

Pathways ahead for New Zealand hill country farming

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Abstract

This paper provides a stocktake of the status of hill country farming in New Zealand and addresses the challenges which will determine its future state and performance. It arises out of the Hill Country Symposium, held in Rotorua, New Zealand, 12-13 April 2016. This paper surveys people, policy, business and change, farming systems for hill country, soil nutrients and the environment, plants for hill country, animals, animal feeding and productivity, and strategies for achieving sustainable outcomes in the hill country. This paper concludes by identifying approaches to: support current and future hill country farmers and service providers, to effectively and efficiently deal with change; link hill farming businesses to effective value chains and new markets to achieve sufficient and stable profitability; reward farmers for the careful management of natural resources on their farm; ensure that new technologies which improve the efficient use of input resources are developed; and strategies to achieve vibrant rural communities which strengthen hill country farming businesses and their service providers.

Keywords: farming systems, hill country, people, policy, productivity, profitability, sustainability

Introduction

This paper provides a stocktake of the current status of hill country farming in New Zealand. It identifies the current body of knowledge pertaining to hill country farming, and gaps that are evident before considering the implications for farming, research and agricultural policy. The study is motivated by the importance of hill country farming to both regional economies and the New Zealand economy as a whole. By the mid-1970s hill country farming had established itself as a highly successful land use with a dominant share of the nation's flocks and herds of more than 50 million sheep and 5 million beef cattle (Statistics New Zealand 2016). However, in the last 40 years there has been major changes in hill country farming. Despite reductions in numbers of farms and livestock in the hill country it remains the nursery of the New Zealand meat industry with large productivity gains achieved and as a result the hill country retains national significance, particularly because of its contribution to New Zealand export receipts. Hence, this paper was motivated by the

need to understand the current situation and inform the future, to identify the constraints and opportunities and provide guidance regarding actions that will facilitate achieving a preferred future (Kerr 2016).

Hill country farming occurs in the context of other hill country land uses, other agricultural and business activities throughout New Zealand, regional and national government policies and the global market for food and fibre. At the regional and national levels this signals that future success depends on engagement with local and national communities of interest and cannot be achieved by a farming/science partnership isolated from the wider society. At the international level this highlights the importance of global consumers, growing competition from cost effective producers in other nations, and the evolution of international commerce and international trade laws and policies. The potential gains from reduced tariffs in foreign markets are large (Saunders *et al.* 2016). However, New Zealand's ambivalence about the benefits from trade agreements is not helpful in securing these opportunities (Harrison 2016).

The domestic environment is not just markets and politics. It is important to consider landowners. Individual family farms dominate the hill country but the enduring nature and large numbers of Māori farms is important. Although Māori farms may still be considered a sleeping giant (Cottrell 2016), he also provides evidence that there is a proportion of high performing Māori farms, and the potential for many more, to achieve high levels of performance.

Another aspect of the domestic environment which is critical is science and the science community. Science which addressed the whole FACE of farming – the farmer, the animal, the consumer and the environment is critical (Fennessy *et al.* 2016). Further, it is when science and farmers make meaningful connections that innovation occurs. Hence, it was proposed that innovations need to be both simple to understand and to implement (Fennessy *et al.* 2016)

The paper consists of six sections: 1. People, policy, business and change; 2. Farm systems for hill country; 3. Soil nutrients and the environment; 4. Plants for hill country; 5. Animals, animal feeding and productivity; and 6. Concluding with consideration of strategies to achieve vibrant rural communities which strengthen hill country farming businesses and their service providers.

People, policy, business and change

Hill country farming is an activity pursued by people engaging with markets and policies via personal interactions with other people. Hill country families and households live both in isolation and in a community. Sustaining social capital is essential to sustain farming and the rural economy. This is an important foundation for the diverse motivations and behaviour of hill country people. However, there are some common characteristics evident among high performing farmers. There is more than profitability that drives them. They have a strong farm team and they have a deep connection to the land. They focus on doing the basics well, run efficient, simple, systems and take calculated risks (Elliott & Wakelin 2016).

Achieving hill country farming goals including enhanced productivity is facilitated by changed understanding and behaviour. Public and private initiatives to enhance hill country farm performance have traditionally involved extension programmes. Successful extension programmes foster an effective learning community where facilitators build relationships based on mutual trust and respect (Gray *et al.* 2016). These authors also highlight the importance of reinforcement of messages and the need to help farmers become evidence-based inquirers into their own practices. It is important that attention is paid to understanding both attitudes and behaviours of the people involved, and the complexity of the farming system (Rhodes *et al.* 2016). Rhodes *et al.* also highlight the importance of both recognising expectations and anticipating the potential for unintended outcomes. Hence, effective design of extension programmes is critical. This requires identification of characteristics of issues and technologies, clarifying the roles of participants, and the adequate resourcing of extension projects (Payne *et al.* 2016).

Given these ambitions, questions remain about the effectiveness of current practice. The concept of "Advance Parties" is one popular approach and is being utilised in the deer industry encouraging adoption of new practices to improve profit from deer farming (Moffat 2016). This is consistent with the long argued thesis that extension services should focus on early adopters. It also highlights the importance of leadership, an open and trusting environment and some information for action. An alternative approach to extension is that of focusing on social media or at least utilising social media as part of a more traditional programme. This provides the opportunity to create alternative communities of interest, and one to one extension experiences via a range of platforms (Casey *et al.* 2016). These authors also argue that effectiveness with social media requires shifting resources to providing content and maintaining reliance and credibility.

Farm performance and farm behaviour is strongly influenced by Government policies. These policies both evolve through time and vary in their effectiveness. Given the potential for policies to have unintended consequences there is a strong case for farmers to be engaged in policy development (Crofoot 2016). Similarly, there is a role for scientists in policy development. A common focus of considerable policy conversation is that of regulation. It is important that when considering regulation policymakers consider alternative policy instrument before selecting what is perceived to be the optimal approach (Weimer & Viner 2005). Policies and regulations can focus on the required outcomes or the required method to achieve the desired outcomes. The alternative approaches pursued by different Regional Councils suggests there is not yet an agreed approach. Similarly, with regard to climate change policy there is no evidence that policy is in a steady state, and there is opportunity for farmers, scientists and policy analysts to do further work to clarify effective, efficient and sustainable climate change policies that are applicable in the hill country. Maintaining the social licence to operate is a bigger issue than maintaining freedom to farm livestock and utilise fertiliser. Policies need to address bigger issues such as gene editing and other technologies that have the potential to be part of solutions to current problems.

Hill country farm products are in large measure exported to distant markets. Hence, the future depends on constructive engagement with international consumers. Historically, spot trading has characterised many farmer business relationships. However, there is emerging evidence that the future lies in aligned transparent partnerships with other farmers, processors and customers, where there is a focus on delivering to specific targeted customers with verifiable claims of authenticity (McDermott & Scrimgeour 2016). This requires attention to improved contracting and logistics supported by accurate, relevant and timely information flows.

Farm systems for hill country

Hill country farming can be considered from a farm systems perspective. During recent decades farming system research has evolved with increased understanding of biophysical processes and social drivers of systems behaviour (Stevens *et al.* 2016). Farm systems research has sought to both enhance system understanding and explore potential solutions for contemporary and anticipated opportunities and problems. Stevens *et al.* documents more than 230 papers pertaining to farm systems in the New Zealand hill country and categorises them into purpose related groups. They note the many challenges that remain and provide an illustrative list pertaining to resource

use optimisation, climate change issues, ecosystems servicing, land use competition, farm business structure and financing, and the sustainability of communities.

Farm systems research not only informs system design and farm management practice, it provides a framework for guiding monitoring performance and facilitating benchmarking and productivity analyses. Numerous software developments have emerged that can be utilised to this end. One example of this is StockCARE, a programme built on monitoring and benchmarking but with attention to data collection, interpretation and utilisation of information related to the key production system (Mulvaney & MacColl 2016). A challenge for many farmers, advisers, analysts and scientists is the range of software applications in existence and how they do and do not fit together. Progress in this domain has been enhanced by the advent of cloud-based software that facilitates recording, analysing and reporting information about farm practice. When the software is based on an integrated value chain approach it provides for accurate feedback on the impact of farm decisions on product quality (Isaacs & White 2016). Isaacs & White also argue that integration with other farm planning and financial software provides a single entry farm information system.

Monitoring of farm systems is crucial for informing real time operational decisions and for evaluating performance over time. Accurate and efficient monitoring of pasture production is important for pasture management and optimising production and consumption throughout the year. Manual measurement of biomass in remote hill environments is expensive and difficult to estimate given spatio-temporal variability (Phillips *et al.* 2016). Yet as Phillips *et al.* have reported, this need not be a binding constraint given the development of models within a topographic framework that can utilise electronic, spectral and field data to accurately estimate hill country biomass.

The evolution of working farm systems is critical if industry participants are to understand the appropriateness and relevance of new opportunities. For example, a rigorous intensification programme at Lorne Peak Station in Southland has seen diversification of pasture species, the inclusion of lucerne and fodder beet in the farming system and increased profitability (Taylor *et al.* 2016).

Farm systems research in the hill country has focused on livestock operations. However, the emergence of honey production from Manuka plantations has shown that there are alternatives to livestock farming in the hill country beyond planting trees for lumber and letting land revert to natural vegetation. Millner *et al.* (2016) provide evidence that plantation Manuka from selected varieties produce high levels of normalised nectar dihydroxyacetone (DHA), and can increase economic

returns from some hill country that is marginal for livestock production. They also report that basal stem measurements provide an accurate assessment of carbon sequestration.

Future farming systems research will be an amalgam of techniques and disciplines to create robust solutions (Stevens *et al.* 2016). The conceptual framework for farm systems research is now well established. The software capacity to facilitate farm systems research has advanced considerably but it is not fully utilised. The challenge is to identify the most important questions to answer using these approaches and to have sufficient people and resources to address the questions. It is critical, however, that the profession does not let the biophysical and technological analyses become disconnected from the economic and financial challenges.

Soils, nutrients and the environment

Successful hill country farming depends on effective soil management to grow pasture and fodder crops for utilisation by livestock. Effective management is also crucial so that the natural capital of soil and nutrients is not lost through erosion or other transfer processes. Minimisation of losses and transfer is appropriate to sustain the quality of receiving environments, especially water bodies. Effective soil and nutrient management starts with appropriate land use. However, this needs to be complemented by effective pasture and livestock management complemented by appropriate lime and fertiliser regimes.

A combination of land use capability (LUC) mapping and the development of farm plans are key elements in sustaining the productivity of New Zealand's hill country (Cameron 2016). Although the LUC system is well established, Cameron notes that national LRI and LUC mapping is at a level where it is too generalised for farm level planning and analyses.

Given an understanding of an individual property, management of soil fertility and structure requires careful attention to pasture species, stocking rates and grazing practices. This requires consideration of the biophysical characteristics of different components of the farm: soil type, slope, aspect, altitude etc.; consideration of the farm infrastructure – subdivision and provision of water etc.; and consideration of the farm management/labour capacity to manage pasture and livestock. Edmeades *et al.* (2016) argue that when developing a fertiliser plan it is appropriate to divide a farm into blocks based on their actual, planned or potential productivity, while taking account of the relevant soil group.

The application of lime and nutrients via a fertiliser regime is key to sustainable hill country farm systems in New Zealand. In the last decade, major reviews have

been published on the phosphorous (P), potassium (K), and sulphur (S) nutrient requirements of clover-based pastures in New Zealand (Edmeades *et al.* 2016). These authors report that when these targets are compared with the measured fertility of a wide range of farms it appears there is considerable room to improve productivity by enhancing soil fertility levels.

Where appropriate regimes are maintained, fertility and productivity is sustained as demonstrated by Mackay & Costall (2016). However, it is interesting to note that this study reports that land receiving 375 kg/ha of superphosphate since 1980 did not see an increase in Olsen P levels between 2003 and 2014. Field sites with well documented long-term and diverse management histories provide invaluable insights and checks on the understanding of hill country pastoral ecosystems.

Soil acidity is a challenge in many hill country environments and it has long been known that this and the associated aluminium (Al) toxicity severely limits the establishment and growth of legumes in New Zealand high country pastures. Research has indicated that Al toxicity extends across many soil orders and climatic zones in New Zealand with Brown soils showing the highest Al concentrations, while Al levels were much lower in the volcanic soils (Whitley *et al.* 2016). Economic analysis undertaken by agKnowledge suggests it is always economic when ground spreading lime on clover-based pastures to increase the pH to the biologically optimal range of 5.8 to 6.0, but with the extra costs of aerial topdressing the optimal target is a pH of about 5.5 to 5.6 (Edmeades *et al.* 2016).

Application of fertiliser by air to hill country in a long established practice in New Zealand. However, the recent application of differential rate application technology (DRAT) which uses Global Positioning Technology (GPS) has greatly improved precision but there is still the potential for further increases in precision (Chok *et al.* 2016). This advancing technology facilitates the application of fertiliser at varying rates according to the slope and the application of nitrogen and lime at variable rates according to slope (Morton *et al.* 2016). The use of this technology enhances the economic benefit from fertiliser application and reduces the risk of adverse environmental outcomes from fertiliser application.

The advent of policy concerns about greenhouse gas emissions has provided impetus for greater consideration of the potential to store carbon in soils. Wide spaced trees on pastoral land are a common feature of many landscapes. Trees such as poplar and alder offer the potential for considerable carbon storage as part of pasture-tree systems. However, evidence to date on the influence of the trees on soil carbon stocks is mixed, varying with sites, spacing and species, suggesting further research is necessary to gain a

better inventory of soil carbon knowledge and a better understanding of the carbon storage processes (Douglas *et al.* 2016).

Soil erosion has long been recognised as an important problem in large areas of New Zealand hill country. Various erosion-reducing practices have been adopted that reduce the risk and prevalence of erosion. For instance, in some situations hundreds of dams have been built to stop runoff which amongst other things, protects tracks and fence lines (Ford & Ford 2016). Two recent scientific advances have examined the recovery processes after erosion events and erosion associated with grazing fodder crops on hill slopes. Research at Whatawhata Research Station in the Waikato, identified four geomorphic zones within landslides and soil recovery varied more between zones than between landslides of different ages (Noyes *et al.* 2016). They also reported the least recovered shear zones comprised less than 25% of the landslide area. The increased growing of fodder crops on slopes has increased sensitivity to the potential for erosion associated with poor grazing practices. Research has shown that cattle treading during winter forage grazing causes rapid downslope movement of soil with redistribution of soil with erosion on the convex sites and accumulation on convex slopes (Penny *et al.* 2016). They also report over half the erosion on convex sites exceeded soil production rates and will reduce topsoil thickness.

As mentioned previously, farm management decisions impact the ongoing productivity of soil but also levels of contaminant losses. Pastoral hill landscapes do show increased losses of sediments, nutrients and faecal coliforms to waterways and elevated water temperatures relative to forested landscapes (Dodd *et al.* 2016). These authors also note low-altitude steepplands have high spatial and temporal variation in the delivery of contaminants to receiving environments due to vegetation structure, animal behaviour, and climatic factors – all driven by topographic diversity. Effective mitigations across various scales do exist but Dodd *et al.* argue future research attention should focus on nitrogen and faecal dynamics, long term effectiveness of mitigations and the improvement of integrated tools to clarify trade-offs and synergies.

Plants for hill country

Livestock production in the hill country is based on animal nutrition derived from pastures and other forages grown in the hill country, with minimal amounts of supplementation bought in from outside regions predominantly associated with adverse weather events. Pasture and forage productivity and the effective utilisation of the biomass produced is critical. Given the challenges and costs of pasture establishment, pastures remain in place for long

periods. Effective pasture establishment lays a foundation for persistence. This is challenging with steep non-cultivable country and hence oversowing is the usual response. Optimising the amount and density of resident vegetation at oversowing and selecting a seed mix tailored to site specific conditions leads to improved outcomes (Tozer & Douglas 2016). Pasture establishment is sensitive to the weather conditions at the time of this activity and seedling establishment and survival rates can be low. Management strategies, such as changing the microclimate through increased litter enhance establishment and survival rates dramatically. This is as a result of reduced soil temperature, with more water being retained in the top soil (Tozer *et al.* 2016). Microsite effects are potentially important due to the variance in site characteristics. However, recent work in Hawkes Bay and North Canterbury indicated that slope and associated environmental factors were not significant factors influencing persistence of sown species (Douglas *et al.* 2016).

The costs and risks associated with pasture establishment are high hence it is important to get the basics of fencing, stock water and fertiliser in place before engaging in a pasture renewal programme, especially one associated with new forage varieties (Fraser *et al.* 2016). Further, there are alternatives to oversowing in some situations. Hill country cropping can be pursued both to produce additional fodder such as a high-yielding brassica crop, and be part of a pasture renewal programme. Crops can be successfully grown on non-tractor hill country following practices similar to no tillage flat land operations but using aerial application of materials (Lane *et al.* 2016). An interesting observation from this work was the need to invest in slug control to reduce crop damage.

A crucial challenge is determining which legume and grass species should be grown in the hill country. In responding, it is important to note the changes in farm systems and practices in the last three decades. Cosgrove & Field (2016) note the periods of sub-maintenance P and S fertiliser usage, increased use of N fertiliser, reductions in stocking rates increases in numbers and weights of lambs weaned per ewe, and confinement of sheep and beef to hill country as dairying expanded onto finishing land. Some success is being achieved with the perennial herbs chicory (*Chicorium intybus*) and plantain (*Plantago lanceolata*), though these authors point out that weed challenges are pervasive. There is potential for the development of new cultivars for hill country given the germplasm available. Nichols *et al.* (2016) argue that new approaches to breeding offer the potential to increase genetic variation for and selection of traits of interest, though they warn commercial realities are a major factor determining availability of appropriate cultivars. They emphasise

making better use of the genetic variation in the Margot Forde Forage Germplasm Centre, making more use of interspecific hybrid populations, more targeted selection for specific traits and the application of genomic breeding methods. A complementary approach is to search internationally for potential species. Such a search in Tasmania identified a number of species with superior drought tolerance and persistence relative to the traditional varieties (Hall *et al.* 2016). This resulted in the commercial release of four grasses and five legumes in that State. Legume choice requires careful consideration given the spread of clover root weevil and increased capability to manage hill country according to slope and aspect. There is much diversity among subterranean clover and *Biserrula* species. Molecular markers may help in the selection of soft-seeded subterranean clovers (Ghamkhar *et al.* 2016). These authors argue for screening of subterranean species for a balance between persistence and seed harvest. They also argue *Biserrula* is a new candidate for summer-dry hill country.

The quality of grazing management determines the performance of the species that are established. Improving grazing management requires an understanding of pasture responses to defoliation and how to achieve both quality and quantity in farm forage supply (King *et al.* 2016). These authors implicitly argue that the interaction between pasture management and animal performance will be driven by farmer decisions focused on the marginal costs and marginal benefits of achieving an ideal pasture. Pasture quality is maximised when sufficient grazing pressure is applied to maintain pasture covers at a level where the grass inflorescence presence is limited, but there are an array of factors that limit farmers ability to achieve this, not least the weather. The decisions of farmers throughout the country results in a slowly evolving botanical composition of New Zealand hill country pastures. Three national surveys have provided important information in the past and there is opportunity in future to pursue a mixed approach of both fixed sites (research sites) and farms surveys to understand responses to management changes and identify future input requirements (Cosgrove & Field 2016).

Animals, animal feeding and productivity

Livestock farming systems dominate New Zealand hill country mainly running sheep and beef cattle but there are also important populations of deer, dairy heifers and wintered dairy cows. Livestock farming practices have evolved considerably over the last 3 decades with implementation of pregnancy scanning, body condition scoring, improved lamb survival, the feeding of triplet bearing ewes pre-lambing to enhance survival, use of terminal sires and cross-breeding, and breeding

at younger ages amongst other initiatives (Morris & Hickson 2016). Not surprisingly, productivity has improved considerably, but further opportunities abound.

Opportunities for improved feeding regimes derive from recognition that: interactions between genetics, nutrition, physiological state and the environment are drivers of performance; nutrition in early life can influence life time performance; and the opportunity to focus on individual animal needs rather than flock or herd averages (McCoard *et al.* 2016). These authors also note that pastures and fodder crops provide variable supply of many nutrients and there is opportunity to use advanced nutritional complexes to maximise rumen microbial and physiological efficiency. Likewise, there are opportunities associated with amino acid supplementation.

There is clear evidence of production gains from improved feeding of ewes both from scientific studies and from increased performance by the national flock. A major challenge for farmers is to cost effectively generate more feed in winter to utilise the information gained from scanning and other technologies and operationalise more nuanced feeding regimes (Johns *et al.* 2016). These authors argue relevant feeding standards must be used, with an allowance for pasture wastage added to feed allocation; ewe liveweight must be known; feeding of ewes in late pregnancy must be controlled until lambing with feed intake being adjusted regularly; and that there are major gains from reducing summer and autumn feed demands to release feed for winter. They also argue, traditional feed requirements used in the industry are inaccurate, and that most farmers have inaccurate estimates of their ewe liveweights. Reducing the mortality rates amongst high fecundity flocks is critical for both farm productivity and consumer acceptance.

The performance of beef cattle systems is often constrained by the role beef cows play in controlling surplus feed in summer and autumn to maintain food quality for other classes of stock (Morris & Hickson 2016). However, these authors identify ways to increase the efficiency of beef breeding systems including using a smaller maternal cow with a terminal sire, offering faster growth rates superior carcass traits; from calving 2 year old animals and by reducing foetal losses and neonatal calf deaths. Similarly, the potential for dairy cattle genetics being integrated into the beef industry has long been recognised – but with diverse motivations. Given the beef sector's reliance on beef breed sired calves from dairy farms the challenge is to determine if more of these calves can be derived from high quality sires of known merit and earlier calving, as opposed to deriving from late season natural mating with sires of unknown merit. Burggraaf & Lineham

(2016) report research finding dairy beef calves sired by EziCare Hereford bulls were lighter at birth than those from unrecorded bulls and required less calving assistance. They also report they had similar growth rates during rearing and finishing and so the lower birth weight was not a constraint on achieving growth goals. Success in this space suggests use of EziCare semen for artificial insemination of dairy cows has the potential to produce appropriate calves earlier in the season. It should be noted there was variation in the growth rates associated with individual sires.

Beef operations today are much more heterogeneous than the historic breeding farms and finishing operations. Growing many small mobs of bulls on intensive hill operations is one example (Ford & Ford 2016). A contrasting example is the use of cull dairy cows as a flexible tool for pasture control on East Coast hill country (Muir *et al.* 2016), which was shown to be a profitable activity, noting the importance of pregnancy testing animals on arrival and the gradually transitioning the cows to the hill country.

Conclusions

This paper highlights current knowledge and knowledge gaps and opportunities for enhancing farm management practice, scientific research and government policy. The conclusions follow the structure of the paper focusing on people, policy, business and change; farm systems for hill country; soils nutrients and the environment; plants for hill country; and animals, animal feeding and productivity. It identifies approaches to: support current and future hill country farmers and service providers, to effectively and efficiently deal with change; link hill farming businesses to effective value chains and new markets to achieve sufficient and sustained profitability; reward farmers for the careful management of natural resources on their farm; ensure that new technologies which improve the efficient use of input resources are developed; and, implement strategies to achieve vibrant rural communities which strengthen hill country farming businesses and their service providers. These challenges require immediate attention and investment in horizon two and horizon three science that addresses both the emerging opportunities and lays the foundation for the less explicit opportunities (Coley 2009).

The hill country of New Zealand has inherent beauty and character but it is people who sustain its biophysical integrity, derive incomes from it and enjoy it non-monetary values. Hence, individuals, communities, scientists and government institutions seeking to enhance hill country environments and productivity must work with the people who live and work in the hill country and those engaged with hill country farmers and communities. Successful hill country farmers are highly motivated, respond to constraints and incentives

and their commitment sustains greater population densities in the hill country than other land uses such as forestry.

Farm performance is underpinned by existing knowledge and the gaining of new knowledge and its application. The scientific and agribusiness communities have sound knowledge of the principles of modern extension programmes but it is difficult to adequately resource such programmes, and there is limited knowledge about the social characteristics and motivations of non-farming rural populations. The challenge is for extension programmes to more effectively invest in understanding motivations to change (or not to change) and supporting confidence to change. This requires both inclusion (of stakeholders) and deep engagement sustained by effective two-way communication. It must address motivations, goals, strategies and plans associated with forced and voluntary change. This will include mainstream extension methods such as “Advance Parties” and focused and relevant field events with examples of successful change but enhanced with a wider portfolio of tools such as new generation mentoring, the provision of research papers and professional information on a single website and the incorporation of social media components.

Farmer-processor linkages have evolved so that there are a range of relationships possible between farmers and processors. However, these relationships are still dominated by spot market transactions. Farmers need clarity around markets expectations, most clearly seen when they are industry standards. The ability to objectively measure progress against defined standards builds confidence. Consistent approaches to the use of environmental plans pertaining to on farm natural resource management, can be achieved by the alignment of councils and companies. Advances of this type will result in both better farm practice and better farm businesses.

Greater alignment and engagement between farmers and processors requires farmers have good knowledge of their own businesses and choose a partner whose aspirations and systems align. This requires sustained communication between farmers and processors building an appreciation of markets and resulting in product being delivered to specification and on-time. Both parties have to accept risk through contracts that are honoured and as a result building shared values and trust. There are opportunities to document and disseminate case studies of successful value chains and for these to be used in industry education programmes.

Sustaining vibrant rural communities which underpin hill country farming businesses and their service providers requires investment by Government, Local and Regional Government, rural communities

and family farm businesses. Government initiatives to sustain rural education, enhance the delivery of tele-communications and sustain rural infrastructure are critical to sustain hill country farming and associated rural communities. Farmer and bank transition packages to facilitate existing employees to farm ownership assists new generations to invest their lives in hill country farming. The development of employment packages that attract and retain good employees, through good housing, wages and professional development is essential. The results of industry action will be greatly enhanced if Government maintains sustained engagement with the hill country and does not limit its focus to “average” New Zealand farms. This is particularly true for national policies such as those pertaining to climate change, science infrastructure and social investments.

Hill country farms are dynamic systems that are part of wider biophysical and social systems. Ongoing investment in understanding these dynamic systems is essential if there is to be improved decision making pertaining to production and marketing, resource use optimisation, climate change, ecosystems servicing, land use competition, farm business structure and financing, the sustainability of communities and a host of other hill country challenges and new opportunities such as those associated with Manuka honey production. Additional work is also required to achieve the widespread use of management information systems that align with farmer practice and the informational requirements of farm advisers, processors and regulatory agencies. Many opportunities exist to make better use of “the cloud”, new data sources such as those pertaining to topography, and better access to advanced computing capabilities.

The maintenance of soils through farm management and the application of fertilisers sustains pastures growth to underpin livestock production in the hill country. Existing scientific knowledge provides a basis for soil testing and fertiliser advice that has the potential to further enhance hill country production and reduce adverse environmental impacts. Likewise, there is room for further refinement of DRAT technology to enhance the precision of aerial application of fertiliser. Further research is justified not only on the basis of the potential enhancement of productivity but also to improve environmental outcomes. Hence, research is required to address nitrogen and faecal dynamics, long term effectiveness of mitigations and the improvement of integrated tools to clarify trade-offs and synergies. The increased intensity of grazing on some hill country blocks and the additional use of fodder crops on hill country suggest the importance of further research pertaining to livestock induced erosion. Likewise, contemporary policy concern about green-house

gas emissions suggest further research on carbon sequestration.

The successful selection, establishment and maintenance of plants for hill country farm operations provides the foundation for animal feed and production of animal products. The ability to manage properties with greater attention paid to variations in slope, aspect, soil type provides opportunity to better match fertiliser programmes, plant species and grazing management. This suggests further research utilising the genetic variation in the Margot Forde Forage Germplasm Centre, more use of interspecific hybrid populations, more targeted selection for specific traits and the application of genomic breeding methods. Farmers would benefit from improved knowledge about alternative subterranean clover species and the characteristics of *Biserrula*. Given the interaction between plant species and soil status under different fertiliser regimes and farm management there is a strong case for retaining long term networks of sites for biophysical measurements for decades, and hopefully, centuries.

The performance of livestock farming systems in the hill country is hard to determine given the greater variety of systems that exist and the unique biophysical characteristics and management variation associated with each farm. Despite the implementation of new technologies such as pregnancy scanning, many of these technologies are used in less than optimal ways. Research could usefully seek new generation technologies that perform the same task more efficiently and ways to adapt the technologies so they better fit farming practices. The better linkage of farming information systems to planning feed allocation and its implementation is just one of many opportunities to improve practice. There are opportunities for greater attention to enhancing beef cattle genetics, animal health practices and emergent farming systems such as the use of cull dairy cows for pasture control on hill country properties.

Hill country farming continues to play a major role in the New Zealand economy. Productivity in the hills has markedly increased over the last 3 decades but it is important that farm practice, scientific research and government policies address current and emerging challenges so that the hill country can continue to be both an attractive home to rural New Zealanders and a productive and environmentally acceptable contributor to national welfare.

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