was heavily weighted toward very well-resourced stakeholders, with minimal representation from freshwater protectors and conservationists. The forum worked through many issues over four years, produced three reports and made many recommendations, but none so far have any chance of halting freshwater decline.

The NPS was finally put in place in 2011, but it has been justifiably criticised as being too little and too late and unlikely to produce any improvement in water quality. This framework gives limits and numbers to achieve the goals of the NPS. It has ambitious sounding expectations for 'maintaining or improving freshwater quality', but crucially the numbers and limits in the National Objectives Framework (NOF) just do not match up with these aspirations. Rather they allow for a deterioration of the problem. Worse still, most of the parameters used in the past to measure the health of freshwaters are not included in the NOF.

As an example of the weakening of standards was the inclusion of only one nutrient standard in the NOF (nitrate) and the new limits are a 10-fold weakening of previous guideline levels, going from the ANZECC year 2000 guideline of 0.61 milligrams per litre to the new bottom line of 6.9. The quality bands (A, B and C) for water quality were set so that less than 1% of the rivers in New Zealand would breach the bottom line and almost all would score an A, as shown in **Figure 2**. To give some idea of just how much ground was given here,

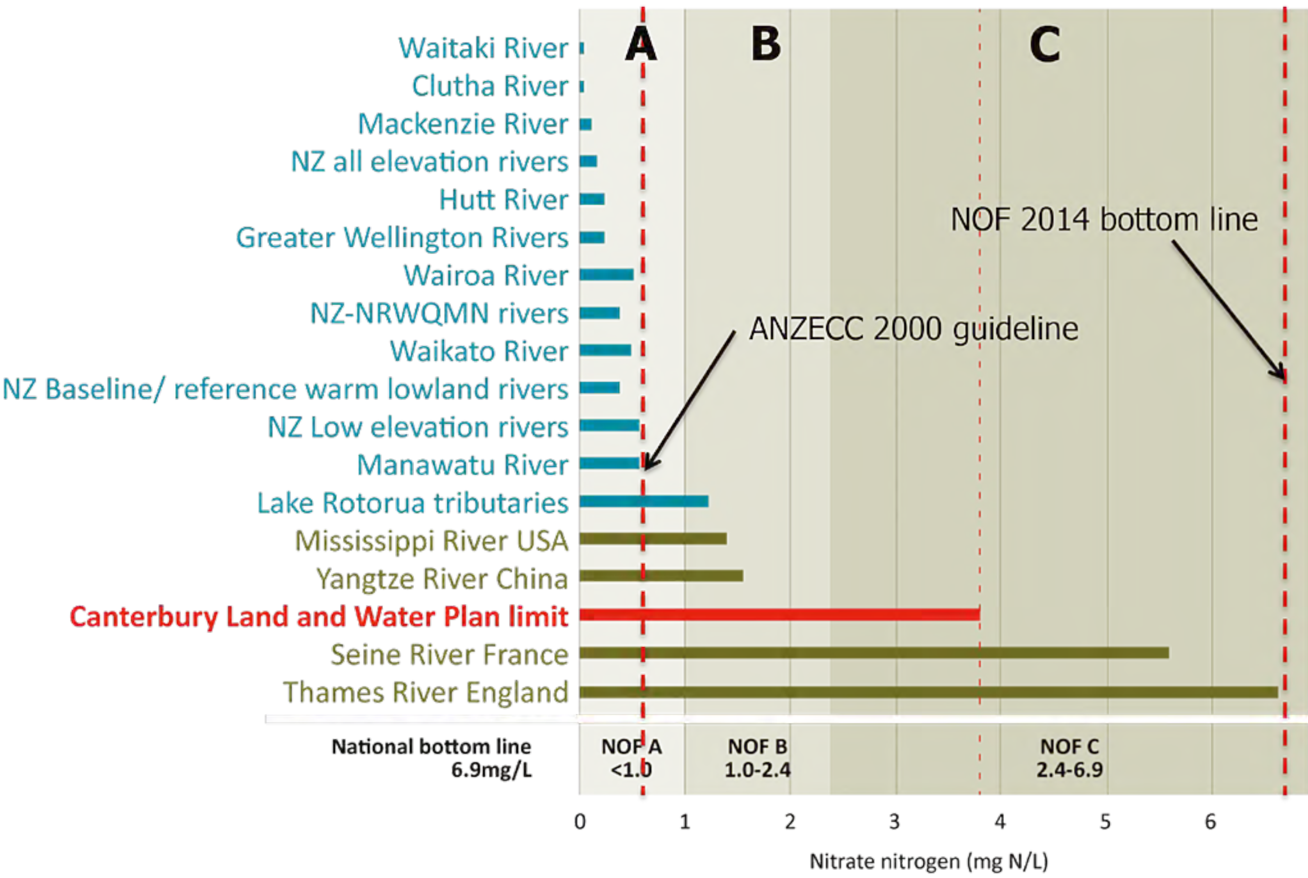

Figure 2: Graph comparing the median levels of nitrate nitrogen from a range of rivers in New Zealand and overseas. The three bands (A, B and C) shown are from the National Objectives Framework 2014. The ANZECC guideline trigger level for nitrate nitrogen (0.61 mg/l) is shown as a dotted line

In terms of biodiversity declines, ironically none of the threatened native fish species have any legal protection. Indeed, at least five threatened fish species are harvested commercially and recreationally.

comparison with other countries shows that some of the most nutrient polluted rivers in the world like the Yangtze in China and Mississippi in the United States would score a B under this new ranking.

In terms of biodiversity declines, ironically none of the threatened native fish species have any legal protection. Indeed, at least five threatened fish species are harvested commercially and recreationally. Absurdly, the Freshwater Fisheries Act 1983 formally protects the extinct grayling last seen in the 1930s and some introduced fish, mainly trout and salmon, but not native fish.

The native fish are protected only if they are not used for 'human consumption or scientific purposes', therefore in reality they have no protection. In addition, four of the five species that make up the whitebait catch (juveniles of the migratory galaxiids – a popular recreational and commercial seasonal harvest in New Zealand) are listed as threatened. So 50 years after the endemic grayling's extinction a law was passed to protect it, and other native fish species have no legal protection apart from harvesting rules.

Voluntary approaches

Other than the NPS on freshwater management the only significant response to date from central government to the many freshwater issues was the negotiation of a voluntary accord with the largest dairy company in New Zealand, Fonterra, signed originally in 2003 and regularly updated since. This agreement, originally called the Clean Streams Accord, was between Fonterra, regional councils and the Ministry for the Environment and required that farmers undertake a number of measures to reduce their impacts on freshwater.

The agreement at first appeared impressive but closer investigation revealed many failings, including that the accord lacks any real ability to enforce requirements, and the stream fencing requirements ignore the smaller streams where actions would be most effective. A further crucial flaw is that all the monitoring requirements are for assessing whether the accord requirements are being implemented, rather than any assessment of if they are in fact improving water quality.

The result has been that while the accord progressed stream fencing, it did not include riparian buffer zones and mostly only occurred on larger waterways. What it did do was to focus publicity on the continuing problems of dairy effluent management and it resulted in the uptake of farm nutrient budgeting. The downside was that it gave regional councils a pretext to continue to defer introducing rules to address the impacts of farm intensification and diffuse pollution. So the result was that while the accord was a great public relations tool for the industry to suppress criticism, there is no evidence that it has done anything to halt the decline of water quality. The updates to the accord that have occurred since its inception have not addressed any of the issues raised above, and in 2013 the phrase 'clean streams' was removed and it is now called the Water Accord.

Summary

The continuing degradation of the health of freshwaters in New Zealand is a sad indictment on this country and its resource management. While the resource management legislation includes all the right words and intentions, the implementation has clearly failed, mainly because it missed the key problem – diffuse pollution. There are many costs associated with these failures and the resulting degradation will unfairly place these on future generations. Despite these shortcomings, the massive weakening of protections evident in the NOF (a product of the LAWF) will sadly ensure worsening water quality in the future. The primary recent driver of freshwater degradation is clearly intensive agriculture, and it can now be seen that in the medium term they have not gained from this weakened environmental regulation. In fact, they are now less resilient to market fluctuations. So this process has been a lose-lose situation for farmers and the environment. We should (and could) be leading the world in sustainable agriculture and instead we are following the worst performing countries – this must change and change soon.

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KEVIN OLD AND PETER NUTHALL

Governance on New Zealand farms

Farms in New Zealand continue to increase in value and output. With this increase many consultants and professionals are questioning whether traditional ownership and governance models continue to be suitable.

Introduction

To form the basis of such a discussion it is essential to have information on the current situation. To discover the basic arrangements a nationwide survey was carried out over the latter half of 2013 with a mail questionnaire having being sent out in June 2013. With a response rate of 36%, well above the normal, some confidence can be placed in the information collected.

Some farms have large investments and it is argued they could well benefit from having advanced governance systems involving a range of 'advisors'. The respondents' data showed that while 64% of farms and horticultural units had a net investment of $5 million or less, there were still 4.2% with net assets in excess of $15 million. Several of these reported a net asset greater than $25 million.

The real issue is whether farmers, particularly on the larger farms, can gain from the input of additional people besides the main manager and the traditional accountant and lawyer input. This input of outside people can come in a range of forms from a single consultant, to an informal committee, through to a formal board, each one of which will have an associated cost which must be more than covered by the advantages. As has always been the case, farmers have consulted bankers, accountants and lawyers from time to time. This will continue no matter the governance put in place.

The question of a definition of governance can be problematic. What is governance relative to management? Formal definitions do exist, but in the end an all encompassing team must provide direction in all areas relevant to the life of a farm.

The sections that follow provide data on the background which might influence decisions on governance systems (mainly ownership situations), information on the people responsible for making strategic and tactical decisions, details of the structure of the boards and advisory committees that do exist on some farms, information on whether farmers believe their knowledge of governance systems is reasonable and the degree of 'happiness' about their existing system, the origins of any help a farmer has obtained, and finally some concluding comments. In this discussion 'governance' is considered to cover more than just the traditional governance that formal boards in large organisations generally regard themselves as being restricted to.

Who makes the strategic decisions?

Decisions on management and governance questions are still largely made by sole traders or the partners in simple partnership arrangements. By far the majority of farmers believe they can personally provide the total management input necessary, other than the input of consultants, accountants and lawyers. Also most farms are run as partnerships or as sole traders. Spouse partnerships dominate other than for the $20-25 million net asset range where the wider family is involved in the partnership. However, the number of farms in this category is small compared with the lower total net investments. When it comes to the level of assets held by the various players in the ownership situation, the majority are held by the farmer, a spouse, or in some form of trust, although private company arrangements are also important.

Decisions were divided into 'strategic and long-term policy' relative to 'tactical and/or short-term questions including day-to-day decisions'. **Table 1** provides information on the long-term decision responsibilities and you would expect boards and advisory committees would come into prominence here.

Table 1: Percentage of farmers and other groups (cell-based) that mainly make the strategic and long-term policy decisions (by net investment level)

Asset range ($)	Make all	Confer	Committee	Board	Partnership	Sole decider	Trustees
<10 million	78.01	35.34	5.36	2.70	55.17	61.32	27.86
>10 million	59.68	53.97	19.67	21.67	62.29	30.51	36.07
>15 million	53.57	62.07	27.59	24.14	55.17	25.93	28.57

Make all = make all decisions but with advice from family/friends/colleagues. **Confer** = frequently confer and take advice from a professional consultant. **Committee** = often have committee of lay and professionals to help through formal meetings. **Board** = have board of directors that frequently meet and has the final say. **Partnership** = as a partnership we make most decisions. **Sole decider** = make decisions without discussions with others. **Trustees** = farm is owned at least in part by a trust and you consult the trustees. **Other** = decisions are mainly made by a manager/sharemilker/lease.

This data clearly shows the importance of 'farmer' control relative to making use of advisors in various forms. In interpreting the figures it is important to examine individual rows due to the overlap of the categories. It will be noticed that as the investment increases, the 'sole decider' dominance over decisions declines quite markedly and 'conferring' increases.

Who makes the tactical decisions?

In **Table 2** the same information as provided for the strategic decision is presented for tactical decisions about which you would of course expect the farmer to feature prominently. Other information not presented here divided the respondents into farm types. It was clear there are few significant differences across them although sheep farmers do seem to confer less – perhaps isolation has an impact.

Table 2: Percentage of farmers and other groups (cell-based) that mainly make the tactical and/or short-term decisions including day-to-day decisions (by net investment level)

Asset range ($)	Make all	Confer	Committee	Board	Partnership	Sole decider	Trustees
<10 million	69.13	45.33	7.07	2.97	54.41	50.94	23.23
>10 million	53.22	52.45	18.96	18.03	50.00	20.69	30.36
>15 million	55.17	60.71	19.23	25.00	46.15	22.22	20.00

See Table 1 for a definition of the column headings.

Overall, it is clear that both strategic and tactical decisions are largely made by the farmers themselves, albeit after discussions, with formal boards and committees being seldom used except for the larger farms. It is also noticeable that as the investment increases there is a greater tendency towards 'conferring' when making decisions, and that advisory committees and formal boards increase. It will also be noted that even for tactical decisions advisory groups are involved.

Overseeing boards and committees

The net asset levels, and the number of farms held by each manager (farmers report they have an ownership interest in, on average, 1.75 farms), would all tend to suggest some farmers, even if a minority, are becoming quasi-corporate operators. Because multi-farm operations can become quite complicated (one farmer had seven properties), it is important to determine the extent of the move to have formal advisory systems.

Table 3 presents data covering the details of the advisory committees/boards used by farmers. Besides the tendency for larger farms to use boards and committees, dairy farmers are also moving in this area. As noted the number of multiple farm operators, which is higher in the dairy industry, probably encourages this move.

As the investment increases, the 'sole decider' dominance over decisions declines quite markedly and 'conferring' increases.

Table 3: Percentage of farms with a formal board or an advisory committee according to farm type, profit level and net asset range (percentage of farmers in each cell)

Farm type	% with board	% with com'te	$ profit range	% with board	% with com'te	$ asset range	% with board	% with com'te
Int sheep	1.70	4.54	<50,000	1.17	5.47	<5 million	1.74	5.04
Sheep/cattle	4.54	0.75	50-100,000	2.78	2.78	5-10 million	3.97	6.35
Deer	0.0	0.0	100-150,000	0.0	8.47	10-15 million	14.71	11.76
Cattle	3.54	1.77	150-200,000	7.84	3.92	15-20 million	16.67	8.33
Dairying	6.34	10.45	200-250,000	13.04	13.04	20-25 million	50.00	0.0
Other animal	0.0	0.0	>250,000	12.16	8.11	>25 million	36.37	0.0
Fruit/viticulture	3.45	3.45						
Cash crop	0.0	8.00						
Flowers/orn	0.0	0.0						
Vegetable	0.0	0.0						
Other	2.70	2.70						

Overall, formal boards and committees are not prominent. The highest figures are for dairying and horticulture, as might be expected. For the profit level and net asset categories, particularly for boards, there is a clear increasing trend as each category increases. While not given in the data, you might expect some of the higher profit/net asset farms to be public companies and consequently there is a need for a formal board. **Table 4** examines more details about the boards/committees.

The net asset levels, and the number of farms held by each manager (farmers report they have an ownership interest in, on average, 1.75 farms), would all tend to suggest some farmers, even if a minority, are becoming quasi-corporate operators.

Table 4: Number of members in the boards/committees and meeting details for governance boards/committees

Range – no. of members involved	Percentage in each number range	Range – meetings/year	Percentage in each range	Range – days per year devoted	Percentage in each range
<=2	23.2	<=1	24.7	<=1	19.1
3	29.3	2	17.3	2	6.4
4	20.7	3	8.6	3	4.8
5	14.6	4	19.8	4	3.2
6	8.5	5	0.0	5	4.8
>=7	3.7	6	9.9	6	9.5
		7	0.0	7	6.4
		8	2.5	8 to 9	4.8
		9	0.0	10 to 11	9.5
		10	1.2	11 to 12	4.8
		11	0.0	12 to 22	6.4
		12	12.3	23 to 33	4.8
		>12	3.6	>33	16.0
Mean	3.64		5.41		21.84

It is clear that the number of members in the committees/boards are all relatively small, with few meetings per year involving a wide range of time input. Also, for a few farms the number of days is quite excessive, which more than likely relates to family members being on the board/committee and their likelihood of being constantly and intimately involved in commenting on decisions and problems.

It is only in the number of meetings per year that there are significant differences between the farm types. For the number on the boards/committees, and the number of days members devote to their work, there is little difference. The varying profit and net assets levels do not appear to influence the details of the governing boards or committees.

Overall, however, most committees/boards involve few members who meet infrequently, perhaps every three months. Surprisingly, the number of days members devote to their duties is high in some areas. As noted, it is suspected that some boards involve the farmers themselves as well as their spouses and together they regard themselves as spending many days on farm business.

Farmers' knowledge of governance systems and happiness with current system

It may be many farmers have not considered the idea of an advisory committee or formal board, let alone assessed the advantages they might obtain. To check this the respondents were asked to rate their level of knowledge of governance systems and, in addition, their happiness with their current system. Of course this data is subjective and relies on what little, in some cases, knowledge of the area they hold. **Table 5** gives this general data.

Table 5: Beliefs on the governance knowledge levels and farmers' views about their 'happiness' with their current system. Column percentages are given for each degree of belief with 1 being 'total agreement' through to 5 'not true'

Score on 'degree of belief'	Awareness of governance structures	Happiness with current governance system
1	33.6	54.6
2	22.2	26.9
3	23.3	13.4
4	9.3	3.2
5	11.7	1.9
Average	2.43	1.71

It would seem farmers who consider risk and have personal attributes involving conscientiousness, consultation and anxiety, and consider their families and the wider community, are overall more thoughtful over governance issues.

Quite a large number of farmers believe (44%) they are not familiar with the alternative structures, and this probably leads to the last column where farmers (18.5%) are not totally happy with their current system. When these figures are examined for different profit levels and net assets there are only minor differences, which are statistically non-significant.

In the interests of improving awareness, and understanding better the factors leading to the farmers' 'happiness' with their current system, the data was further analysed. The farmers' score for each of these variables was correlated with a range of other variables:

For happiness, the analysis showed that net assets per person, the farmer's conscientiousness and anxiety levels, and their tendency to consult with family and friends all had significant correlations. Components of a farmer's objectives were also correlated with 'happiness'. Those farmers expressing a strong interest in supporting their family, and who had objectives covering a balanced view of most aspects of farming (profit, leisure, way of life, environment), tended to be more content with their governance system. However, it was clear that other unrecorded variables were also likely to be important.

For 'awareness', the variables best correlated with the measure were a farmer's age, education level, profit per person, physical efficiency, conscientiousness, anxiety, family and friend consultations, consultation with the wider community, and being a risk averter as well as being a family and community supporter.

It would seem farmers who consider risk and have personal attributes involving conscientiousness, consultation and anxiety, and consider their families and the wider community, are overall more thoughtful over governance issues. In addition, net assets and profit levels (as expected) are also important. A farmer's age and education also influence awareness – there is no surprise in this.

Assistance used in setting up and running governance and succession systems

Given the general lack of boards and committees, it is interesting to consider where farmers obtain their succession and governance information. **Tables 6** and **7** contain data helping to explain where the farmers turn. Farm consultants will be particularly interested in this information. Of course, it is not entirely clear what the farmers believe constitutes 'succession and governance plans'. Also note that data is provided for 'farm advice' contributions.

Table 6: Average hours of various advisor types' involvement in succession/governance and farm advice

Type of advisor	Average hours p.a. spent on succession/governance	Average hours p.a. spent on farm advice
Farm consultant	7.01	20.74
Accountant	4.94	5.68
Lawyer	3.60	2.95
Business consultant	4.13	7.64
Banker	3.40	8.75
Company representative	7.40 (n=5)*	13.56 (n=16)*
Trusted person (e.g. relative)	31.95 (n=20)*	50.59 (n=27)*

*The starred figures are the number of farmers answering the question and are presented where the numbers were low

Farm consultants are clearly important contributors relative to the other categories, both on succession/governance and farm advice, with the latter of course really standing out. But the 'trusted person' is also very important for a few farmers (note the number of farmers providing the information). Company representatives also feature for a small number of farmers.

Interestingly, **Table 7** shows farm consultants are important to the smaller farmers and, at the other extreme, to the very big. On the other hand, accountants and lawyers seem to feature more for the larger farms, and also surpass the consultant in some cases. For middle-sized farms, the 'trusted person' is very important to some.

Table 7: Use of various advisor types on succession/governance issues according to farms' net asset investment – average hours p.a. used on each type

Asset range $	Farm consultant	Accountant	Lawyer	Business consultant	Banker	Company representative	Trusted person
<5 million	7.46	4.20	2.41	1.23	1.67	11.33	8.17
5-10 million	6.78	4.55	5.19	11.43	4.67	1.50	79.50
10-15 million	5.45	7.60	6.61	1.80	10.00	N/A	26.00
15-20 million	3.50	5.40	3.14	N/A	N/A	N/A	8.00
20-25 million	6.67	23.17	9.33	5.00	N/A	N/A	10.00
>25 million	12.20	12.43	11.43	9.33	0.50	N/A	20.00
F prob	0.998	0.000	0.000	0.051	0.001	0.202	0.189

Note: Where N/A is given it usually means no answer has been provided by the small number of farmers falling into the category or no farmers are in the category. The F probability reflects the significance of the differences. A figure of .000 represents total significance whereas '.999' reflects zero difference, such as in the first column

Concluding comments

At this stage in the development of formal farm governance and advisory committees, neither are at all prominent in the life of the New Zealand farm. This no doubt partly stems from a lack of knowledge of what might be possible, but the data also suggests that many farmers (rightly or wrongly) do not believe committees/boards can contribute to the success of their farm.

For professionals who believe some form of board or committee can help over and above the other professionals involved, two things are required. One is to help provide farmers with a better understanding of what the formal groups might contribute, but just as importantly, obtain information on the monetary benefits such formal groups will provide relative to the costs. Farmers are always interested in improving their net profit and nothing persuades them more than the monetary facts. Of course, some farmers will find the confidence provided by a board or committee also of value, as they do for many consultants. Sharing the risk can be worthwhile.

When the data on profit was analysed, there were no obvious differences between farms with advisory committees/boards and the rest of the respondents. As the farms were of all types, locations and sizes, the only way to have a reasonable comparison was to compare profit per labour unit where the manager was included as a labour unit. For the farms with boards/committees the profit per person was $47,443, whereas for all other farms it was $49,930, but the difference was not significantly different. However, we do not know what would have happened if the farms with a board/committee did not in fact have one.

The data was also used to measure the managerial ability of the managers as a percentage figure using a predictive equation from past research on managerial ability. Farms with boards/committees had a 61.1% rating compared with 60.5% for all other farmers – the difference is again non-significant.

At this stage in the development of formal farm governance and advisory committees, neither are at all prominent in the life of the New Zealand farm.

Thus the currently available data on profit and ability does not show up obvious differences, although it must be recognised the numbers with boards/committees is not yet great – 75 in this study out of 805 respondents. The advantages other than profit are not documented. It was clear farms with boards/committees had lower net assets per person ($1.8844 million) than other farms ($2.2382 million). However, one thing is very sure. Farms with boards/committees reported they spent, on average, $5,559 per annum on advice. The remainder spent $820 per annum. As you would imagine, this difference was highly significant.

However, there is nothing more certain than that farms will become larger over the years and be more complex. As this occurs many will push for formal boards and advisory committees, but in so doing the costs and benefits should be clearly researched, and similarly the legal and moral responsibilities involved.

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Hamish Fraser

Hamish Fraser has just finished four months working as a farm management consultant for Macfarlane Rural Business, servicing the South Canterbury and North Otago regions. This profile looks back at how he came to consultancy as a career choice, and how he has managed to blend this with his involvement in his family's expanding farm business.

Early career choices

Hamish grew up on his family's farm in the Hunter Hills south of Timaru, which is where his passion for agriculture was born. He attended Timaru Boys' High School and a significant amount of time was spent on the sports fields. This culminated in a successful rugby career both at school and at regional level, and is where he got his first taste of leadership. While at school he still spent most of the summer holidays in the deer shed, velveting stags or deer fencing, as the numbers on the farm increased.

At school it was perceived that a career in agriculture was only an option for those who did not achieve academically, and this resulted in career advisors and teachers encouraging Hamish to pursue other paths. His parents were very supportive of his choice of a civil engineering degree at Canterbury University, especially as his father (like many in his generation) regretted not having the opportunity for further education when he left school.

Very quickly into his first year Hamish realised that engineering was not what he was passionate about, so he went back home to milk cows for a neighbouring property – his first dairying experience. This resulted in much discussion with his father, further convincing him that the family had a big opportunity to convert part of the farm to dairy.

Lincoln University

This also convinced Hamish that extra education in agriculture was not only an exciting prospect but where his true passion lay. He soon changed direction, beginning an agricultural science degree. His first focus was on production systems – plants, animals and soils – as these were the aspects he was familiar with given his experiences growing up. However, it was the farm management courses that he enjoyed the most and they broadened his perspective of what farming was all about.

Although his degree was science-based it was heavily focused on the management disciplines. In his final year he completed an honours project on understanding stakeholder perceptions of the velvet supply chain and what the convergent and divergent issues were.

Throughout university Hamish also spent time back at home, playing an active role in the family's first dairy conversion and then its subsequent management.

Rural finance

While he enjoyed university, Hamish didn't know where he wanted to specifically end up. His mother continually encouraged him to consider a job in rural finance, which he was adamant he did not want to do as it held no interest. As it turns out, mothers really do know best. Towards the end of his final year, and with no other opportunities in the pipeline, he decided to apply for a banking role with the National Bank in their graduate programme. He spent time talking to many other recent participants and seeing the confidence, amount of responsibility and progress they were making, he decided it was a very good opportunity.

Hamish was fortunate enough to be offered a job with the National Bank, training in an experienced team in Christchurch, before being ready after five months for his own clients in Hamilton. After spending 12 months in the North Island, which helped to increase his understanding of the differences between North and South Island farm systems, he was ready to go back closer to the family business.

He settled back into life in South Canterbury and spent much of his work time in North Otago. Hamish found this job to be very rewarding, getting to understand at a deeper level what makes successful businesses operate and taking the best parts of all of those he worked with and integrating the ideas back into his own family's business. More importantly, he learnt what to avoid or not do.

The best part of the job, and the unexpected benefit, was the relationships. Hamish gained great satisfaction in seeing his clients progress and in helping the next generation to be involved in their family businesses. He also valued getting to personally know so many people. The best skills he believes he developed in this role were relationship skills, but also networking in these rural communities.

Life as a consultant

As time progressed, Hamish was becoming more involved in the family business and trying to juggle a full-time job meant that it was time for a change. Everyone expected that the logical next step was to head back full-time to this business, but he had other plans. He wanted to have more structured involvement in it, but also still get the benefits of working outside the farm gate, growing his networks, and working with farmers which was his passion.

This challenge was discussed in-depth with his mentor, Andy Macfarlane. The natural fit was to work as a farm consultant, treating the family business as his largest client, so he could get the best of both worlds. Hamish wanted to continue to develop his skills in the pastoral sector, advising to family businesses in the sheep, beef, deer and dairy sectors. He saw there were huge opportunities for him locally to add value and continue to help clients achieve their goals.

Family business

Over the past 10 years Hamish's parents have significantly grown the family business to its current point where they are:

- Milking 1,650 cows and control their own dairy support
- Farming 2,000 red deer focused on velvet and trophy production
- Running an international hunting tourism business at home and in Central Otago
- Involved in an equity partnership milking of a further 700 cows
- Developing an agricultural helicopter contracting business, the most recent venture.

Hamish's current major input is ensuring there are the structures, disciplines and people within the business to support this growth. This has led to him being employed as a part-time CEO, officially reporting to the board which has an independent director. In this role he ensures the business has the right people doing the right things, the farms are operating the most efficient farm programme, and the right targets are being set and achieved.

He also acts as the CFO for the equity partnership, taking full accountability for driving profit in the business. Where required, he provides management support to his brother, Duncan, who runs the hunting business and helps with sales. This is another fortunate position as it takes him around the world marketing and exposes him to a very wide range of people and experiences. His most recent role is that of GM for the latest start-up company, the helicopter business, which has been set up with another family, the Cox's. Sam Cox is the main pilot and driving force behind this business.

All family members play a crucial role in the business. Duncan, the younger brother, runs the hunting business. Cameron, the older brother, who works as an agricultural accountant for BDO in Christchurch, also plays a crucial role – putting his expertise to use. Hamish's parents are still the main driving force behind the business, but are gradually ceding responsibility as the boys want to step up.

Although it keeps him very busy Hamish loves his roles in the family business due to the range of jobs he undertakes, the skills it allows him to develop, and the rewarding experiences he has. The best part for him is working with his parents and two brothers, seeing the progress that everyone is making, and the fun that is had along the way.

Work-life balance

Being so busy, Hamish's biggest challenge is getting a work-life balance. Outside of work, when time allows, he enjoys hunting and getting his hands dirty on the farm. He lives with his fiancée, Fiona, on her family's sheep and beef farm which is a short distance from the home farm. After a successful career with Heinz Watties in Christchurch she moved down to South Canterbury. She is now working in the hunting business and has enjoyed getting out of the city and back to the country. Without the support she provides at home Hamish would not be able to fit in everything he does.

Career development and leadership

Hamish wants to contribute to the future leadership of the primary sector. He enjoys the challenges that come with leadership – of getting the best out of people, problem solving and identifying opportunities. This led him to become a Kellogg Rural Scholarship holder in 2013 as the next step in his career development. In time, he feels it could lead to completing a Nuffield Scholarship.

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