PASTORAL INDUSTRY FORAGE DISCUSSION DOCUMENT

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Prepared by James Morrison Consulting Ltd

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We would also like to acknowledge the foresight of the board of Pastoral Genomics, which recognised the need for the discussion document and strategy, but also that the decision to develop one rested with the wider industry. They convened a workshop meeting in October 2015 with participants from 15 different industry organisations and hammered out the agreement to proceed and form the steering group.

Early in this project, the 2016 Hill Country Symposium provided a forum to launch this work with sheep and beef farmers. We would like to thank the NZ Grassland Association, in particular the organising committee, for their advice and hospitality.

Other organisations that generously contributed include: (in no particular order) the Pasture Renewal Charitable Trust, Grasslanz Technology, Agriseeds, PGG Wrightson Seeds, DLF Seeds, Cropmark Seeds, Agricom, Ravensdown, Ballance Agri-Nutrients, the Ministry for Business, Innovation and Employment (MBIE), Lincoln University, Massey University, On-Farm Research, Deer Industry New Zealand, the Bio-Protection Research Centre (BPRC), Federated Farmers, Horizons Regional Council, Hawke’s Bay Regional Council, AgFIRST, Landcare Research, AgCARM, Dow AgroSciences, Farmax and Landcorp.

Finally, we would like to acknowledge the many individuals including farmers, more than a hundred of you, who met both individually and in workshops across the country to contribute their thoughts towards this industry discussion document. Your advice and insights have been invaluable.

We hope this discussion document does justice to the world-leading expertise and achievements of the New Zealand forage sector.

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1.0 BACKGROUND

1.1 The Pastoral Industry Forage Strategy

Vision

The 20-year vision for the pastoral industry forage strategy is to:

Grow the sustainability and profitability of individual farmers and the long-term prosperity of New Zealand by increasing the value of forage grown on New Zealand farms.

In this vision, "value" includes the traits and management policies that contribute to the economic and sustainable performance of pastoral farms. Ideally all traits should be captured in Forage Value[1] type economic indices (tailored for sector needs) but there will be times when foresight on traits is required to inform breeding programmes before these traits have a current economic value.

Objectives

The aims of strategy are:

- Develop five-year action plan in support of the 20-year vision, and
- Recommend the approach that a joint government and industry investment model should take, including the role of processors and the linkages between markets and farmers, to support the outcomes identified in the discussion document.

Establishment

The pastoral industry forage strategy project was established jointly by the Foundation for Arable Research, Beef + Lamb New Zealand, DairyNZ, AgResearch, the New Zealand Plant Breeding and Research Association and the Fertiliser Association of New Zealand, with input from the Ministry for Primary Industries.

1.2 Steering Group Member Organisations

- Foundation for Arable Research (FAR): The applied research and information transfer organisation responsible primarily to New Zealand arable growers.
- Beef + Lamb New Zealand: The farmer-owned industry organisation representing New Zealand's sheep and beef farmers.
- DairyNZ: The farmer-owned industry organisation representing New Zealand's dairy farmers.
- New Zealand Plant Breeding and Research Association (NZPBRA): Represents commercial seed companies as the major developers of plant varieties for New Zealand's arable and pastoral sectors.
- Fertiliser Association of New Zealand: represents member fertiliser companies to address issues of common public good.
- AgResearch: The lead Crown Research Institute for pasture-based animal production systems.
- Ministry for Primary Industries (MPI): The government ministry responsible for the pastoral sector.

[1] The DairyNZ Forage Value Index currently includes ryegrass cultivars and is based on independently calculated Economic Values (EV) and Performance Values (PV) for seasonal dry matter production.

2.0 WHY FORAGE MATTERS

2.1 Economic Significance

Pastoral farming is enormously significant to New Zealand's economy, accounting for over $20 billion in annual exports, which is approximately 75% of all agricultural exports and 45% of all merchandise trade exports. The wider economic contribution from the pastoral sector includes the manufacturing and services industries that are associated with this produce.

Value of Pastoral Exports[2]

Year ended 30 June ($ million FOB)	2011	2012	2013	2014	2015
Meat	$5,553	$5,287	$5,407	$5,798	$6,542
Wool	$717	$776	$678	$733	$805
Dairy	$12,036	$12,455	$12,177	$16,860	$13,170
Other Animal Products	$764	$936	$939	$846	$853
Livestock	$225	$237	$238	$208	$370
TOTAL PASTORAL	**$19,294**	**$19,691**	**$19,439**	**$24,444**	**$21,739**

In New Zealand, pastoral farming involves predominately extensive farm systems where ruminant animals such as cows and sheep graze on pastures and crops, which are broadly referred to as forages. This involves considerable land and capital[3]. Of the estimated 13.3 million hectares of grasslands in New Zealand[4], which includes low fertility grassland and high-country tussock areas, pastoral farming occupies 12 million hectares with more than 38,000 farms. The breakdown of the major farm types is shown in the table below. While other farm types exist, such as goats, those are relatively minor.

Farm Type	Number of Farms	Agricultural Area (000 HA)	Proportion of Area
Dairying	12,150	2,415	20%
Sheep & Beef Farming	25,113[5]	9,328	78%
Deer Farming	1,128	287	2%
All Pastoral Farms	**38,391**	**12,030**	100%

These over-arching figures do not reflect the considerable diversity in the production and value of different pastoral land. Dairy farms tend to occupy highly productive flat or rolling cultivatable land, including some land converted from sheep and beef farming which reflects the dynamic nature of the pastoral industry. The average dairy revenue per hectare in 2014-15 was approximately $7,000. While some sheep and beef farms are also on highly productive land, many are on hill country which is less productive. Although not directly comparable, the average sheep and beef farm generated gross revenues of $756 per hectare in 2014-15. Between the various farm classes this ranged from $3,137 per hectare for South Island mixed finishing farms to an average of $104 per hectare for South Island high country farms.

[2] Compendium of NZ Farm Facts, 2016, Beef + Lamb New Zealand

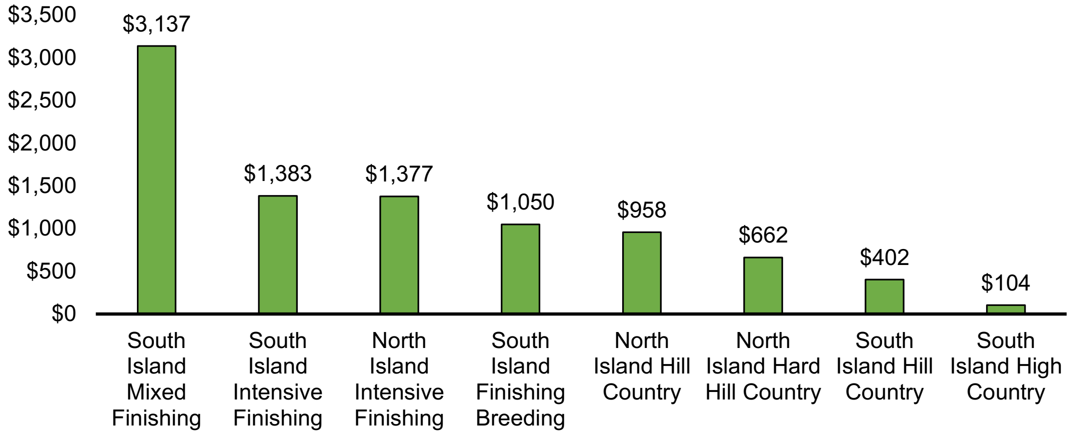
[3] New Zealand pastoral farm systems are still typically less capital intensive compared to other developed nations.

[4] LUCAS NZ land Use Map, MFE

[5] The number of commercial scale sheep and beef farms is estimated at 12,500. Also note these figures are not exclusive as some farms may include a combination of sheep and beef, dairy and/or deer.

Sheep and Beef Farm Performance by Farm Class

Total Gross Revenue per ha, 2014-15



Area (000 ha)	427	759	972	1,753	2,016	1,317	1,346	1,982
Area (%)	4.0%	7.2%	9.2%	16.6%	19.1%	12.5%	12.7%	18.7%

Gross revenue for a given type of farming roughly represents the level of production per unit of land, which is highly dependent on the ability to grow forages and harvest them directly using grazing animals. One of the challenges for farming, and a key challenge in meeting pastoral industry growth aspirations, is to improve this production capacity. Clearly one of the major opportunities lies in increasing the productivity of New Zealand's vast tracts of North and South Island hill country which together comprise 54% of total sheep and beef farm land, excluding high country.

Forages are not the only feed employed in the primary sector. A recent analysis of feeds used in the New Zealand dairy industry[6] estimated that while the national dairy herd has doubled over the last 25 years, the feed demand is now increased by 2.6 times. In the 1991 season, nearly 97% of this feed demand was met through pastures and crops grown and grazed directly on the farm, and primarily supplemented with silage harvested and then fed later. However, in recent years New Zealand dairy farmers have imported nearly 8% of their feed requirements. The sheep, beef and deer industries are far less reliant on imported supplements. Overall, while grazed forages remain the foundation of the pastoral sector, they are not the only source of feed.

Season	Cows Milked (million)	Feed Demand (million t DM[7])	Forages Grazed in situ	Harvested Supplement	Imported Supplement[8]
1990-91	2.40	9.46	96.7%	2.0%	1.3%
2000-01	3.49	15.71	94.2%	3.3%	2.4%
2010-11	4.53	21.06	87.5%	4.9%	7.5%
2014-15	5.02	24.73	85.8%	6.3%	7.9%
25-year Increase	**+109%**	**+161%**			

The next section outlines why grazed forages are the basis of New Zealand's competitive advantage in the pastoral sector, and the implications of this for the forage industry.

[6] Feed Use in the NZ Dairy Industry, DairyNZ Economics Group, June 2016
[7] Tonnes of Dry Matter: this is a common metric referring to the production of forage
[8] "Harvested Supplement" includes maize grain, maize silage, barley, wheat, oats and cereal whole crop silage;
"Imported Supplement" includes PKE, Brewers Grain, Soya Bean, Cotton Seed, Tapioca and some residual imports;

2.2 Global Competitiveness

New Zealand farms are primarily extensive grazed systems, with most animals living outside directly on the pastures where they feed. This contrasts with many international competitors whose farms are more based on feedlots where crops are cut and carried to animals which are housed inside. Each type of farm system is designed for a specific environment, and uses different plant species and different cost structures. Any significant advance in the productivity of foreign farm systems – particularly their ability to produce feed – threatens the relative competitiveness the New Zealand system. This is explored further in the subsequent section on future challenges.

It is also important to consider the intrinsic value of New Zealand's pastoral farming systems and their environmental performance. This value also has some scientific foundation in the nutritional composition of products, such as for grass-fed meat and milk, which provides a sound basis for health claims. Farming system provenance could potentially become central to our competitiveness. i.e. the competitive advantage of New Zealand's grazed farming sector may not rest on being "the best in world", so much as being the "the best for the world".

However, future of agricultural markets and production is uncertain. There is no way of knowing whether the differentiation of products based on the provenance of farming systems will become more important for consumers of New Zealand produce than either sourcing the lowest cost of product, or that which is produced closest to the consumer. The answer may be that more than one factor is necessary to succeed. It is important that the New Zealand farming sector prepare for all eventualities until the right choices become more obvious.

Global Scale and Exposure

New Zealand's pastoral sector is heavily exposed to international markets. New Zealand exports over 95% of dairy, sheep and beef production which compete directly with produce from around the world. This means that the cost of production for New Zealand's farming systems relative to international competitors is a key factor in determining the competitiveness and profitability of the sector. This relative importance of international markets to New Zealand should not be confused with New Zealand being important to the world. While New Zealand's export focus means it is a major participant in the globally traded sector of the market, it is only the 8th largest dairy producer accounting for less than 3% of the 735 billion litres of milk produced globally[9]. New Zealand also only produces 1% of the world's beef and 5% of the world's sheep meat[10,11].

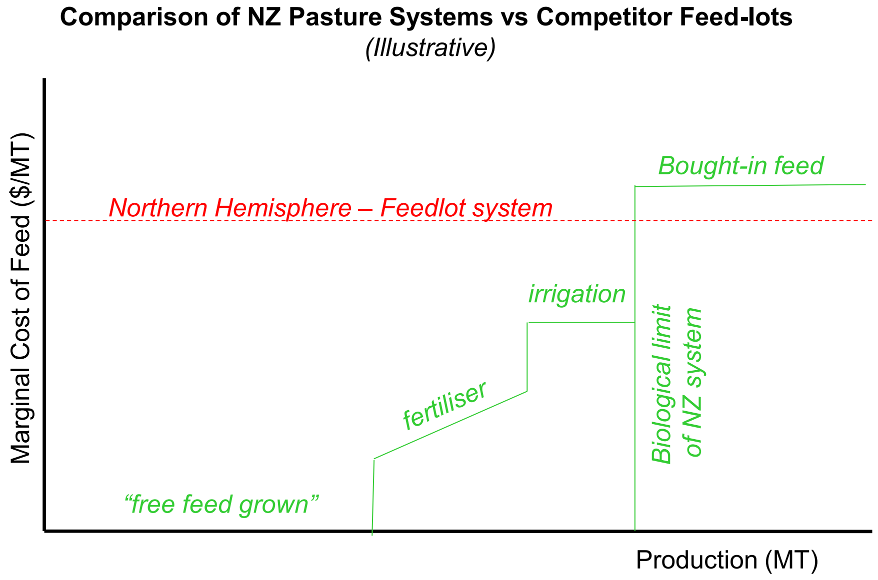
One sector in which New Zealand does have a significant share of global production is pasture seed. New Zealand produces 6.7% of the world's perennial ryegrass seed and 38% of the world's white clover seed[12]. It is also significant in red clover, Italian ryegrass and cocksfoot. New Zealand dominates the internationally traded market in perennial ryegrass and white clover, with pasture seeds accounting for over half of the NZ$200 million export seed trade. The key point in this is that there is no other global supplier that can be reasonably expected to supply New Zealand's requirements for pasture genetics.

Contrast of New Zealand System versus International Competitors

The New Zealand pastoral farming system has two advantages over competitors. The first is the relatively high feed utilisation obtained under well managed grazing, with no intermediary costs and minimal losses between feed production and consumption.

The second competitive advantage of the New Zealand pastoral system is that the direct costs of the first tonnes of pasture grown on-farm are practically nil, requiring only maintenance fertiliser to replace the essential elements used in production. The natural occurrence of sunshine and rainfall, and a temperate climate are key factors. New Zealand farmers boost this feed supply through inputs including nitrogen and phosphate fertiliser, irrigation, cropping, pasture conservation, and bought-in supplements as well as continually seeking to improve grazing techniques. These inputs increase the cost of each additional unit of feed. In contrast, Northern Hemisphere feedlot systems relying on bought-in feed have approximately the same direct costs for the first tonne of feed as for the last tonne. In fact, while the New Zealand system tends to have a higher marginal cost and hence reduced marginal return for each additional unit of feed produced, feedlot systems become more efficient with higher inputs as capital utilisation improves. The different profile for the marginal costs of feed for the two systems are shown below.

[9] Source: Fonterra
[10] Source: Beef + Lamb New Zealand, USDA, AHDB Beef & Lamb (UK)
[11] While New Zealand leads the world in farmed venison, this is not a significant part of our national production and faces unique challenges in market access and acceptance.
[12] Source: National and export trends in herbage seed production, Pyke et al, Grasslands Conference, 2003



The optimal level of production in any system depends on the value which can be obtained for the product (eg milk, meat, fibre or livestock) compared with the marginal cost of feed. The ability of the New Zealand system to adjust to changes in market conditions provides considerable resilience. Ultimately the capital value of the land will also adjust in response to the market. In contrast, feedlot systems have very little short-term flexibility if their imported feed costs rise above the value of the market.

Importance of Feed Costs

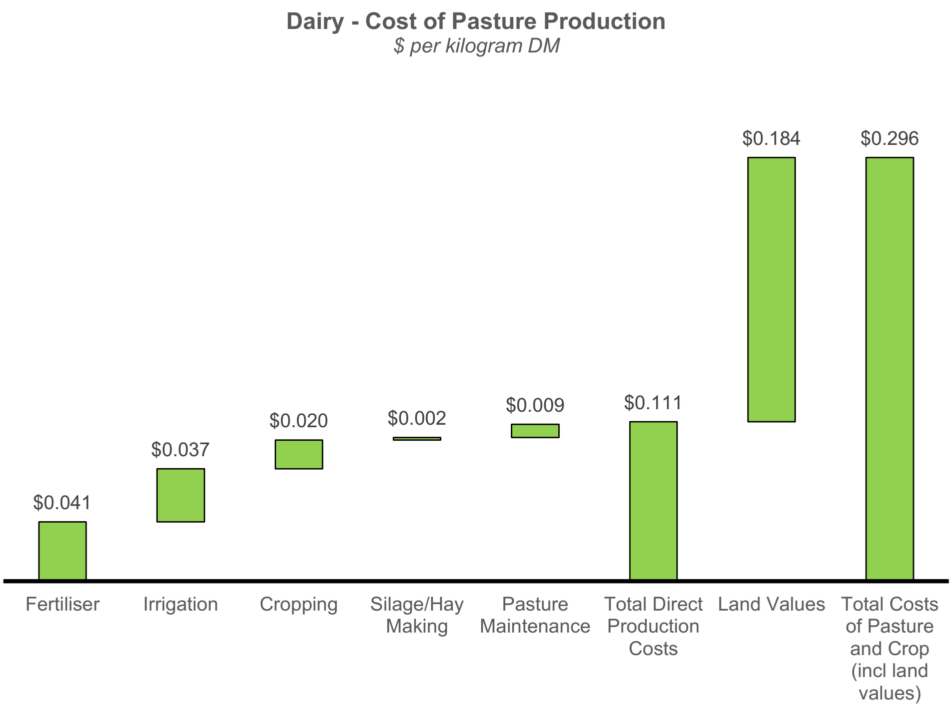
Direct feed related costs comprise 42% of farm expenditure for sheep and beef farming[13] and 50% of direct working expenses for New Zealand dairy farm systems. The clear implication is that managing the cost of producing forages, and the total cost of feed relative to farm revenue, is highly important to the overall performance of the sector.

Expense Type	Dairy	Sheep and Beef
Feed & Grazing	33%	10%
Support Block Lease	2%	0%
Fertiliser	12%	21%
Irrigation	1%	2%
Re-grassing	1%	5%
Weed & Pest Control	1%	5%
Total Direct Feed Costs	**50%**	**42%**

These figures are based on the average cost of feed on New Zealand farms, and include bought-in feeds. As outlined in the previous discussion, they represent the current level of direct expenditure which in turn reflects the market conditions.

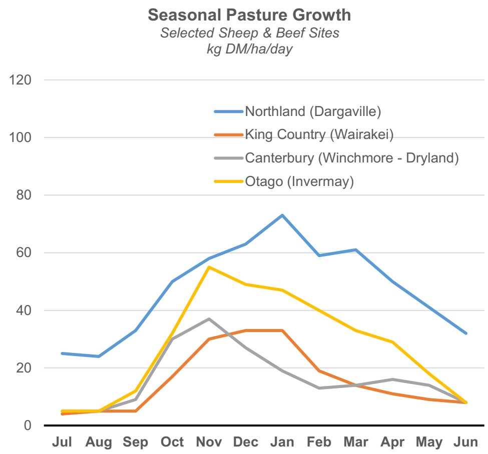
Although every farm system is different, an average cost of pasture production can be constructed to illustrate the key points. This is shown below for an average New Zealand dairy farm[14]. The direct cost of pasture production, excluding land and capital costs, is just 11.1 cents per kilogram of dry matter. Land itself is the most expensive component (albeit a sunk cost for an existing farm), with a cost of 18.4 cents per kilogram of dry matter. However, land values reflect the underlying productivity of the land plus a degree of speculation. In the event New Zealand was to lose its competitive advantage, it is reasonable to assume that land values would tend to adjust accordingly.

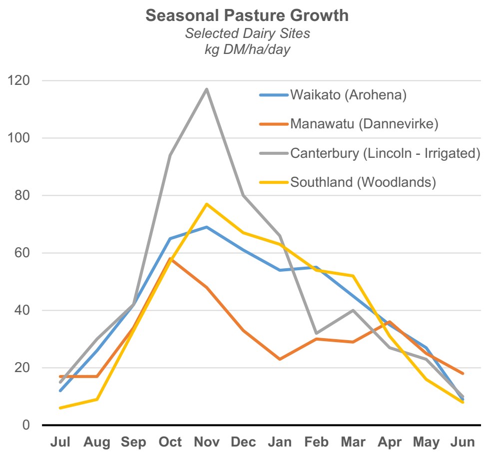
[13] Source: Derived from Compendium of New Zealand Farm Facts, 2016, Beef + Lamb New Zealand, and the DairyNZ Economic Survey 2014-15.
[14] Source: DairyNZ Economics, average land values assumed to be $35,000 per hectare.



Seasonality

An important aspect of the New Zealand farm system is seasonality[15]. Most of New Zealand is classed as having a temperate climate, with the possible exception of Northland, where the climate is more sub-tropical. Forage production generally peaks in the warmth of late spring and early summer, given sufficient moisture[16], and is at its lowest during the colder winter months. Winter growth rates are typically below 20 kilograms of dry matter per hectare (kg DM/ha/day), and potentially as low as five in the coldest areas. Summer growth rates may exceed 60 kg DM/ha/day, especially under irrigation. The figure below shows pasture production across a range of different farms and regions throughout a typical year[17].

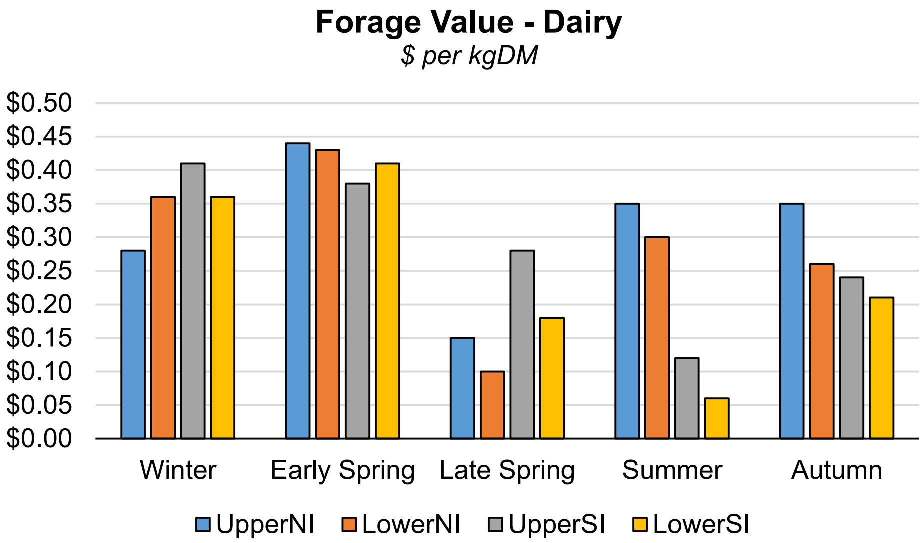




[15] Note: Our Southern hemisphere seasons are counter-cyclical to the Northern hemisphere and thus potentially provides additional opportunities in export markets.
[16] Areas prone to summer dry conditions (generally eastern zones) are the exception to this. The graph also demonstrates the effect of irrigation (Canterbury) increasing spring/summer growth.
[17] Sources: DairyNZ (Feed Budgeting) and Beef + Lamb New Zealand (A guide to feed planning for sheep farmers)

New Zealand's extensive pastoral grazed farm systems are designed to match the animal feed demand to this seasonal feed supply from grown pasture and forage crops. For dairy farms, this means cows are usually calved from July so that the high feed demand associated with milk production (lactation) matches the increasing feed availability and peak in late spring. Likewise, sheep breeding systems have lambing and the consequential feed demand increase coinciding with more feed becoming available as temperatures and sunshine hours increase (mainly through spring, although timing depends on location). Ideally, animals destined for slaughter are finished quickly to the required weight on high quality feed. As the pasture feed supply begins to diminish through autumn dairy cows are progressively dried off and sheep and beef animals are sent for slaughter. It is vital that pastoral farmers manage feed demand and supply as this balance affects both the quantity and quality of forage production. Pastures which are either over-grazed or under-grazed are less productive.

Forage has a different value depending not only on its use, but also on the time of year reflecting whether there is a general surplus or deficit of feed. The DairyNZ Forage Value Index, developed in New Zealand since 2013 to quantify and rank forages in terms of their economic value in dairy farm systems, provides a calculation of forage value by location and season for any given value of milk payout. The following chart provides an example for ryegrass dry matter (DM) based on a payout of $5.53 per kilogram of milksolids[18].



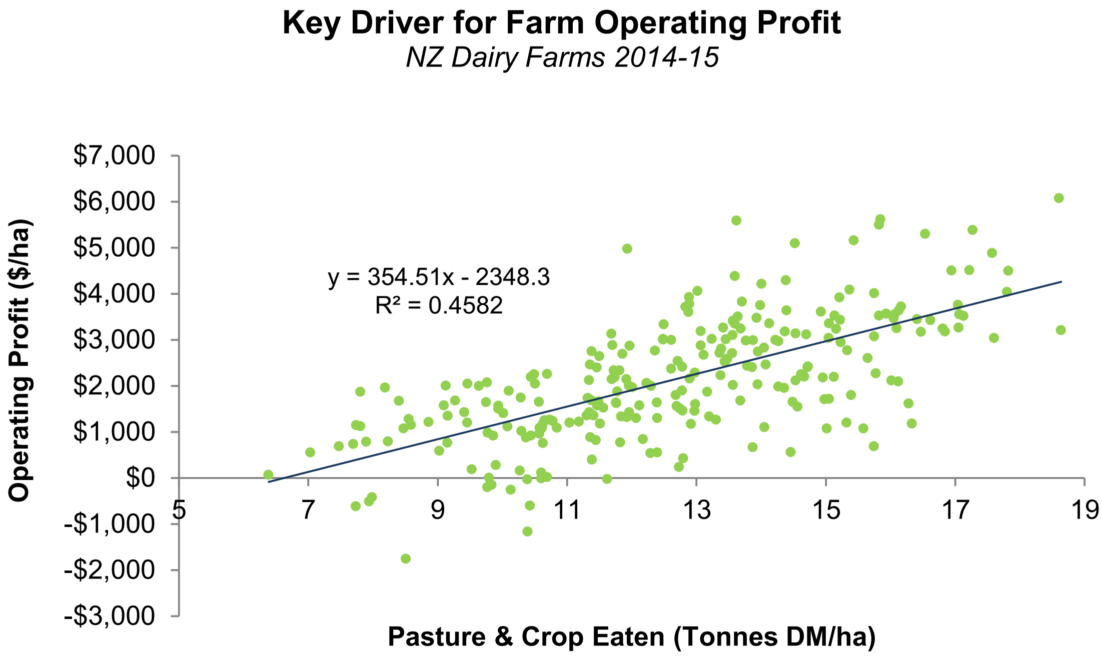
One of the implications for increasing the value of New Zealand forages (in this case, for dairy farm systems) is that producing more forage during winter and early spring periods has greater value compared with late spring, and in the Upper North Island compared with the Lower South Island. This value is driven by the relative deficits in feed versus demand that occur at those times.

Forage Utilisation Drives Farm Profit

A fundamental principle of forage-based grazing systems is that not only must the forage be grown effectively, but it must also be consumed efficiently by the grazing animals. Under good grazing management, approximately 85% of the forage grown can be consumed. This is critical to the performance of the system.

The factor most highly correlated to dairy farm operating profit is "pasture and crop eaten", which means the forage grown and consumed on the farm[19]. This does not mean there is no place for imported feed, but simply that forages remain the key to profitable farming in New Zealand.

[18] Source: Forage Value Manager, DairyNZ
[19] There is no corresponding analysis for sheep and beef farms, although a moderate correlation exists between "net meat production" and EBITR



Source: DairyNZ Economics Group

Forage Crops

The previous section highlighted not only increased use of imported feeds in dairy systems but also forage crops. Forage crops are useful in providing a significant quantity of feed at particular times, for example winter crops used when grass growth is relatively low. However, while forage crops can produce significantly higher quantities of feed compared with pasture, they also require significantly higher input costs and management. A key question is whether crops improve profitability over pastures.

Relatively recent research has reported on the effects of integrated cropping and pasture renewal on the performance and profit of dairy farms across several regions[20]. This work concluded that the benefits of cropping largely depending on successful crop and pasture establishment, with an improved pasture established after the crop that then persisted for at least four years. The implication is that cropping by itself does not improve the profitability of grazed pasture-based systems.

Also, in a five-year farmlet research trial, cropping sequences were introduced to approximately 12.5% of a pasture-based dairy system with the aim of improving the annual feed supply, herd productivity and overall profitability[21]. This work found that pasture growth for the two farmlets was similar, averaging 16.6 t DM per ha per year. While the inclusion of crops did add an extra 1.7 t DM per ha per year over the "all grass" treatment, averaged over the five-year trial, financial analysis indicated a $338 lower operating profit per hectare per annum for the cropping farmlet for the first two years. This was balanced by an advantage of $560 per ha per annum for the cropping system over the next three years. The research found, not surprisingly, that the benefits depended on whether the crop increased dry-matter production cost-effectively, and on whether it was then fully utilised in the system. Opportunity costs also played a part, where land was out of production during the cropping cycle.

In any case, there is a practical limit to the cropping which can be integrated into a farm system. This seems to be between 10% and 15% of the total farm area. Any more can create feed deficits while the ground is prepared, and the crop is growing, as well as a relative oversupply once the crop is ready. There are also considerations of management effort and associated expenses that go into the crop.

These findings highlight that while cropping has a role in New Zealand farm systems, pastures form the core of the system and are absolutely essential to performance.

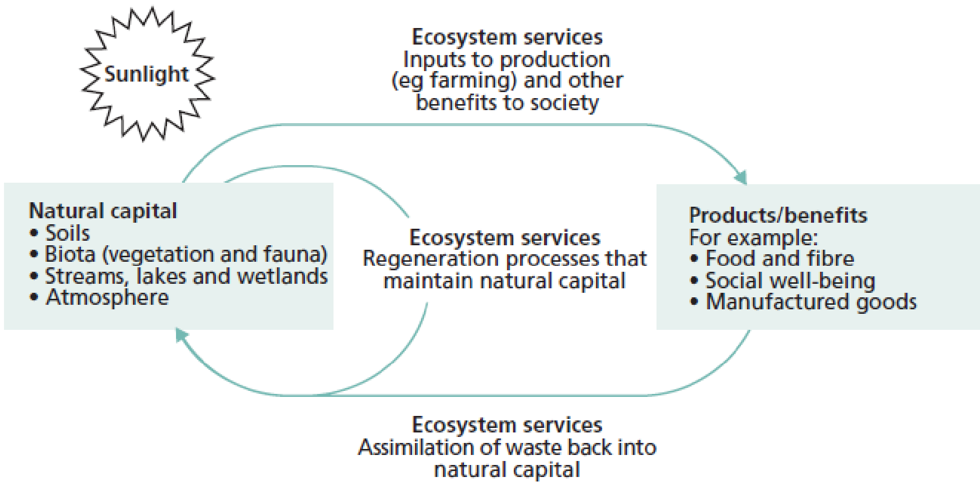
[20] Effects of integrated cropping and pasture renewal on the performance and profit of dairy farms, Bryant et al, 2010
[21] Integrating high yielding crops into a Taranaki dairying system, MacDonald et al, 2012

2.3 Stewards of the Land

The pastoral farming sector occupies a significant proportion of New Zealand's landscape, and thus plays an important role in the sustainable management of New Zealand's environment. Pastoral farmers broadly aspire to be stewards of the land, and to leave the land they farm in better shape than when they started. They also recognise that their performance with regard to environmental outcomes potentially affects more than just their own property, and therefore impacts on other stakeholders must be considered[22].

A 2004 report from the Parliamentary Commissioner for the Environment[23] highlighted the increasing intensification of New Zealand farming. While the products and benefits of farming for our society are valued, the report outlined an equal concern that natural capital be maintained or enhanced for future generations. The four criteria for the sustainability of farming systems are:

- Regeneration — using renewable resources efficiently and not permitting their use to exceed their long-term rates of natural regeneration
- Substitutability — using non-renewable resources efficiently and limiting their use to levels that can be offset by substitution by renewable resources or other forms of capital
- Assimilation — not allowing releases of hazardous or polluting substances to the environment to exceed the environment's assimilative capacity
- Avoiding irreversibility — avoiding irreversible impacts of human activities on ecosystems



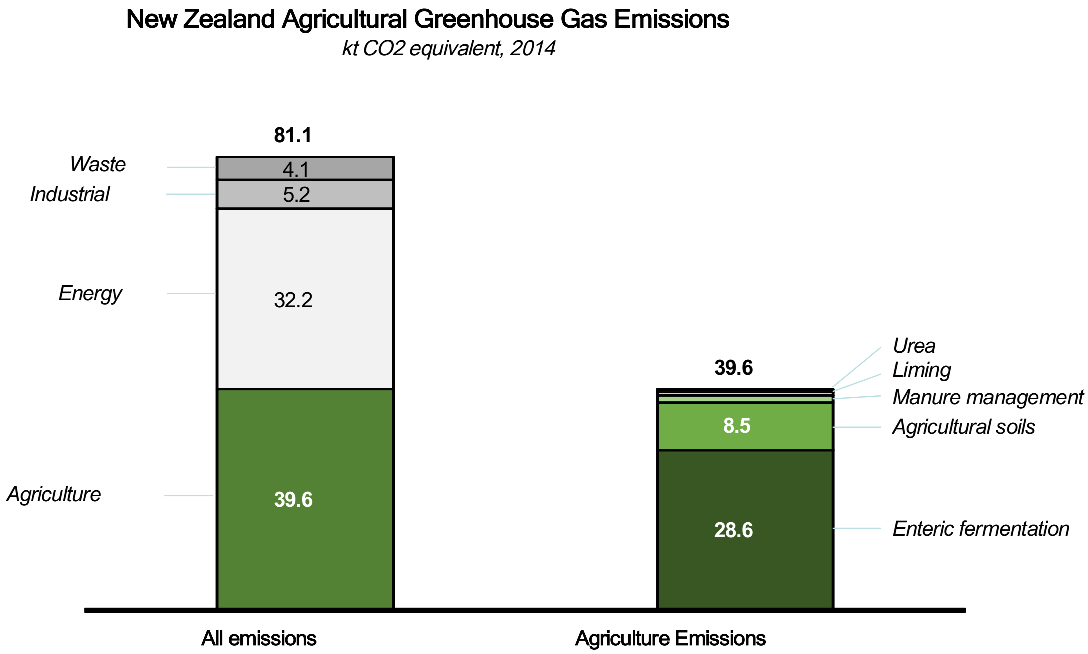
In New Zealand, public policy is focused mainly on managing environmental outcomes rather than dictating inputs and processes. This is a tremendous advantage when compared with the pitfalls of a bureaucratic approach such as in the European Union which stifles innovation. The quid pro quo is that New Zealand farmers must be proactive in developing solutions. There is also a risk that this advantage will be lost over time if regional regulators introduce prescriptive regimes through mechanisms such as Farm Environment Plans in their respective jurisdictions.

The focus of New Zealand's regulation of environmental outcomes is primarily on receiving environments. In simple terms, that means water, soil and atmosphere. At present, the focus has been on atmosphere (greenhouse gases) and fresh water. However, it is sensible to anticipate that the policy framework will be extended to include soil.

Atmospheric Emissions

The New Zealand Government under the Paris Agreement recently announced a target: to reduce greenhouse gas emissions to 30% below 2005 levels by 2030. Although New Zealand's contribution to global emissions is small, its reputation as a trading nation implies an obligation to contribute fairly towards the global effort to reduce greenhouse gas emissions and the risks from climate change.

[22] This paper also recognises the National Science Challenge, 'Our land & water', which aims "To enhance primary sector production and productivity while maintaining and improving our land and water quality for future generations".
[23] Growing for Good: Intensive farming, sustainability and New Zealand's environment, 2004



Agriculture contributed approximately 49% of New Zealand's greenhouse gas emissions in 2014[24]. Of this, 72.4% (28,647.4 kt CO2-equivalent) of the total emissions from the Agriculture sector were from methane through enteric fermentation, followed by 21.5% (8,526.3 kt CO2-e) of nitrous oxide from agricultural soils, 3.2% from manure management, 1.5% from liming, 1.4% from CO2 emissions from the application of urea fertiliser, and 0.1% from field burning of agricultural residues[25]. These figures for agriculture do not include the greenhouse gas emissions embedded in the manufacture of chemical fertilisers, which is estimated to account for a further 1,500 kilo-tonnes of CO2-equivalent emissions.

While overall agricultural emissions have increased since 1990, the "emissions intensity" as measured relative to each unit of milk or meat produced on farms has declined on average by 1% per annum. This has been due to more efficient use of resources across all sectors. Nonetheless, the reputation of New Zealand's agricultural trade remains vulnerable to criticism and could potentially result in non-tariff trade barriers. Also, the potential threat of additional costs such as carbon tax being imposed on agriculture make it imperative to develop solutions.

The pastoral sector recognised this imperative and established the Pastoral Greenhouse Gas Research Consortium (PGgRc) in 2003. This unincorporated joint venture invests about $5 million annually in greenhouse gas research. With a shared goal of reducing agricultural greenhouse gas emissions, the PGgRc works closely with the New Zealand Government and its New Zealand Agricultural Greenhouse Gas Research Centre (NZAGRC) to ensure optimal investment of research funds. Forages and the associated farming systems are recognised as integral factors in New Zealand's agricultural greenhouse gas emissions, and therefore important areas of research.

Fresh Water

Pastoral farming in New Zealand is increasingly accountable for the effect it has on fresh water resources in New Zealand. Pastoral land use contributes three principal pollutant types: the nutrients nitrogen (N) and phosphorus (P), sediment, and faecal microbes. Nutrient enrichment of waterways can lead to unwanted growth of plants (waterweeds and algae). Excess sediment may cause siltation, impair oxygen transfer processes and degrade water clarity. Faecal matter and its associated pathogens presents a risk to human and animal health through waterborne infectious diseases. An additional consideration is the effect of water abstraction for irrigation on waterways and aquifers.

The degraded condition of rivers and streams in lowland catchments in New Zealand has been repeatedly described by researchers and is recognised by the wider public. The public have a predominantly negative view of the impact of dairying on water quality and council monitoring has shown that dairying is responsible for some of the poorest water quality outside of our urban centres[26]. In comparison, sheep and beef farms are less intensive but

[24] New Zealand's Greenhouse Gas Inventory 1990-2014, MFE, 2016
[25] New Zealand's Greenhouse Gas Inventory 1990-2014, MFE, 2016
[26] Report developed as part of the Ministry for the Environment's (MFE) environmental reporting programme

occupy country that is more prone to erosion and hence phosphorous and sediment losses. This issue is now also gaining attention.

The National Policy Statement for Freshwater Management 2014, amended in 2017, (NPSFM) directs regional councils to set community-driven objectives for the quality of their water bodies in the future and to set limits to meet these objectives. The government has set a national target of making 90% of New Zealand's rivers and lakes swimmable by 2040. It changed the NPSFM 2014 to support the swimming target.

Some of the key requirements of the NPSFM are to:

- Safeguard fresh water's life-supporting capacity, ecosystem processes, and indigenous species
- Safeguard the health of people who come into contact with the water through recreation
- Maintain or improve the overall quality of fresh water within a region
- Protect the significant values of wetlands and outstanding freshwater bodies
- Follow a specific process (sometimes referred to as the National Objectives Framework or NOF) for identifying the values that tāngata whenua and communities have for water, and using a specified set of water quality measures (called attributes) to set objectives
- Set limits on resource use (for example how much water can be taken or how much of a contaminant can be discharged) to meet limits over time and ensure they continue to be met
- Determine the appropriate set of methods to meet the objectives and limits
- Take an integrated approach to managing land use, fresh water, and coastal water
- Involve iwi and hapū in decision-making and management of fresh water
- Require regional councils to work towards the national target for swimming.

The pastoral farming sector recognises that the current policy regime which focuses on achieving outcomes (rather than specifying inputs and practices) provides the motivation to work with government and regional councils and the scope to develop innovative solutions. Forages and how they are managed are central to these solutions, just as they are central to the natural processes of nutrient cycling that occur within pastoral farming systems. The pastoral farming sector is currently investing in activities concerning forages, and in working with regional authorities, which includes:

- Specifying "good farm management", for example the Matrix of Good Management developed in conjunction with ECAN
- Better understanding and accurate measurement of the impacts of pastoral farming on fresh water
- Developing new forages and farm practices that result in less nitrate leaching
- The Farmers Leaders Group has committed to working towards making New Zealand's rivers swimmable by future generations.

There is a significant risk for the sector that if fresh water quality is further degraded, and that this is construed to be due to farming activities, that policy will tend towards more prescriptive measures which will impose constraints on farming practices without scope for innovation. This a particular risk where such restrictions are not based on good science and as a result may potentially be ineffective and have detrimental consequences for the sector out of proportion to any benefits.

Soil

Soil requires a different approach from water and atmosphere which are receiving environments. It is part of the ecological infrastructure or natural capital that underpins all pastoral systems. As well as provisioning services, the soil also regulates to ensure clean water, nutrient cycling and carbon storage, while hosting more than one quarter of the world's biodiversity.

Soil is essentially a finite and non-renewable resource unless considered on very long timescales. Climate, primary production, cities and infrastructure, as well as the legacy of past actions, all impact upon the soil resource and its ability to provide life-supporting ecosystem services. A recent New Zealand study showed the economic value of the services provided by soil dropped by 65% when the topsoil was lost in a single instance of shallow mass movement. Fifty years after erosion, the ecosystem services only recovered to 61% of the un-eroded value[27].

The most significant pressures on the soil resource in New Zealand include many inherent to the development of pastoral agriculture:

[27] Dominati & Mackay, 2014

- Irrigation, particularly with increased application on soils with little natural capital such as stony soils or hilly terrain
- Addition of chemicals, and potential contaminants, as more of our pasture systems intensify
- Inadequate vegetation cover, resulting in erosion and sediment transfer to freshwater particularly in vulnerable hill country and on fragile lowland soils under cultivation. An estimated 1.14 million hectares of hill country is classified as erosion-prone in New Zealand, with erosion estimated to cost $100-150 million per annum in loss of nutrients, production, damage to infrastructure and aquatic habitat (Ministry for the Environment, 2007)
- Poor matching of land use to inherent capability is a widespread problem with cropping on fragile or sloping land or production forestry on steep, highly erodible land. An estimated 65% of soils have a physical limitation to pastoral agriculture and 95% are unsuitable for horticulture and yet the pressure to develop these soils is increasing
- Past deforestation is still having an impact on the erodibility of today's national landscape. The cost of erosion together with the likelihood of increased erosion with climate change suggests this is one of the highest priority pressures.

These challenges are not separate from those involved in fresh water and greenhouse gas emissions. The loss of soils from pastoral systems through erosion also contaminates waterways. Losses and sequestration of soil carbon from soils also affects atmospheric emissions.

One of the issues is a lack of comprehensive knowledge about the status of New Zealand's soils, compounded by the diversity of soils and the farming systems which use them. Efforts are underway to map the status of New Zealand soils through S-map, a digital soil spatial information system for New Zealand. It comprises the National Soil Database (NSD) with point data on soil attributes, a modelling and inference system, as well as a number of platforms to deliver information to end-users. However, definitions of land use capability can be problematic, and efforts such as the NSD are not nearly so well integrated with the requirements of the pastoral sector as the soil databases compiled by the fertiliser sector. However, one of the key limitations of the fertiliser sector is that soil fertility tests are naturally concentrated in the areas with highest fertiliser use and this excludes large tracts of land especially in more difficult hill country. This discussion document found it impossible to combine the information sets in any useful and comprehensive way.

At the current time there is no overarching policy regulating soil use and conservation in New Zealand. While the existing NPSFM has some effect, it does not recognise soil as a finite resource, nor regulate to prevent impacts on the soil resource. However, it is in the wider interests of the pastoral sector to ensure that this natural capital is not lost or degraded. It is, quite simply, impossible to grow forages well without good soils.

2.4 Current Sector Aspirations

The industry vision for this Pastoral Industry Forage strategy is to grow the profitability of individual farmers and the long-term prosperity of New Zealand by increasing the value of forage grown on New Zealand farms. This vision is consistent with the aspirations of both government and the pastoral farming sectors. However, the current targets expressed in the different sector strategies mostly focus on revenue, animal production or other outcomes instead of focusing on forages as the key factor contributing to those outcomes.

Ministry for Primary Industries:

MPI's "Our Strategy" sets out MPI's purpose as Growing and Protecting New Zealand and its ambition that New Zealand is the most trusted source of high value natural products in the world. The four outcomes MPI is working towards are:

- Growth – New Zealand's food and primary sector grows the value of its exports
- Sustainability – New Zealand's natural resources are sustainable in the primary sector
- Protection – New Zealand is protected from biological risk and our products are safe for all consumers
- Participation – New Zealanders participate in the success of the primary industries.

The Government's Business Growth Agenda has the objective of increasing exports as a percentage of gross domestic product from 30% to 40%. To achieve this, the primary industries need to double the value of exports in real terms from $32 billion in June 2012 to $64 billion by 2025. Part of this growth will come from implementing productivity gains (within natural resource constraints) in the primary sector. As the single largest part of the primary sector, pastoral farming is critical to achieving this goal.

Dairy Farming:

"Making Dairy Farming Work for Everyone: Strategy for Sustainable Dairy Farming 2013-2020" sets out strategic objectives across 10 areas. Four key targets broadly relevant to the Forage strategy are:

- Farm Profit: Profit from productivity increases from an average of $50/ha per year to $65/ha per year by 2020
- Research and Development: Research delivers farm systems that increase production and increase profit by $110/ha per year while reducing the environmental footprint by 30%
- Biosecurity & Product Integrity: The dairy industry and government authorities have robust biosecurity systems, and farm practices ensure the milk supply is free of contaminants
- Environmental Stewardship: The dairy industry fulfils all commitments listed in the Sustainable Dairying: Water Accord, and 80% of New Zealanders agree dairy farmers are good stewards of the environment by 2020.

DairyNZ has more recently embraced a "Pasture First" initiative with a specific forage target to "harvest an additional tonne of dry matter per hectare".

Sheep and Beef Farming:

The Beef + Lamb New Zealand strategy sets out to "help farmers make informed business decisions and promote their collective interests". The strategic aim of supporting informed business decisions is closely aligned to the Forage strategy. The first priority is investing in research and development that meets the needs of farmers and the sector. This has a specific goal to:

- "Encourage widespread uptake by farmers to achieve a 3% improvement in farm productivity with associated lifts in profitability".

Initiatives such as the Red Meat Profit Partnership are also relevant, but have no specific targets concerning forages.

Deer Farming:

The vision for the deer industry is "a confident and growing deer industry". The strategic objective most relevant to forages is "Sustainable On-farm Value Creation". The measures of success include increasing animal growth rates such that slaughter dates are advanced by 16 days and carcass weights increase by 2kg on average. While improved feeds and feeding strategies are central to achievement of these success measures, the industry does not define any forage-specific performance objectives.

New Zealand Plant Breeding and Research Association (NZPBRA):

NZPBRA company members are the predominant suppliers of new improved plant genetics to the New Zealand pastoral industry. The aspirations of NZPBRA members are to increase the productivity and profitability of New Zealand farmers through:

- Introduction of new species and improved cultivars that are specifically adapted to New Zealand conditions and management systems
- Investment in research and development of market leading forage related technologies
- Development of sustainable farm management systems that will result in maximising returns from inputs
- Driving on farm adoption of new plant technologies and systems

This Pastoral Industry Forage Strategy will form the basis for the transformation of the pastoral industry and guide a collaborative approach that NZPBRA will be fully engaged in.

In summary, with the exception of NZPBRA, forages do not currently receive the same focus as animals or overall system performance within the strategic objectives and targets for other industry groups. The absence of aspirational targets for forages linked to sector performance is a shortcoming that must be addressed, and is the central purpose of this discussion document.

3.0 THE NEED FOR A FORAGE STRATEGY

The forage sector is defined as the pastoral farming sector plus all the supporting institutes, agribusiness, marketing and export companies and other organisations that depend on and supply the pastoral sector in various ways. This section outlines that rationale for pulling these groups together to focus on a common plan for forages.

3.1 Challenges

There are a multitude of significant challenges facing the future of the forage-based farming sector in New Zealand.

These challenges (which are detailed in the subsequent sections) include pressure from markets and consumers, potentially disruptive shifts in climate, damage from invasive pests, and a more restrictive and prescriptive operating environment. Added to this, there is the fundamental challenge involved in bringing the entire sector with tens of thousands of individual farm operations along in the journey. Some of those farms face difficult business environments and other issues which make it difficult to adapt and change.

These challenges will not be met by the market alone. They will require a significant investment of time and resources to overcome. This discussion document contends that a conscious and coordinated plan for the forage sector is imperative, and overrules any argument for independent approaches by various parties.

3.2 Coordination

The forage sector is fragmented, with industry groups each defined by the animal species and products. Each group currently has its own separate approach and capability.

The peak bodies funded by levies represent farmers, and are defined by the species of animal and their main agricultural product. They are aligned to a degree with the respective processing and marketing companies for each agricultural product. The farmer members themselves also identify with their group as being different from the others, reinforced by factors such as the land type that they occupy. There is an uneven distribution of wealth across the groups, which in turn drives different levels of capability and constraints on investment. The competition between these groups for resources is also a genuine cause for some negative feelings. All these factors drive a degree of separation between groups in the forage sector.

There are also instances where commercial agribusiness interests have quite naturally assumed leadership of their own areas in the absence of any other contenders, and their desire to seek a competitive advantage.

At the same time, there has been a proliferation of joint-industry bodies formed to bring various parties together on key issues. These include the Pastoral Greenhouse Gas Research Consortium, and Pastoral Genomics. While these have an extremely useful role in coordinating on specific issues, they also each demand separate investments and time commitments by stakeholders. On top of that the contestable environment for science funding forces research groups to compete and naturally this also engenders multiple proposals. All of this means there are multiple layers of funding and funding bids, even just for those areas solely concerned with forages, with no comprehensive forage sector strategy to guide the investment from the top or across funding structures.

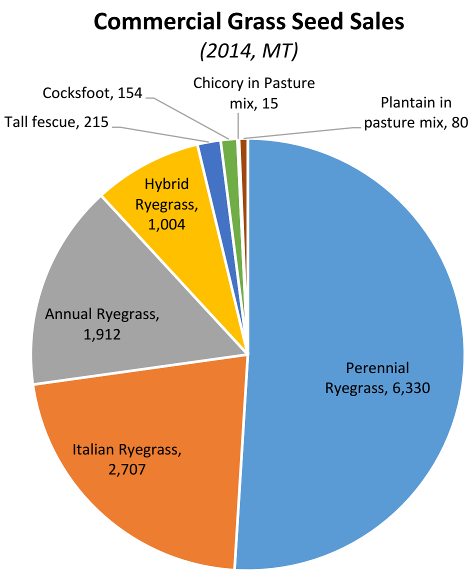
This is a problem because New Zealand’s forage sector is small. The New Zealand market for forage seeds is a fraction of the global seed industry which was valued at $53.76 billion in 2014 and is projected to reach $92.04 billion by 2020[28]. New Zealand’s forage sector simply cannot afford the luxury of multiple, uncoordinated approaches.

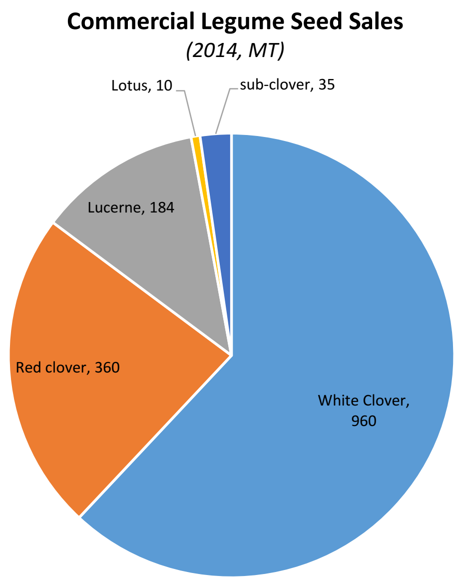
[28] Seed Market by Type, Seed Trait & Region - Global Trends & Forecast to 2020; marketsandmarkets.com, June 2015.

3.3 Market Failure

Commercial investment is focused mainly on the predominant forage systems for cultivatable land, and the main forage species used in these systems, with effective market failure in seed availability for the more challenging farm environments and minor forage species.

The current market for forage seeds highlights the extent to which ryegrass and clover dominate the New Zealand seed industry[29]. Sales of all ryegrass types comprise 96% of grass seed sales by volume, as shown below in metric tonnes of seed sales. White clover comprises 62% of legume seed sales by volume. Red clover is also significant at 23% of legume sales. Lucerne sales have grown over the past decade to now comprise nearly 12% of the legume seed market. It is entirely reasonable that in the absence of any other consideration the seed industry should therefore focus its efforts on producing various ryegrass (perennial, Italian, annual and hybrid), white clover, red clover and lucerne cultivars in that order.





This issue extends to the security of supply and quality of seed for minor forage species. Recent papers note issues with the availability of seed for minor legume species suitable for hill country, and that foreign seed is also often not well adapted to New Zealand conditions[30].

A further related market failure potentially occurs in determining the breeding objectives for forage improvement where seed companies have different priorities and drivers compared with the pastoral farming groups using the seed. While this has been largely resolved between the dairy industry and seed companies supplying ryegrass cultivars, it still exists for other sectors and plant species.

[29] Seed Sales data sourced from NZPBRA and discussions with seed company executives. See also attachment 2.
[30] Availability of seed for hill country adapted forage legumes, Monk et al, 2016

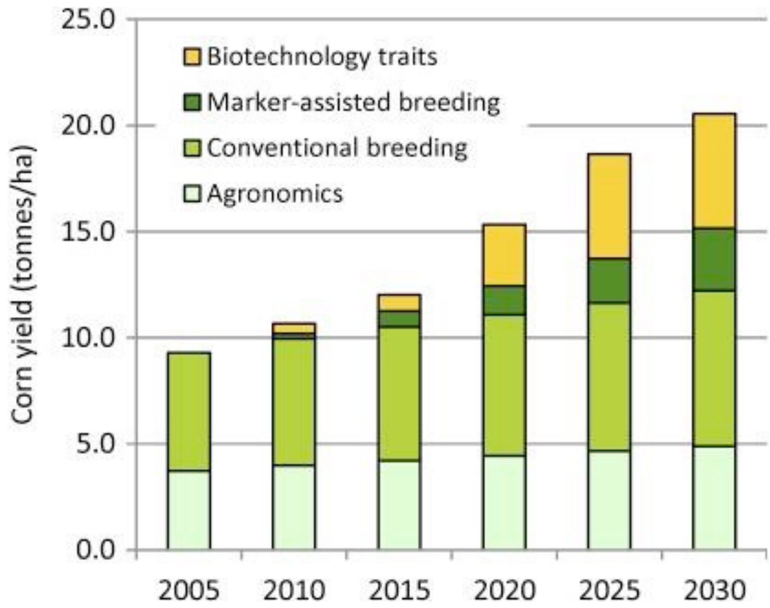
4.0 CURRENT CHALLENGES FOR FORAGE SECTOR

4.1 Keeping up with the Competition

New Zealand's pastoral farming sector is potentially threatened by faster productivity increases occurring in Northern Hemisphere farm systems. These advances are possible in feeds such as corn/maize, alfalfa and soya bean which have far greater scale and hence greater research investment capacity than is available for plants used in New Zealand pastoral systems.

A prime example is United States (USA) corn yields where the introduction of hybrid corn increased the rate of gain and this accelerated further in the 1950s as single cross hybrids were introduced. Corn yield growth rates peaked at an annual-average rate of 3%-5% in the 1960s but then steadily declined to a relative rate of 0.78% per annum during the 1990s[31]. That rate of gain is comparable to gains currently being made in New Zealand ryegrass cultivars. Similar patterns are observed in other feed crops.

However, the high level of investment in technologies such as genetic modification, genomic selection and gene editing technologies means that the next agricultural revolution in these crops could be realised soon. A near-doubling of USA crop production by 2030 is thought possible as these advances stack with improvements in conventional breeding and agronomy[32]. This forecast is shown in the figure below for USA corn. The world is hence just entering a new phase.



New Zealand's competitive advantage also potentially rests on the provenance of its agricultural produce. This is regarded as a key strength, but the distance of New Zealand from consumer export markets as well as a heavy reliance on commodity products means New Zealand's supply chain can fail to communicate important market signals to producers. New Zealand's agricultural export marketing companies have a key role to play in how the forage sector responds to meet consumer market needs.

4.2 Pest and Pathogen Pressure

Pests, mainly invertebrates and weeds, are estimated to have cost New Zealand's agricultural sector around $2 billion in 2008. This comprises $837 million in direct output losses, or $1,590 million including a multiplier factor[33] to account for related losses. Also, agriculture was estimated to spend $480 million on defensive costs versus pests in 2008. Around three quarters of the cost of output losses was for animal and invertebrate pests as shown below. Agricultural pests account for 65% of the cost of all pests nationally.

[31] Trends and Variability in U.S. Corn Yields Over the Twentieth Century, Kucharik, 2004
[32] Increasing Crop Productivity to Meet Global Needs for Feed, Food, and Fuel, Edgerton, 2009.
[33] Economic Costs of Pests to New Zealand, Nimmo-Bell / MAF, 2009. Defensive costs attributed on pro rata basis.

Total Output Losses ($ million) *(before multiplier)*	Plant	Animal & invertebrate	Total Impacts	
Agriculture	202	635	837	65%
Horticulture		25	25	2%
Forestry	37	227	264	20%
Marine		15	15	1%
Other	63	88	151	12%
Total Output Losses	**302**	**885**	**1,292**	

Critically, invertebrate pest pressure is also undermining farmers' faith in pasture renewal which is the key mechanism for improvement of forages on farms nationally. This problem is illustrated in a statement from a dairy industry representative in the North Waikato:

[North Waikato] dairy farmers have a mixed view on pasture renewal value. Certainly, those on peat soils are very disillusioned with pasture persistence. Because of insect damage many farmers direct drill 20-40% of their farm each year to stitch up their pastures and get some winter feed. They also grow 8-12% of their milking platform in maize as part of their pasture renewal programme.

Researchers have also observed increasing difficulties with persistence, especially where drought and insect pressure combine to have a compounding effect in damaging pastures. Soil-borne pathogens may also play a part in difficulties with both pasture establishment and persistence. A recent study, using Farmax modelling of measured pathogen impacts, showed costs to dairying of greater than $750 per hectare per year through clover root disease alone, with greater dollar losses in Waikato than South Island pastures[34].

In terms of weeds, introduced pests such as Californian thistle have adapted well to New Zealand conditions and have an extensive range across both North and South Island pastures. Some commentators have estimated that Californian thistle alone costs the pastoral sector $700 million in lost farm revenue each year[35]. This is at odds with other estimates of output losses, but still indicates the scale of the issue.

Recent high-profile biosecurity failures also highlight the vulnerability of farming to new introduced pests and weeds.

4.3 Environmental Outcomes

Farmers must deliver on environmental outcomes and this requires new solutions and approaches if productivity is to be maintained or increased. This is relevant to forages and forage management.

The various aspects of environmental outcomes have already been outlined in section 1.3 which deals with greenhouse gas emissions, the national policy statement for freshwater management and soil conservation. That section highlights that New Zealand's public policy framework is focused mainly on managing environmental outcomes rather than dictating inputs and processes, which is beneficial because it creates incentives for improved approaches. However, there is a risk that this advantage will be lost and innovation stifled over time if regional regulators introduce prescriptive regimes through mechanisms such as Farm Environment Plans in their respective jurisdictions.

The current focus for farmers is being driven by the National Policy Statement for Freshwater Management. This has some immediate implications for the forage sector regarding both forage improvement and pasture management. The main issues related to forage are:

Nitrate Loss: Particularly for dairy farm systems, nitrates from stock urine can pass through soils and contaminate groundwater. Specific forage-related factors include:

- Ability of plants to utilise nitrogen, including their root structure, root depth and response to seasonal conditions (for example, plants may be semi-dormant in winter and less able to utilise available nitrogen)
- Feed composition of forage plants including the level of nitrogen and/or compounds which affect metabolic function in animals and consequent nitrogen excretion

34 Cost of root disease on white clover growth in New Zealand dairy pastures. Wakelin, Eslami, Dake, Dignam & O'Callaghan. 2016: Australasian Plant Pathology 45: 289–296.
35 On the economics of invasive plant: The case of Californian thistle in New Zealand, Bourdot et al,

Sediment Loss: Particularly from steeper country, mainly drystock farm systems, where pasture or other forage plants do not sufficiently stabilise soils, and/or where grazing stock contribute to soil erosion. Also, where cultivation methods (including crops) and over-grazing can damage or expose soils and increase the risk of sediment loss.

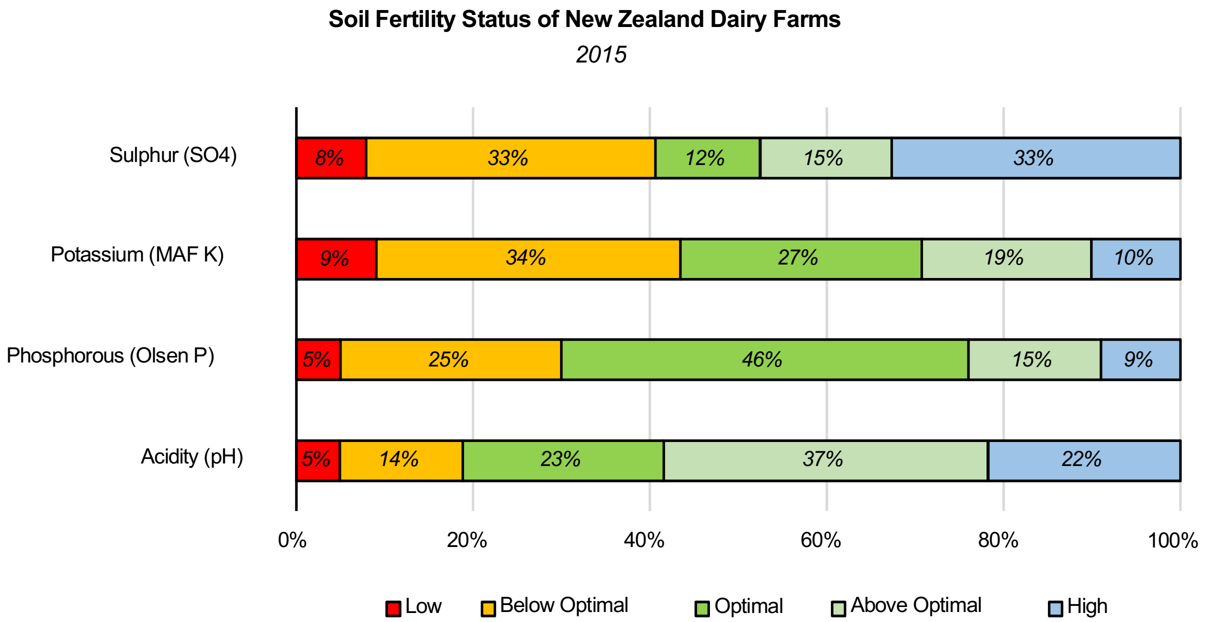
Phosphorous Loss: Principle causes are the same as for sediment loss.

The challenge for the forage sector is to develop improved forages and forage management approaches that can achieve better outcomes, and for farmers to work out how to adopt these within their own farms.

4.4 Soil Fertility

The science of soil fertility is very well established, and has underpinned New Zealand's agricultural performance throughout its history. However, managing optimal soil fertility, moisture availability and soil health is challenged by climate, topography, aspect and pressures to increase production. The essential elements in soil fertility for plant growth are sulphur, potassium, and phosphorous. Soil pH is also important, particularly for legumes.

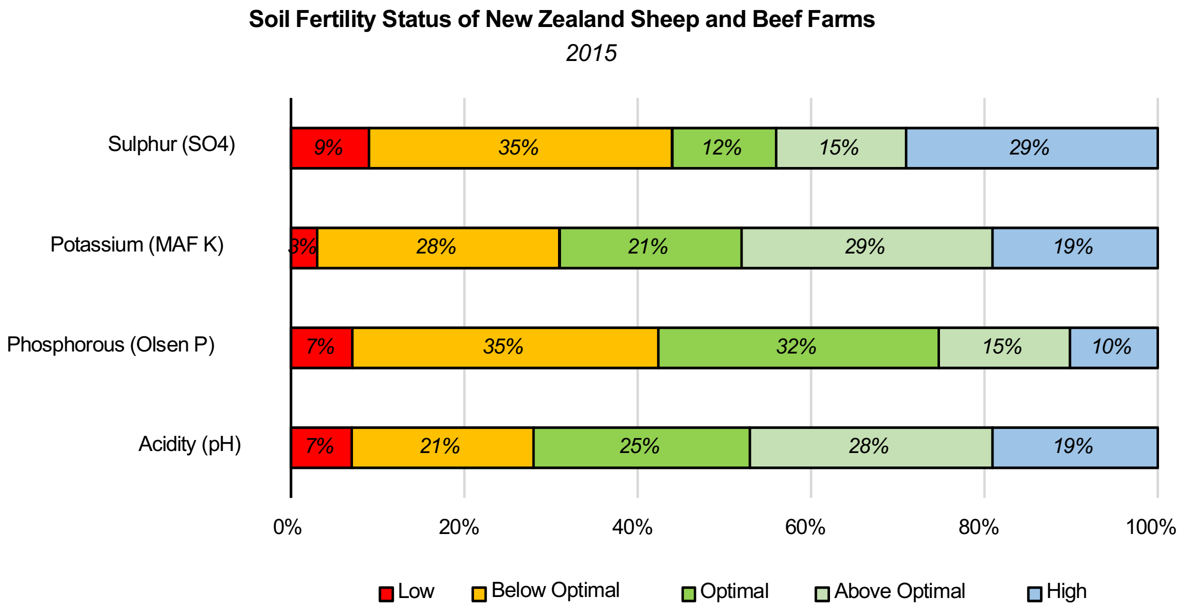
Dairy farms tend to be located on flat, cultivatable land where soil fertility is most easily managed. The higher stocking rates and rotational grazing systems associated with dairy farms are also conducive to a more even distribution of nutrients in stock dung. Evidence from fertiliser tests[36] conducted across New Zealand dairy farms shows that less than 10% of those tested have low fertility which would have a significant and negative effect on forage production and indicate under-investment. Most farms lie in the middle bands at or near optimum levels. Approximately 10% have high levels above optimum which would indicate a risk of excessive loss of nutrients and/or wasted investment. However, even within a dairy farm with optimal levels of soil fertility, there are still variations between and within paddocks that affect pasture performance.



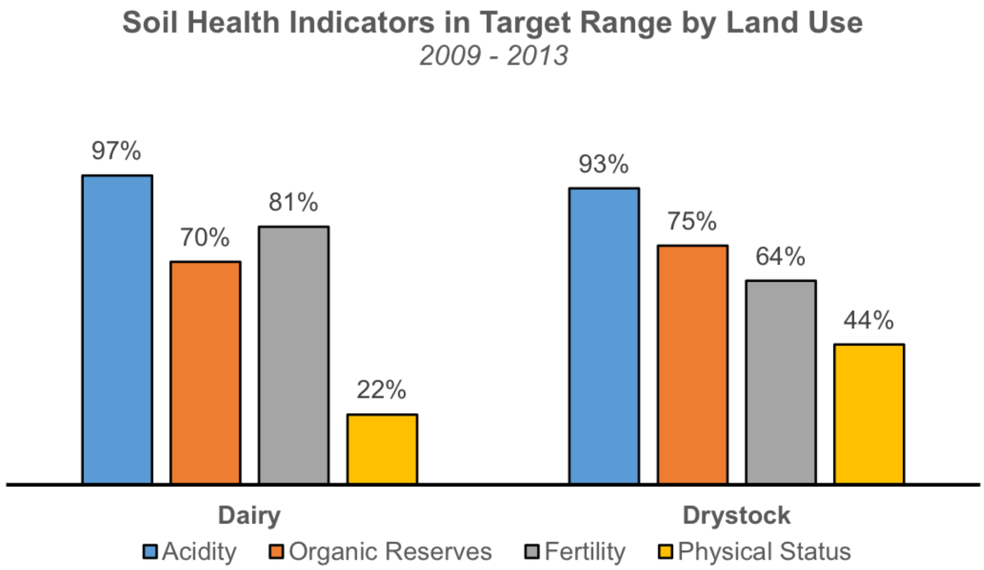
Sheep and beef farms generally occupy steeper country which presents challenges. Machinery access is often limited, so aerial applications of fertiliser are required, and precision application is more challenging. Stocking rates are typically lower, so nutrients are not recycled as evenly around the paddocks. Steeper topography also tends to result in the migration of nutrients down-slope, with accumulation occurring in concave areas. Slope and aspect also limit productivity and hence the returns to investment in soil fertility. However, the available soil test data[37] indicates that the soil fertility status of sheep and beef farms tested across New Zealand is only marginally less than for dairy farms. Also, approximately the same proportion of tests showed nutrient levels that were high above the optimal levelThis finding highlights a major issue with the available data. It is only collected from commercial tests where the farmer contracts the testing agency to assist in decision-making about fertiliser applications. Even on sheep and beef country, this is much more likely to be on the cultivatable land than elsewhere. This approach creates a biased sample that ignores large areas of productive pastoral land which are not tested.

[36] Source: Ravensdown
[37] Source: Ravensdown

An alternative perspective on soil status and fertility obtained from Landcare and regional councils[38] shows that drystock (sheep and beef) farms have a substantially lower number of sites with fertility in the target range (64%) compared with dairy which has 81% in the target range. However, experts in the forage sector dispute the definitions employed by Landcare Research in this analysis, which indicates a lack of coordination between these groups.



Farmers could improve productivity by more extensive soil testing and investing in fertility. The New Zealand pastoral sector requires a more comprehensive approach to evaluating and recording soil status, particularly for hill country. This should not be limited to just commercial tests, as it is now. Ideally, this wider approach should be embraced by all the stakeholders, including MPI, the Ministry for the Environment (MfE), Landcare Research and regional councils.

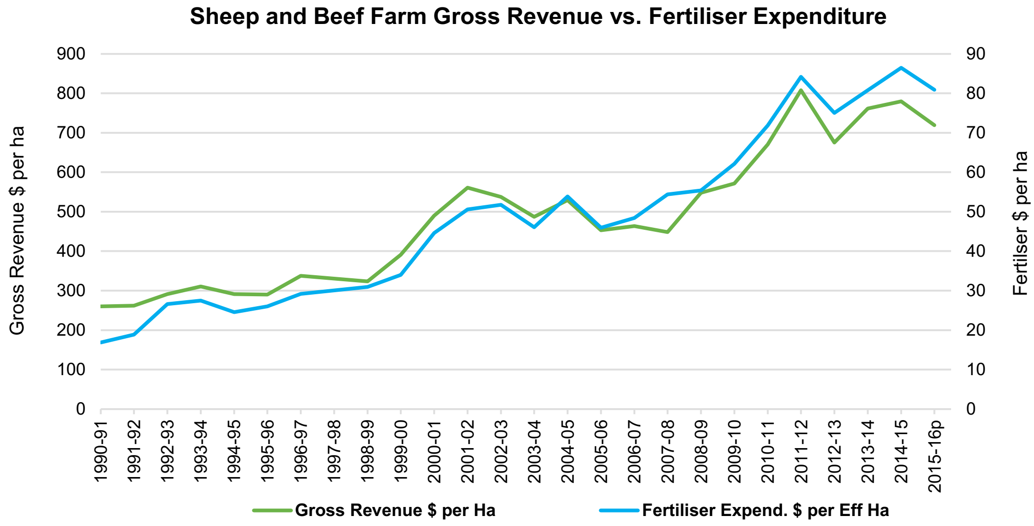


[38] Statistics NZ: Data obtained from Landcare Research; Regional Councils, Unitary Authorities

4.5 FARMER CONFIDENCE

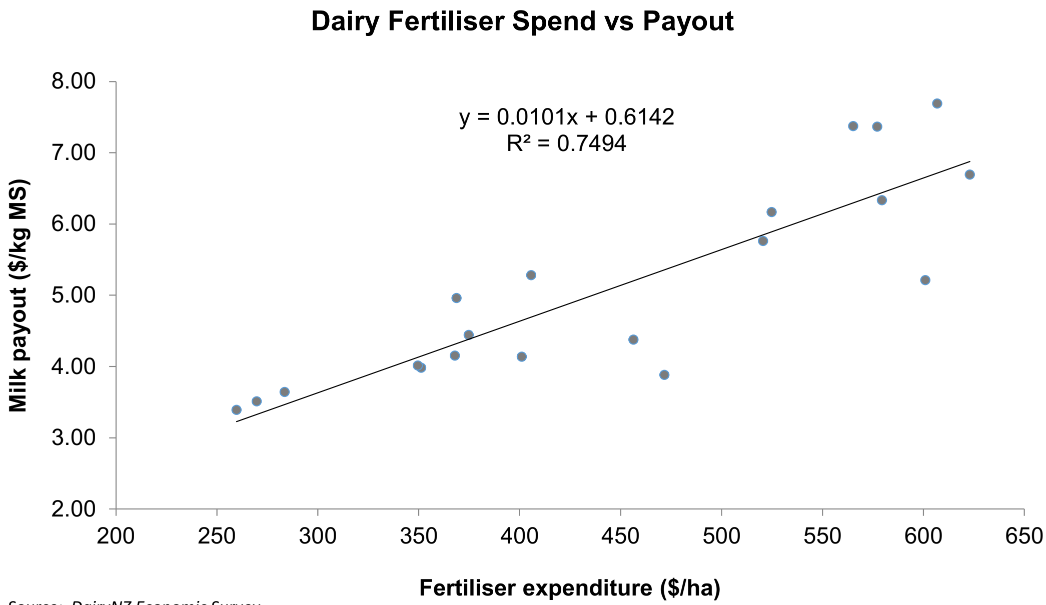
One of the main barriers to change and improved performance in the forage sector is farmer confidence in both the improved idea or innovation and their ability to implement it profitably on farm. This is not a reflection on the farmers themselves, so much as a reflection on farm economics and the risks associated with farming. Where cash flow is constrained and the financial return on an investment is dependent on uncertain factors such as weather, conservative decision-making is a rational response.

A prime example of this conservative approach is evident in the relationship between gross farm revenue and fertiliser expenditure on sheep and beef farms in New Zealand. Sheep and beef farmers appear to fund fertiliser maintenance out of available cash flow, rather than making a commitment to the expenditure as a necessary and profitable item.



Source: Beef + Lamb New Zealand Economic Service, Sheep and Beef Farm Survey

A similar pattern is also evident in dairy farming where fertiliser spend is correlated with payout.



Source: DairyNZ Economic Survey

An important consequence of this behaviour is that farm systems which are generating strong, reliable cash flows have a greater appetite for investment back into the business. A typical example is a dairy farm system under irrigation. The ongoing investment improves the underlying asset, of which soil fertility is one aspect, and cash flow is further strengthened. This also applies to other on-farm investments such as subdivision by fencing, and pasture renewal.

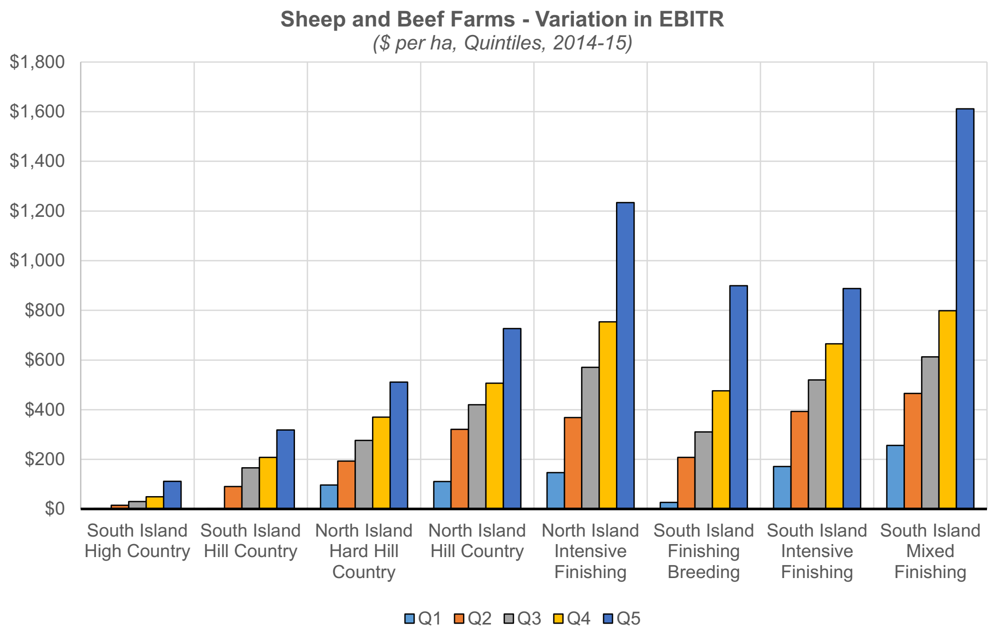
Conversely, farm systems which have weaker and less certain cash-flows tend to defer discretionary expenditure on fertiliser, infrastructure and farm system change. The continued deferment of expenditure results in sub-optimal soil fertility and poor on-farm infrastructure, so that the whole system operates at a sub-optimal level. Consequently, the challenge to make positive changes becomes even greater. Problems of this type have developed over decades, and have become ingrained within the system.

Commercial agribusiness companies are far more likely to engage successfully with farm systems that are operating with strong, reliable cash flows because those farmers are better able to commit to regular purchases. By the same token, there is less incentive to engage with farms that have weak and uncertain cash flow.

This situation creates a very real dilemma for the overall forage sector, particularly from the perspective of investing public monies. Somehow, the sector needs to find a way to “bootstrap” the least productive farms into a position where the farmers themselves have greater financial security and thus confidence to make improvements. That will in turn create better engagement with commercial agribusiness.

4.6 On-Farm Capability

On-farm capability is not uniform, and this makes a significant contribution to the variation in forage system performance between similar farms. The extent of variation in performance is significant for all farm types. The figure below demonstrates the extent of the variation in profit, measured here as earnings before interest, tax and rent (EBITR) in dollars per hectare for sheep and beef systems. Similar degrees of variation exist across dairy farm systems, even between neighbours on very similar farms.



A recent study of the dairy farming has confirmed that management is the biggest factor driving financial performance. The difference in profit between the top 10% and the bottom 10% of dairy farms is about $3,000 per ha, with a standard deviation of around $1,300 per ha. The study demonstrated that about 30% of this variance can be attributed to known factors such as soils, climate and irrigation. However, 35% is attributed to farm team and management performance[39]. The research also found that found that every dollar a farm employer invests in staff training (fees and lost work time) results in an extra $3 to $15 of profits per hectare.

[39] Returns from training in the dairy farming industry, Scarlatti/DairyNZ/Primary ITO, July 2016

5.0 FUTURE CHALLENGES FOR FORAGE SECTOR

5.1 Climate Change

Climate change is threatening current farm systems. Aside from warmer temperatures and changes in weather, there are also effects associated with rising carbon dioxide levels, and potentially even wider effects on global trade due to disruption of historical production and trade relationships.

New Zealand is already experiencing climate change, with long-term trends toward higher average temperatures, more hot extremes, fewer cold extremes, and shifting rainfall patterns in some regions[40]. More change is expected, with the changes relevant to agriculture including:

- Average temperatures expected to rise further, depending on future greenhouse gas emissions
- Spring and autumn frost-free land area expected to at least triple by 2080s
- Up to 60 more hot days per year (over 25°C) for northern areas by 2090
- Significant shifts in rainfall patterns including a rise in extreme rainfalls (up to 8% more intense rain for every 1°C of warming, but with significant regional variations), and more time spent in drought in eastern and northern New Zealand where it is projected to double or triple by 2040
- Decline in peak snow accumulation by about 30–80% at 1000 metres and by about 5–50% at 2000 metres by 2090 (which will reduce snow melt river flows in eastern South Island) and therefore have consequences for irrigation water supplies

Rainfall changes and rising temperatures are expected to shift agricultural production zones and timing of some activities. The impact on dairy, sheep and beef pasture production is expected to vary widely across the country. Some areas particularly in cooler southern regions are likely to benefit from a warmer climate, if farm management practices change to make the most of increased pasture production. Other regions face increased drought risk and uncertain changes in severity of pests, weeds and disease pressures. Pests, pathogens and invasive weeds are almost certain to become an even bigger problem, and pests currently confined to northern zones will probably migrate further south. For example, Northland might be considered a case study in how other regions will be impacted by changing climate in the future. Disruption of existing bio-controls may also occur through changed climate patterns. Erosion could also become an even bigger problem on farms, depending on how rainfall, and especially storm frequency, changes.

Another important effect to consider is rising atmospheric concentrations of carbon dioxide. Atmospheric carbon dioxide has already increased about 35% since 1800 (from 280 to 380 parts per million [ppm]), and it will reach between 450 and 1,300 ppm by the end of the century depending on the ongoing rate of emissions[41]. Not only is this a major factor in climate change, but it could also dramatically influence the performance of the pastoral sector. When ryegrass and other temperate pastures are grown under carbon dioxide enrichment, productivity increases dramatically at first. But over time, organic nitrogen in the plants decreases and productivity diminishes in soils where nitrate is an important source of this nutrient. Research has found this is due to elevated carbon dioxide concentrations inhibiting photorespiration, which in turn inhibits shoot nitrate assimilation.

The effect of global warming will not be confined to New Zealand. It is possible that many countries around the world will face challenges to their food security. Food exporters such as New Zealand stand to benefit from increasing food demand[42]. For the agricultural sector this could mean increased revenues and hence the potential to invest more and adapt faster. It could also have unexpected consequences in shifts in trade policies and trade barriers, as well as consumer perceptions associated with agricultural produce.

The net implications of climate change for New Zealand's forage sector are more complex than just climate change. There are potential opportunities as well as threats. Anticipating and meeting these challenges is a major priority.

[40] IPCC Fifth Assessment Report (2013) - New Zealand findings (NIWA report
[41] United States Environmental Protection Agency
[42] Impacts of Global Climate Change on New Zealand Agriculture, NZAGRC (2012)

5.2 Restrictions and Prescriptive Farm Practices

Farmers in the future may be increasingly restricted in where they can farm, what farm practices and tools are permitted, or they may even be required to follow prescriptive farm plans. This may require new forage solutions and approaches. The following table indicates some possible implications for forages.

Driver	Possible Future Requirements	Possible Implications for Forages
Fresh Water	Greater restrictions on all nutrient losses	Imperative to better optimise soil fertility, manage nutrients and improve nutrient utilisation
	Lower caps on permitted nitrate leaching rates	Economic imperative to develop and adopt forages that reduce nitrate losses, potentially through lower N composition Potential constraint to some stocking rates on extensively grazed pastures leading to de-intensification and reduced feed demand, leading to reduced pasture renewal rates Imperative to develop high legume pastures in response to restrictions on N fertiliser use Potential land-use change
	Pastoral farming is restricted on erosion-prone land with high phosphorous and sediment losses e.g. with high slope	Pasture renewal on hill country is reduced Demand for improved forages for hill country is reduced Some feed demand for breeding animals necessarily shifts from hill country to less restricted areas, forcing a change in farm systems
Atmosphere	ETS[43] applies to agriculture	Economic imperative to develop and adopt forages that reduce livestock emissions, potentially through forage composition
Soil	Cultivation techniques are restricted	Pasture renewal on cultivatable land must use compliant techniques that conserve soil Pest issues are compounded
	Cultivation of fragile soils is restricted	Pasture renewal rates are reduced in some areas, or new techniques suitable for fragile soils must be developed and adopted
Environmental Protection (Agrichemicals)	Commonly used pesticides are restricted or not permitted	Economic imperative to register new chemistry, or develop alternative methods of pest control such as biological controls
	Commonly used herbicides are restricted or not permitted	Economic imperative to register new chemistry, or develop alternative methods of weed control Imperative to develop alternative pasture renewal technologies that are effective without these herbicides

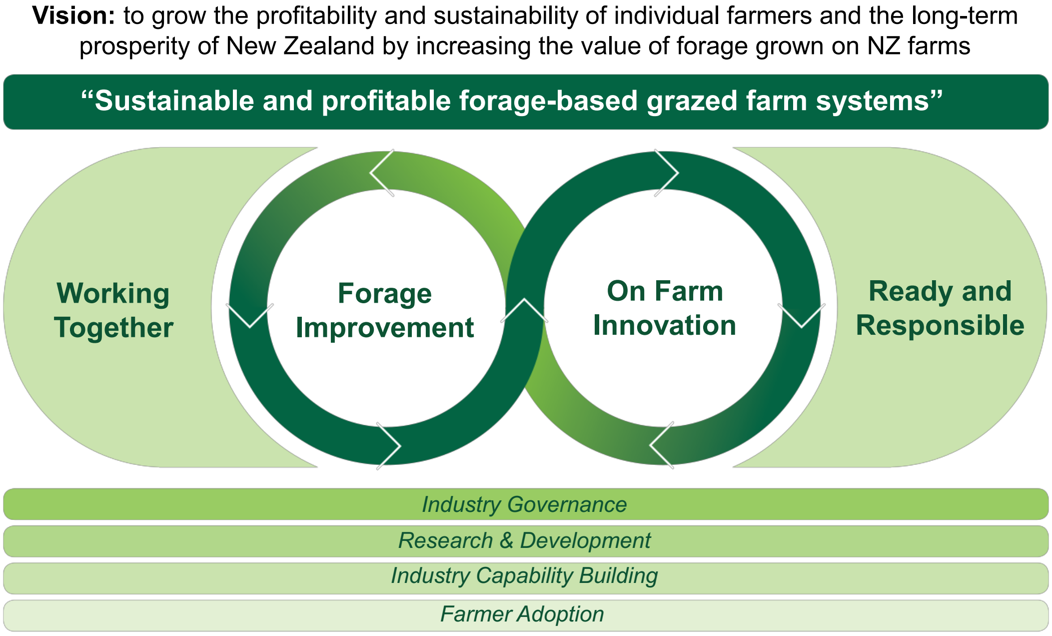
The forage sector must be proactive in developing new forages and tools to meet future requirements. The alternative is increasing constraints, less effective methods for pasture renewal, and a consequent weakening of the supporting structures including commercial agribusinesses which depend on farming.

[43] Emissions Trading Scheme

6.0 THE FORAGE STRATEGY

6.1 Forage Strategy

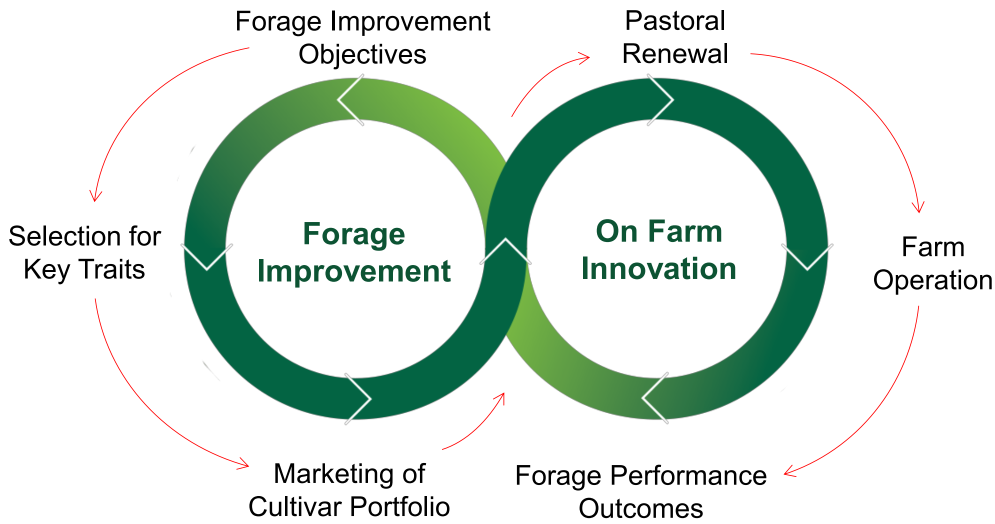
To achieve the vision, we need sustainable and profitable forage-based grazed farm systems. This requires a raft of initiatives from addressing industry governance issues to developing biological solutions to working with farmers to get change happening on-farm. To make sense of all this, this discussion document proposes four overarching themes. These address key choke points that will determine how well and how fast New Zealand's pastoral industry achieves the vision.



Working Together is included as the first theme, because it is imperative for all the forage-based sectors including dairy, beef, sheep, and deer to have a common plan together with the seed industry and cooperate on key issues that affect forages. The Working Together initiatives have been identified to provide an overarching direction and governance for other areas. These address concerns around a potential lack of coordinated investment, confused messages and missed opportunities in policy setting and direction between the parties.

The Forage Improvement and On Farm Innovation themes are interdependent. Building on the insights from the 2011 Forage Review[44], these represent each one as a linked system. The system for forage improvement, is largely driven by commercial seed companies. Research organisations play a supporting role. The second system collectively represents all the farms in the sector. The readiness of farmers to adopt new forages and innovations that improve their own farm operations creates the economic incentives for forage improvement by the commercial sector. Within each of these two spheres of activity, key initiatives are identified to accelerate the improvement and adoption processes and address choke points. The primary connection linking the two systems is the supply of, and demand for, improved forage cultivars as shown below.

[44] The 2011 Forage Review was a collaboration primarily between DairyNZ and NZPBRA: https://www.dairynz.co.nz/publications/feed/2011-forage-review-guide/



The "Forage Improvement" theme recognises commercial seed companies as the main participants in improving and supplying forages. The value of improved forages lies in their potential to increase farm system productivity, improve environmental and animal welfare outcomes, and potentially improve product attributes. The process of forage improvement includes the technologies, processes and evaluation methodologies for forage improvement. The initiatives recommended in this theme address the key areas that can accelerate forage improvement and expand its scope to broadly include all the New Zealand pastoral sector.

The "On Farm Innovation" theme includes the adoption of improved forages through pasture renewal, the development of forage system innovations that incorporate improved forages, the demonstration of improved forages in farm operations and observation of forage performance outcomes. It also incorporates the development of technology packages and supporting industry capability to facilitate the correct implementation of these forage systems. These are all essentially about farmer change. The theme therefore identifies key initiatives to create more attractive options and increase engagement with farmers, whose choices ultimately determine the direction of the sector.

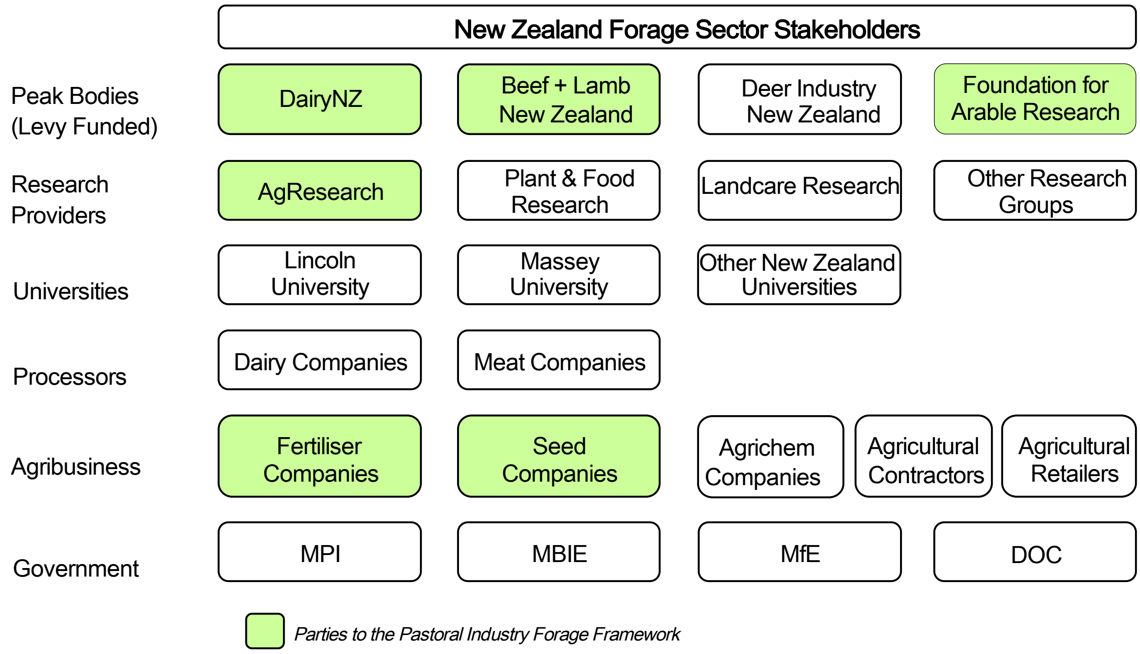
The "Ready and Responsible" theme looks ahead and identifies where proactive efforts are needed to manage the reputation of the forage sector as a responsible industry now and in the future. It incorporates the integrity of the forage-based food production system, and proactive actions to develop appropriate farm management practices for improved environmental outcomes.

6.2 Working Together

Key Objective: Establish a joint forage industry strategy and approach to common issues.

This document represents the industry initiated forage discussion document. However, this is only a first step towards a more coordinated industry approach. The main parties who direct investment and research in the forage sector include the peak industry bodies representing pastoral farming, crown research institutes, agricultural universities, related commercial agribusiness, processors and government. Of these, the seven parties directly represented in developing this discussion document are highlighted.

These organisations already work together on various initiatives and leadership groups concerning forages. In some cases, such as the 2011 Forage Review, these initiatives have addressed systemic issues in how the parties interact. However, cooperation tends to be around significant research efforts that pool industry good and public-sector funds towards common efforts such as Pasture 21, the Pastoral Greenhouse Gas Consortium and Pastoral Genomics. Even in the case of research, activity in different areas is not coordinated. There is also insufficient coordination around key matters of policy and direction affecting the sector.



The Forage discussion document identifies four strategic initiatives for working together more closely:

1.1 Coordinated Forage R&D Investment

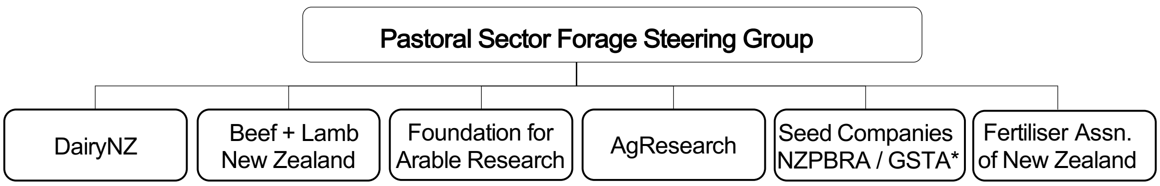
1.2 Joint Forage Sector Biosecurity

1.3 Joint Position on Forage System Provenance and Product Integrity

1.4 Coordinated Regulation for Forages, including:

- Climate Change – Emissions Trading Scheme (ETS)
- Agrichemicals
- Genetically Modified organisms (GMOs)

The overarching recommendation is for the Pastoral Industry Forage steering group to continue to guide and facilitate the strategy. Its proposed role is as a coordination point, facilitating across the pastoral sector. It will own and maintain the strategy on behalf of the stakeholders. The proposed steering group will comprise six stakeholder organisations as shown below.



*GSTA is the NZ Grain and Seed Trade Association.

The steering group anticipates working in two main areas of Science & Agronomy and Markets & Regulation. These areas have different issues and stakeholders, and complementary advisory groups may be formed for dealing with specific issues. In Science & Agronomy the issues relate to areas such as science investment, forage biosecurity and agrichemicals. This requires expertise in forage science and development, and in the use of forages. Markets and regulation need consideration, particularly in terms of positioning the provenance and product integrity of New Zealand's forage sector vis-à-vis export markets and consumers. This requires the expertise of export and marketing companies, as well as parties with direct involvement in the use of forages. It requires coordination of practical issues as well as regulatory plans affecting the forage sector. Principally these include the ETS (greenhouse gas research being a separate science issue), agrichemical policy, and GMO policy.

Focus Areas	**Science & Agronomy**	**Markets & Regulation**
Scope	• *Coordinated Forage R&D Investment* • *Forage Sector Biosecurity* • *Agrichemicals*	• *Joint Position on Forage System Provenance and Product Integrity* • *Coordinated Regulation Frameworks for Forages*

The immediate need is for working groups to be established in five areas relevant to forages:

- Biosecurity
- Forage Value Index Extension
- Beef and Lamb Farm Systems
- Pre-commercial Breeding Technology for Forage Improvement
- Soil Health

The key to success of the proposed steering group will be its ability to have a global perspective across the sector (not dictated by smaller interests), and to secure the commitment of stakeholders in terms of both funding and direction.

Actions:
Formalise the role of the Pastoral Industry Forage Steering Group as the facilitating body across all stakeholders, collaborations and consortiums

Initiative 1.1 Coordinated Forage R&D Investment

There is a clear need to coordinate forage R&D investment.

The forage industry at the primary production level is organised according to classes of livestock animals. This structure is aligned to the processing sectors, but naturally focuses attention on each livestock group, rather than the common factors and overlapping features of their forage systems. The peak bodies of Beef + Lamb New Zealand, DairyNZ and Deer New Zealand are each primarily funded through levies raised on their respective units of production, that is milk and meat. Collectively, these three groups representing the majority of the pastoral sector collect approximately $90 million in levies per annum. DairyNZ and Beef + Lamb New Zealand estimate they directly invest $10.8m and $0.8m of these levies into forage-related research activity respectively, excluding demonstration farms. The deer industry also contributes, and is a participant in the Pastoral Greenhouse Gas Research Consortium (PGgRc), but the quantum is relatively small.

New Zealand Forage Sector

DairyNZ	Beef + Lamb New Zealand	Deer Industry New Zealand
12,150 Dairy Farms	12,500 Sheep & Beef Farms	1,128 Deer Farms
Milksolids Levy: $61 million	Sheep & Beef Levies: $24 million	Deer Levy: $4.25 million
Forage R&D: $10.8 million	Forage R&D: $0.8 million	Forage R&D: Not specified

The forage sector is also supported by Crown Research Institutes (CRIs) and universities, with AgResearch being a key institute in forage research. Its portfolio includes $29.9 million of forage-related research activity, comprising Core AgResearch funding as well as partnerships with the crown, DairyNZ, Beef + Lamb New Zealand, universities, and various other parties. However, the contestable nature of science funding in New Zealand means that this cooperation, and the willingness to share information, is constrained by practical considerations of self-interest. As a result, a great many research proposals tend to originate from each group separately, and with a view to preserving their own interests and capability rather than serving an over-arching forage sector strategy.

Seed companies also invest in research and development, primarily towards developing new cultivars and endophytes. New Zealand's seed industry has sales of between $200 million and $240 million per annum[45], with more than half of this ($103 million to $149 million) coming from grasses and legumes. Much of the remainder comprises brassicas and forage and arable crops. Overall, the seed industry reports investing $22.9 million into plant improvement out of a total $29.6 million R&D budget for 2014. A new cultivar costs approximately $4 million to $4.5 million[46] to commercialise.

Six major joint R&D initiatives in New Zealand are worth noting:

- The Pastoral Greenhouse Gas Research Consortium (PGgRc) exists to provide knowledge and tools for New Zealand farmers, so they can mitigate greenhouse gas emissions from the agricultural sector. The consortium has eight New Zealand agricultural sector partners (AgResearch, Fonterra, FertResearch, PGG Wrightson, DairyNZ, DEEResearch, Beef + Lamb New Zealand, and Landcorp) and works in collaboration with the New Zealand government. The directions relevant to forages include low methane feeds
- Pastoral Genomics is a New Zealand research consortium for forage improvement through biotechnology. It is funded by the Ministry of Business, Innovation and Employment; DairyNZ; Beef + Lamb New Zealand; DEEResearch; Grasslands Innovation Ltd; Dairy Australia; NZ Agriseeds and AgResearch. It is currently focused on genomic selection as a technology for accelerating gains in plant breeding
- The Forage Value Index (FVI) and the supporting New Zealand National Forage Variety Trial (NFVT) system represents a collaboration mainly between the NZPBRA and DairyNZ. It was developed, and continues to be refined, following a 2011 Forage Review project which identified the need for an independent, region-specific, profit-based index for short-term and perennial ryegrass cultivars
- Pastoral 21 is a collaborative venture involving DairyNZ, Fonterra, the Dairy Companies Association of New Zealand, Beef + Lamb New Zealand and the Ministry of Business, Innovation and Employment. It is designed to boost farm productivity and reduce environmental impacts. Its goals are for a $110/ha/year increase in average profitability from dairy production, a 30% reduction in nitrogen and phosphorus losses to water; and a 3% annual meat productivity increase, while containing or reducing environmental footprint
- The Primary Growth Partnership (PGP) is a joint venture between government and industry investing in long-term innovation to increase primary industry market success. Out of a total $759 million in committed investments[47], $612 million is in wool, dairy, meat and pastoral sector investments. The specific pastoral sector investment of $44 million includes relevant projects for precision application of fertiliser in hill country, improved pasture establishment, and nutrient-use efficiency in pastures
- The Better Border Biosecurity (B3) research collaboration, which includes AgResearch, Plant and Food Research, Scion, Landcare Research, MPI, Department of Conservation, the Environmental Protection Authority, the BPRC and numerous industry stakeholders including FAR & DairyNZ

These national initiatives are important, but do not represent an over-arching investment plan for forage sector research. Consequently, there is no clear basis for government to allocate public funding to forage industry priorities versus the highest promises inherent in various funding proposals. Indeed, it is noted that one of the motivations for this report came from feedback from government to Pastoral Genomics to that effect.

A further consideration is that the New Zealand pastoral sector shares some common features with the Australian pastoral sector, particularly in Tasmania and parts of Victoria which also have a temperate climate. While there is some collaboration and co-investment at present, this could be managed on a greater scale. Earlier proposals for an Australasian pastoral powerhouse have not gained traction, but could if there was a better understanding of shared objectives around such areas as achieving better environmental outcomes.

[45] Economic Impact Assessment of Arable Production in 2015 (DRAFT), Berl Economics, July 2016
[46] Source: Commercial seed company
[47] Reported as of June 2017

Actions:
Collate a more complete and accurate view of forage sector investment in New Zealand, accounting for the multiple interests and related parties. Appropriate understandings still need to be negotiated for this information to be shared, building on the work already completed in this report
The Pastoral Industry Forage Strategy Steering Group to convene a Forage Science and Agriculture Advisory Group to coordinate with government and other investors on funding priorities for forage-related research and development
Identify common interests with the Australian pastoral sector and initiate discussions around joint investment in research and development

Initiative 1.2 — Joint Forage Sector Biosecurity

Biosecurity is a vital part of growing and protecting New Zealand's primary and tourism sectors, and our everyday way of life[48]. It is especially vital to protect forage-based farming where pests and diseases can increase costs and reduce productivity. This concerns all forage-based farming activities. Therefore, the biosecurity system must include the entire sector and indeed the entire nation. This position echoes the sentiments of the current Biosecurity 2025 initiative being led by MPI.

A current focus is on establishing the Government-Industry Agreement (GIA) with commitments from all the various peak bodies representing each primary industry group. Becoming a signatory to the GIA is intended to establish a biosecurity partnership between the sector and the Crown. The GIA Deed outlines the principles for the partnership and the commitments each signatory makes to engage in the wider biosecurity system and co-invest to improve the collective biosecurity capacity and capability of industry and government in readiness and response. Deed signatories can then negotiate and agree the priority (unwanted) pests and diseases of most concern to them and agree actions to minimise the impact of an incursion, or prepare for and manage a response if an incursion occurs. Joint decision-making and cost-sharing is intended to ensure that industry organisations have a formal role, alongside government, in managing their biosecurity risks. Furthermore, industry sectors represented by sector organisations that have not signed the GIA Deed are not entitled to participate in the negotiation and development of operational agreements for unwanted organisms for specific readiness and response activities. However, they may be subject to cost recovery as a non-signatory beneficiary.

Importantly, each various sector groups are already engaged in biosecurity activity. For example, the dairy industry programme includes work specifically directed at forages:

- Dairy Biosecurity Risk Evaluation Framework
- Velvetleaf response
- Development of a biosecurity farm change initiative
- Involvement in B3
- Funding AgResearch projects for pasture pest research across a range of endemic pasture pests

However, at the time of writing, none of the livestock sectors has yet signed the GIA Deed. Furthermore, the various forage sector stakeholders are not currently intending to make a collective commitment to biosecurity but instead are each considering separate commitments. GIA is considered by MPI the way forward for better biosecurity, particularly in the areas of readiness and response. GIA does not, however, restrict industries creating their own collective action, which the forage sector considers to be important moving forward.

[48] Quote from Minister Nathan Guy, BIOSECURITY 2025 - Protecting to Grow New Zealand, 2016

A first step for the forage sector is to convene a Forage Biosecurity Council (mirroring the Livestock Sector Council) with at least the following representatives[49]:

- Beef + Lamb New Zealand
- DairyNZ
- Deer Industry NZ
- Federated Farmers of NZ (FFNZ)
- The New Zealand Grain & Seed Trade Association (NZGSTA)
- Foundation for Arable Research (FAR)
- AgResearch
- Ministry for Primary Industries (MPI)
- Regional councils (which play a role in the long-term management of established pests)

There is also a clear need to somehow include representatives of agricultural contractors, machine operators and nursery growers who must play a vital role in managing biosecurity risks and containment of pests and weeds already within New Zealand. As outlined in the previous sections, New Zealand already has some of the worst pasture pests and dealing with these effectively is just as important as managing border security. This effort needs to be led by the forage sector as a high priority, and should precede any operational agreements.

Actions
Convene the Science and Agronomy Advisory Group to develop the overarching brief for the forage-related biosecurity plan
Develop an over-arching New Zealand Forage Sector biosecurity plan in partnership with all forage sector stakeholders. This will complement the GIA arrangements and establish the context for Operational Agreements to be negotiated under the GIA
Develop a specific initiative to set standards for agricultural contractors and machine operators to better manage the containment of forage pests and diseases. This will be a consultative process

Initiative 1.3 — Joint Position on Forage System Provenance and Product Integrity

New Zealand's agricultural sector mainly comprises extensive pastoral systems. This is widely regarded as a positive aspect, both in terms of its image and the composition of the products. The challenge for the sector is to convert this provenance into market value with a market premium and dependable market demand for New Zealand's agricultural produce above and beyond what can be achieved otherwise. This sentiment is reflected in a recent statement by New Zealand's special agricultural trade envoy, Mike Petersen:

"It's time to move onto the front foot to generate future wealth with a new primary sector story. Trust, reputation and integrity are the key ingredients"[50].

In terms of image, there is a marked contrast between the meat and dairy sectors in terms of the willingness to base their value proposition on its provenance in terms of extensive pastoral systems. The meat sector has largely embraced the New Zealand proposition, with Silver Fern Farms adopting the tag-line "Made of New Zealand", and the following claim:

Our animals are reared as nature intended, on the lush, green pastures of free-range farms in one of the purest lands in the world. All Silver Fern Farms' lamb, beef and venison are grass-fed and raised with care by our collective of passionate New Zealand farmers. These qualities, combined with our commitment to the highest levels of food safety, ensure our brand and products are sought-after worldwide.

This statement is backed up with a farm assurance programme that validates the animals meet the "grass fed" standards which comply with the US Department of Agriculture's definition of "grass fed". This programme is in turn audited independently. It is also not unique within the red meat sector, with other New Zealand companies having similar programmes. There are exceptions. Companies processing culled dairy cows, which are largely exported as manufacturing beef, will not claim "grass fed" as the animals may have been partly fed on supplements.

[49] The Department of Conservation, Landcare Research and Plant & Food Research may also be included
[50] Farmers Weekly, 22 August 2016

In contrast to the red meat sector, the New Zealand dairy sector has been more reticent in promoting its provenance. This is partly due to New Zealand's heavy reliance on supplying dairy ingredients to multinational customers whose brands do not incorporate "New Zealand" and who require flexibility in their sourcing. It is also due to the current reality of dairy farming where imported feeds comprise nearly 8% of the total national feed budget (see previous sections). While some dairy farmers use less than the threshold 5% specified in the USDA standards, it can also be considerably higher on individual farms. Also, *"some farmers … use imported supplementary feed with their cows, particularly during adverse weather like droughts*"[51], but there has been an economic decision by some dairy farmers to maximise milk production within an overall marketing system that does not provide any financial incentives around specifying the feed supplied to dairy cows. This is a prime example of an unconscious collective decision being taken within an industry. One notable exception to this is in a recent initiative by Synlait to source grass-fed milk for infant formula marketed to the US, and to pay a premium for this supply above the standard milk price.

There is real substance to the grass-fed value proposition. Research spanning three decades suggests that grass-based diets can significantly improve the fatty acid composition and antioxidant content of beef[52]. Grass-fed beef contains between two and five times more omega-3s than grain-fed beef. Similarly, grass-fed milk is richer in omega-3 fats, vitamin E, beta-carotene, and conjugated linoleic acid (CLA). While it may be serendipitous that our farming systems have such benefits, New Zealand can still squander the opportunity through compromising the integrity of the product, or simply failing to market it.

There also needs to be a concerted effort to engage the New Zealand brand. The current efforts around "the New Zealand Story" highlight a disconnection between agricultural and national aspirations. It appears to want to move past agriculture and promote different aspects of the economy.

New Zealand is renowned globally for its clean environment and farming expertise. What isn't widely known is the competitive edge we have in other sectors thanks to the innovation and resourcefulness inherent in our businesses[53].

The business toolkit, and wider New Zealand Story, are designed to tell a more accurate and consistent story about New Zealand offshore, generating greater value for our exports and broadening global perceptions of our country.

However, with agriculture making up 45% of all merchandise trade exports it is disingenuous to suggest that these are not central to generating greater value for our exports. It is vital that the stakeholders in the forage-based farming sectors, which must include the export marketing companies, engage in not only telling a more accurate story about the provenance of New Zealand's agricultural products, but also creating the systems and incentives to protect its integrity. Part of this should include development of grass-fed standards for our farming systems.

Furthermore, New Zealand is already behind the pace in promoting the attributes of its farming systems. Ireland's Origin Green programme claims to be the only sustainability programme in the world that operates on a national scale, uniting government, the private sector and food producers through Bord Bia, the Irish Food Board. Origin Green in fact goes beyond sustainability and explicitly promotes the benefits of Ireland's grass-fed farming systems. At the same time, Ireland's largest dairy company Kerrygold is actively promoting the unique attributes of Ireland's grass-based farming methods to consumers in Europe, the US, Asia and Africa.

Actions
Engage with the New Zealand Story to ensure pastoral agriculture is not left behind, and the kaitiaki, integrity and resourcefulness of New Zealand's forage-based farming sector is better promoted
Establish the business case for a New Zealand grass-fed minimum standard, supported by scientific and marketing evidence, and develop this standard for adoption in both the red meat and dairy sectors
Industry groups to maintain a watching brief on new forage and feeding practices in conjunction with the export marketing companies

[51] http://www.fonterra.com/ "Fonterra and palm kernel expeller"
[52] A review of fatty acid profiles and antioxidant content in grass-fed and grain-fed beef, Daley et al, Nutrition Journal, 2010
[53] The New Zealand Story Business Toolkit, http://www.nzstory.govt.nz/

Initiative 1.4 — Coordinated Regulation for Forages

The forage sector is facing increasing regulation on a wide range of fronts. There is currently only limited coordination of the efforts to manage this. Three areas that have been identified where the forage sector has a lot at stake, and common interests among stakeholders, are:

- Genetically modified organisms (which includes gene editing options under current regulation)
- Agrichemicals
- Greenhouse gas Issues
- New forage species

Genetically Modified Organisms

Genetically modified organisms (GMOs) are a divisive topic, holding great opportunity but also fraught with difficulty for policy makers, product marketers and the primary producers. It is also related to the previous issue of provenance and product integrity. This area must be addressed by the forage sector, and requires coordination of all the stakeholders.

The current regulatory stance in New Zealand precludes the use of GM forages and means it is not practical to field test them in New Zealand. The New Zealand GMO regulatory regime is cautious by international standards, and potentially at odds with some of our major trading partners and competitors, such as other jurisdictions, including key trading partners such as the US, EU, and Australia. While the Royal Commission on Genetic Modification in 2000 recommended that New Zealand should take a cautious approach to genetic modification, but should not shut the door on it, the general effect of the current approach is discouraging. Furthermore, the regulation is potentially already unworkable in the sense that some GMOs created with modern DNA editing technologies are indistinguishable from non-GM organisms.

In contrast, North America, South America, China, and India have already adopted GM feed crops; Europe is growing GM crops on a limited basis; and other countries are at various stages of adoption. These jurisdictions are also drawing a line between the uses of GM crops as animal feed versus direct use for human consumption. The new US GMO labelling law signed in July 2016 allows US dairy farmers to feed genetically modified crops to non-GM cows, without the products then being designated as GM. New Zealand must therefore anticipate the widespread adoption of GM technologies[54] and of pastoral farming products being produced and marketed without labelling as having used GM forages in their farm systems. There is a risk that this renders New Zealand's "GM Free" product proposition largely moot. Ironically, New Zealand-owned GM forage discoveries are already being licenced for use in the Northern Hemisphere. The relevant patents expire from 2029 through to 2033, so there is some urgency in commercialising them even if that means taking the technology offshore. If these traits can be effectively introduced in the feed production systems for the Northern Hemisphere, then New Zealand will face considerable competition.

At the same time, there is currently a degree of anti-GMO market sentiment which makes export marketing companies reluctant to embrace GM technology. GM forages are generally likely to be inconsistent with current consumer perceptions of organic, paleo, grass-fed and other health orientated brand attributes. This manifests in New Zealand company policies which generally do not support GMOs at the current time.

"We also listen carefully to our consumers and customers and recognise the value in New Zealand's global reputation for its GM status, as supported by the current New Zealand regulatory framework". – www.fonterra.com, 2016

The challenge that New Zealand faces is an inherently uncertain future, where GM forages could either be a boon or a hindrance. A 2015 study commissioned by DairyNZ[55] through the Primary Growth Partnership identified four possible global scenarios. Under "Scenario 1: Consumer is King – The volume to value revolution" the ideal positioning for New Zealand is GM-free. "New Zealand's nuclear energy free and GM-free stance is now paying rich dividends as society has become increasingly opposed to these technologies". However, in the somewhat negative "Scenario 2: Governments Dictate – Political chaos & shrinking markets", consumers are price driven and more tolerant of GM technologies. New Zealand's GM-free stance has cost the sector dearly through an inability to access break-through technologies and a consequent loss of competitiveness. These contrasting scenarios highlight what is at stake. It is also unclear whether, and when, consumers will ever really differentiate and weigh the respective environmental benefits of GM forages versus the perceived risks to natural systems. This is a complex and emotive issue where New Zealand's position will have little bearing on the rest of the world, and a very limited ability to influence it.

[54] Source: Pastoral Genomics, Science Report.
[55] Dairy Industry Scenarios: Informing Dairy Farm Systems for the Future, DairyNZ and MPI

However, a broad perspective is needed which places this in the context of obtaining information and maintaining options. For New Zealand as a nation the debate on the introduction of GM forages is premature, and can only harden positions without yet knowing what the future of world markets will bring. The challenge will be to maintain options for both a GM-free future and one which embraces GM technology. This includes developing and maintaining technical capability, without actually crossing the line to push for its adoption. At the same time, New Zealand's regulatory framework must strive to remain in step with the rest of the world so as not to place it at a severe disadvantage under possible future circumstances.

At an overall policy level New Zealand needs to maintain optionality for the future for both GM-free and GM forage possibilities. This requires investors to discern what GM research will best provide options, rather than being premised on a single view of the future, and is most cost-effective towards this goal. The Forage sector can provide advice on achieving this end.

Actions:
The forage sector needs to work collectively with government to ensure the GMO regulations which apply to GM forages continue to be consistent and workable as the technology evolves

Agrichemicals

New Zealand farming systems use both herbicides and pesticides. Herbicides are an extremely important tool in pasture renewal and cropping, being principally used to remove old pastures, including weeds, which would otherwise compete for light, moisture and nutrients. Insecticides are used mainly to control insect pests on forage crops in New Zealand, but also have an important use in seed coating for pasture seed. The main issue facing pastoral farming systems is the possible withdrawal of authorisation for commonly used agrichemicals when there are only limited, and less effective alternatives available. This will be compounded if herbicide/pesticide resistance develops.

In New Zealand, the sale and use of agrichemicals is regulated under the Agricultural Compounds and Veterinary Medicines (ACVM) Act 1997 and the Hazardous Substances and New Organisms (HSNO) Act 1996. The ACVM Act seeks to achieve its purpose by providing that no agricultural compound may be used in New Zealand unless that use is authorised by or under this Act. The HSNO Act is administered by the Environmental Protection Authority (EPA). The purpose of the HSNO Act is to protect human health and the environment by preventing or managing any harmful effects of hazardous substances and new organisms. The EPA regulates the manufacture, import, use, storage and transhipment of hazardous substances including agrichemicals.

The main herbicide used on New Zealand farming systems, as in the rest of the world, is glyphosate. This is a broad-spectrum herbicide that works by inhibiting a plant enzyme and is extremely effective in achieving the complete removal of vegetation. However, as a result of the recent review of glyphosate by the International Agency for Research on Cancer, glyphosate was re-evaluated in 2016 by the European Food Safety Authority and the Expert Task Force established by the WHO to update that risk assessment to include all new data generated since the previous evaluation. One WHO agency found that glyphosate was "probably" carcinogenic, although there was no scientific consensus. The Environmental Protection Authority (EPA) then commissioned a review of the evidence relating to the possible carcinogenicity of glyphosate in New Zealand. In August 2016 this review concluded that glyphosate is "unlikely" to be carcinogenic and should not be classified as a mutagen or carcinogen under the HSNO Act. The review also detected no glyphosate residues in New Zealand raw milk or retail dairy products. Hence the issue has been resolved, at least for the moment.

The issues around insecticides are also linked to the use of GM technologies, in particularly the development of Roundup ready plants marketed by Monsanto where glyphosate can be used without harming the crop. These innovations have a negative perception in some markets, and with groups generally opposed to large business interests controlling food-chains.

Lobby groups in New Zealand continue to pressure national and local government bodies to ban glyphosate and other agrichemicals. For example, the Auckland Council has decided to review its use of glyphosate after a public petition signed by only 3,696 people was presented in July 2016. There is a risk that this type of activism could eventually succeed in some form. As with other activist campaigns, it is vital for primary industry to remain true to the fundamental principles of protecting human health, while still defending its use of agrichemicals that do not present a risk. This is best achieved through a collective representation of the forage sector, working with government and other stakeholders to achieve the best outcomes.

Insecticides are also significant for forages. They are an important part of pasture renewal with their use in seed coats for sown species helping to ensure good establishment of new pasture. After sowing, insecticides are mainly used to control insect pests on forage crops in New Zealand rather than pasture. The main issue with the use of insecticides on pasture, apart from cost, is that they can disrupt the natural predator-prey dynamic and lead to a counter-productive boom in insect pests whose populations recover faster than the associated predator population. Nonetheless, around 79 tonnes of insecticide active ingredient is applied annually to New Zealand pastures[56].

In New Zealand and other parts of the world older insecticides have progressively been withdrawn, albeit slowly. New Zealand's comparatively slow progress in removing broad spectrum insecticides such as diazinon from the market reflects agriculture's high dependence on such products and a lack of alternatives, particularly in the forage sector. There is concern that new insecticides will not be available to the New Zealand pastoral sector to replace older withdrawn products, particularly given the small New Zealand market size and lack of technical support domestically, lack of sufficient data protection for agrichemical companies and other commercial considerations. The main concern is around the potential withdrawal of organophosphate insecticides which dominate the available registered products. There is also a risk that farmers would choose to use "off label" insecticide products, which could undermine the industry's reputation.

Some markets such as Europe are very sensitive towards pesticide usage and residues. New Zealand pastoral farmers may find their heavy dependence on broad spectrum chemicals for pest control is problematic to developing a strong position around provenance and product integrity. The potential for damage to the sector's reputation is significant.

Actions:
The forage sector will engage with AGCARM to include them in the science and agronomy advisory group as it considers agrichemicals
Conduct a joint review of agrichemical use and alternatives in New Zealand, and the assessment and re-registration process, to clarify the potential implications and outcomes for the sector

Greenhouse Gas Issues

Agriculture contributes almost half of New Zealand's greenhouse gases through emissions of methane and nitrous oxide. This is a key issue for the future of the forage sector, particularly in the role it can play towards meeting New Zealand's 2030 emissions reduction target under the Paris Agreement. The New Zealand ETS puts a price on carbon dioxide emissions. This is intended to provide an incentive for people to reduce emissions and plant forests to absorb carbon dioxide. Certain sectors are required to acquire and surrender emission units to account for their direct greenhouse gas emissions or the emissions associated with their products.

Currently, biological emissions from agriculture are excluded from the ETS. This is based on the following rationale:

1. In the absence of viable alternatives to reduce biological emissions per unit of production, New Zealand agriculture cannot respond to a methane and/or nitrous oxide tax with changes in farming practices and hence it would simply reduce the profitability of the sector, and potentially reduce farming activity in New Zealand
2. International competitors in global markets also exclude agriculture from a tax on biological emissions, and would gain an unfair market advantage from an ETS including agriculture
3. New Zealand agriculture is relatively carbon-efficient and a reduction in activity due to tax on biological emissions would lead to a net global increase in emissions when this effect was compensated for with a production increase elsewhere in the world

This exclusion of agriculture from the ETS should be considered a temporary reprieve. It is vital for the competitiveness of the Forage sector that agriculture be excluded from the ETS while its main international competitors are also excluded. However, there are future scenarios where that will change and inclusion in the ETS would actually become a necessary condition for access to key international markets.

[56] A review of insecticide use on pastures and forage crops in New Zealand, Chapman (AgResearch), 2010

Also, the forage sector is already investing significant resources through the Pastoral Greenhouse Gas Research Consortium (PGgRc) to provide knowledge and tools for New Zealand farmers, so they can mitigate greenhouse gas emissions from the agricultural sector. Much of this effort has focused on animal biology. Some work has been done on identifying currently available forages, such as brassica rape and fodder beet, which fed in the right proportions, could lower methane and also nitrogen output. There is also some research identifying plant metabolites that could act as natural nitrification inhibitors to reduce losses from soils, which would in turn reduce nitrous oxide emissions. As this research starts to deliver viable options for farmers to reduce their emissions, the context for the current policy settings will change. However, from July 2016 PGgRc research on low-methane feeds has been put on hold to concentrate efforts on other parts of the programme.

Consideration of options and future timing remain vitally important to the forage sector. Again, working closely with government is essential. There is a risk of a partisan approach being taken as not all livestock are equal in terms of emissions. This discussion document represents the view that the greater good can be achieved by working together. The sector has very recently convened a Biological Emissions Reference Group including representation from farming sector stakeholders, export marketers and government.[57]

Actions:
Identify funding options and re-commence research into forages and feeding regimes for reduced greenhouse gas emissions
Work collaboratively to inform policy and investment affecting the exposure of the sector to risks from both inclusions in the ETS and non-tariff trade barriers related to emissions

New Forage Species

New Zealand's pastoral agriculture is reliant solely on introduced forages, but is now restricted to using only species introduced prior to 1998 unless given dispensation by the EPA. This arbitrary restriction limits the options available to the sector, and is potentially unnecessarily cautious.

Actions:
Work with stakeholders and policy makers to enable the introduction of new forage species where this is justified

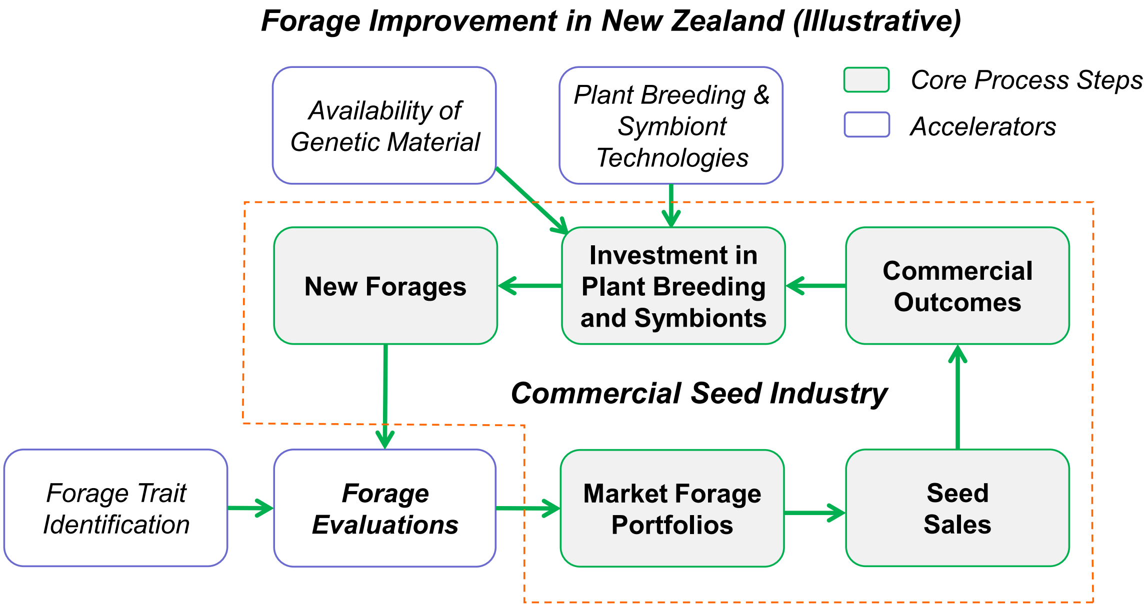
6.3 Forage Improvement

New Zealand's forage improvement system is largely driven by the commercial companies who dominate seed production and distribution. They are supported by research institutes and universities, as well as industry good organisations, and closely linked to the farming sector which they serve. The 2011 Forage Review, which was primarily driven by DairyNZ and the commercial seed companies, identified the feedback in this system fuelled by competitive pressures between the major seed marketing companies.

The forage improvement process involves a cycle of continuous improvement. The core process steps begin with investment in plant breeding leading to promising new plants being developed. These are evaluated and then based on their performance the company adjusts its portfolio and implements a revised market plan. The resulting sales performance drives commercial outcomes and these in turn are a strong driver of investment. Since 2015, this view has become even clearer as AgResearch has since stepped back from commercial plant breeding to focus on plant breeding technologies.

Other parties, particularly research institutes, contribute to this system through making available useful genetic material, and developing improved plant breeding and symbiont (endophyte and rhizobia) technologies. Indeed, these three areas represent key choke-points where further investment has the potential to accelerate the rate of plant improvement for New Zealand forages. Industry good organisations also contribute to the forage evaluation process in New Zealand, particularly for ryegrass. The overall forage improvement process centred on the commercial seed industry is illustrated below.

[57] Biological Emissions Reference Group, Terms of Reference, 24 August 2016



A feature of the commercial seed companies operating in New Zealand is that their economic model is based on seed sales. All the contributing technologies are embedded in the cultivars, which each generally take over a decade and approximately $4 million commercial investment to bring to market[58]. The investment in their development can only be realised through seed sales. While New Zealand is fortunate to have a strong self-sustaining commercial forage seed industry, this can also present challenges for the forage sector where the commercial imperatives for seed companies and various farm systems are not always fully aligned.

It is particularly important that New Zealand's plant improvement system anticipates future challenges including climate change and requirements for environmental outcomes. Given the long timeframes of decades involved in plant breeding, these objectives cannot always be left to the market where the seed market incentives may lag behind the farming sector requirements. Some conscious involvement by the wider stakeholders in the forage sector to promote their cause earlier will be beneficial in this case.

Also among the challenges that this discussion document seeks to address is managing opportunities that would otherwise be missed. These include challenges such as national forage evaluation aligned to farm systems, and the development of genetic (plant breeding) technologies that are simply too big for any single commercial seed company to grapple with alone and where the benefits would not necessarily accrue to a seed company anyway. There are also plant improvement opportunities that are too small as commercial prospects even where the overall value to the wider forage industry might justify the effort, such as for farm systems in challenging environments. This spectrum of opportunities, shown below, is where a Pastoral Industry Forage Strategy can bring the collective resources together to create a better system. The solutions indicated in this figure are described in further detail in the following sections.

[58] Source: 2011 Forage Review

	Too Large	Commercial Opportunities	Too Small
Description	Issues and opportunities that are too large for any single organisation to grapple with, or where the rest of the industry participants will resist change unless the whole industry can benefit.	Opportunities that companies can see enough commercial benefit in to pursue by themselves, in a competitive market.	Opportunities that are too small, or where the initial investment of effort is unlikely to provide a commensurate return to the investor.
Criteria	• Large investment required • Uncertain outcomes • Benefits not exclusive or accrue to sector rather than seed company	Viable commercial business model based on: • Potential profit margins • Market scale	• Immature or small market • High costs to develop (versus following another) • Production challenges
Examples	• Forage Value Index • Developing genetic technologies	• Ryegrass cultivars • White clover cultivars	• Importing and improving new cultivars of a 'minor' forage species
Solutions	• Forage Industry Collaborations	• Commercial Activity	• 'Industry Good' support by farming sector peak bodies

The current market for forage seeds as set out in section 2.3 highlights the extent to which ryegrass and clover dominate the seed industry. Different ryegrass types comprise 96% of grass seed sales by volume. White clover comprises 62% of legume seed sales by volume. Red clover is also significant at 23% of legume sales. Lucerne sales have grown over the past decade to now comprise nearly 12% of the legume seed market. At this level, the market is large enough to support investment in forage improvement. Below a certain threshold, the proposition becomes uneconomic for seed companies unless they are supported by some form of industry subsidy.

This discussion document acknowledges substantial genetic gains have been achieved in a range of temperate forage grass and legume species in New Zealand over previous decades. These gains in forage yield and quality have often exceeded 1% per annum, and compare favourably with gains made in cereals and for similar species internationally[59]. A recent analysis of genetic gain in perennial ryegrass[60] has found that since 1990 the genetic gain in total annual yield has been approximately 0.86% per annum, six times higher than in the decades before 1990. Combined with a focus on the high-value periods of winter, summer and especially autumn this has meant the value to farmers will have been closer to 1% per annum.

The analysis also suggests that many firms continue to commercialise very poor performing cultivars, mostly in Australia, with the performance of the worst performing cultivars marketed in Australia actually falling over time. This highlights the importance of transparent cultivar evaluation schemes and in Australia, the predictable consequence of not having to inform purchasing decisions of Australian producers.

Initiative 2.1 — Forage Evaluation

Forage evaluation in New Zealand has advanced significantly in recent years with the development of an economic index for perennial ryegrass, the Forage Value Index (FVI) since 2011. This is a relatively new concept in forages. By contrast, in dairy cattle breeding the concept of an economic index rating animals and economic values underlying that index is well established. The benefits of a transparent index should be obvious in promoting those cultivars with greatest merit.

Historically, forage evaluation data for individual cultivars was either displayed using absolute numbers for seasonal dry matter production within a season or across all seasons with a notation to indicate statistical differences, or percentage values where a reference cultivar is 100. The adoption of an economic index and routine evaluation approach for perennial ryegrass provides a method to identify traits of economic importance to focus plant breeding efforts better, and to provide clarity for farmers around predicting cultivars that will maximise farm profit. It also allows for routine tracking of genetic gain of individual traits and the economic index[61].

[59] Genetic Improvements in New Zealand Forage Cultivars; Woodfield, 1999
[60] Perennial Ryegrass Genetic Gain in Australia and New Zealand; Harmer, Steward & Woodfield, 2016
[61] *'Development of a forage evaluation system for perennial ryegrass cultivar and endophyte combinations in New Zealand dairy systems', Bryant, Chapman, Leonard, McMillan, Kerr , Judson, Cookson & Edwards, 2013*

The current FVI has been specifically developed to assist in perennial ryegrass cultivar selection for grazed pastoral dairy farm systems to maximise economic value. It is calculated for four regions (Upper North Island, Lower North Island, Upper South Island and Lower South Island), and over five seasonal periods (winter, early spring, late spring, summer, autumn) from performance values for cultivar and endophyte combinations derived from National Forage Variety Trials conducted in each of these four regions. The combination of trials and expertise to generate the FVI represents a significant investment by stakeholders. That investment is also ongoing with continual efforts to extend and improve the index from its current focus on DM yield and timing to also include factors for forage quality and persistence.

This discussion document has identified a significant desire from stakeholders for a similar economic index to be developed for other forages and other farm systems. This would include systems in challenging environments, where for example traits such as nitrogen and phosphorus use efficiency and an ability to access soil moisture at greater depths might be more valuable. In making this recommendation, it is important that the first step should be evaluating the economic justification, and considering how any new index and associated forage trials would be supported with ongoing funding. The current index has been primarily funded by DairyNZ (using levy monies) and NZPBRA representing the commercial seed companies. An index for minor forage species and dry-stock farm systems will require alternative funding sources.

There is also a need to consider incorporating traits that contribute to improved environmental outcomes. The industry needs to develop protocols for evaluating the relevant traits (see next section). This should not be limited to just consideration of perennial ryegrass cultivars.

Actions:
Extend the current Forage Value Index to include new traits, including quality and persistence, underway in a partnership between DairyNZ & NZPBRA
Validate the current Forage Value Index using a three to five-year strain trial
Beef + Lamb New Zealand, NZPBRA and DairyNZ partner to evaluate the opportunity and costs for extending FVI to other species and systems, and identify a suitable funding model where the effort is justified
Contingent on a valid business case and viable funding model, develop a Forage Value Index methodology suitable for sheep and beef farm systems, and re-evaluate cultivars accordingly
Contingent on a valid business case and viable funding model, develop a Forage Value Index to include additional forage species

Initiative 2.2 — New Forage Traits and Genetic Material

Plant breeders use forage trait information as the basis for selection in plant improvement. Identifying and developing a full understanding of forage traits is hence essential to forage improvement. The three primary traits of grasses and clovers driving pasture productivity in grazed forage systems are dry matter (DM) yield, nutritive value or quality, and persistence. While herbage yield and quality are relatively well understood, especially for common forage species such as perennial ryegrass, persistence is more complex.

One of the current research efforts is to better understand the persistence of perennial ryegrass[62]. A recent analysis used 10-year longitudinal data sets (only possible where such trials had been conducted) from perennial ryegrasses trials. The analysis showed high performing cultivars yield significantly higher over three years and this also correlates strongly with their performance through to the eighth year, but the advantage then falls away by year 10. One conclusion is that three-year trials can be sufficient to evaluate forage value over a 10-year period, based on how the performance advantage persists. However, significant questions remain including what plant attributes are important to the overall persistence trait. These are required by plant breeders in their selection process.

[62] Persistence of dry matter yield among New Zealand perennial ryegrass cultivars, Chapman et al, Grasslands, 2015

Additional traits for investigation, including in relation to minor species, include:

- Overall feeding value
- Nitrogen concentration
- Drought tolerance
- Heat stress tolerance
- Tolerance/resistance to insect pest and soil pathogen pressure
- Tolerance to feeding pressure
- Aluminium tolerance (especially of legumes)
- Response to increasing carbon dioxide levels

Nitrogen concentration in forages may be relevant to managing the issue of nitrate leaching, and therefore production levels especially on dairy farms. This direction of forage breeding for improved environmental outcomes is a very recent development. Other traits, particularly drought tolerance, heat stress tolerance and tolerance for increasing carbon dioxide levels are becoming increasingly important to forage improvement depending on the extent of climate change.

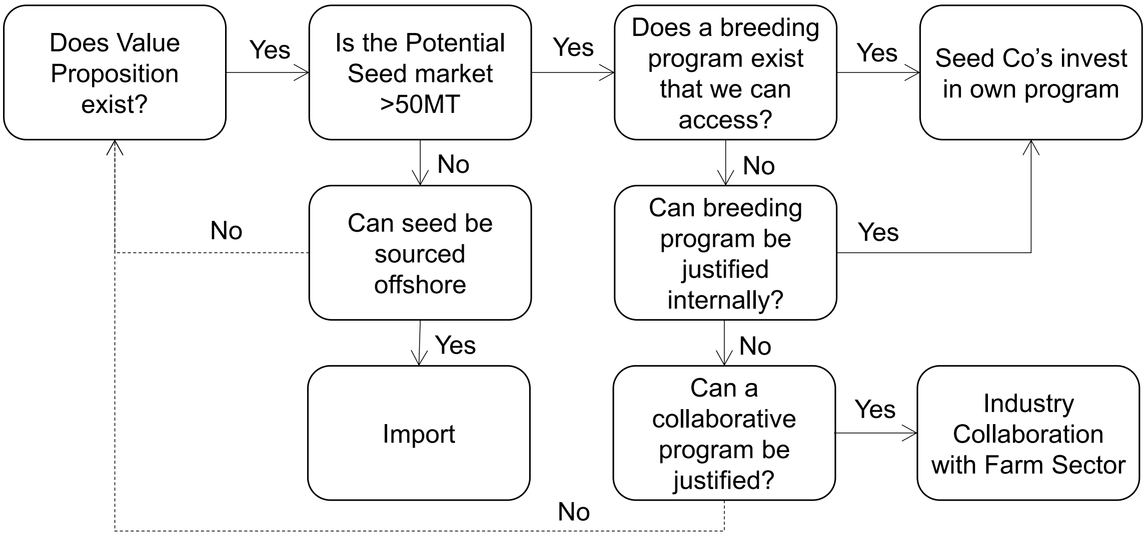
However, public funding for understanding various trait mechanisms and plant tolerance to pests has ceased, leaving it up to industry and the discretion of CRIs with regards to core funding. Science capacity in plant physiology, plant ecology and pest management has already declined due to historical reductions in funding.

Even having identified key traits and their genetic markers, plant breeding still needs to start somewhere. The most important factor is to start with sufficient genetic variation in the desired characteristics. This enables plant breeders to select and multiply the characteristic of interest. The work of the Margot Forde Forage Germplasm Centre in obtaining, conserving, replenishing and distributing germplasm for research and development of new varieties is particularly vital. The collection currently includes over 90,000 seed samples, and recent collection missions around the world continue to generate important opportunities for New Zealand plant breeders – especially in traits suitable for more challenging environments.

There is also a need to source improved plant material from international breeding programmes for minor or alternate forage species. Different species which are already adapted to different environmental stresses may provide better options than attempting to breed ryegrass and white clover cultivars for every purpose. Specific examples include deep-rooted, top-flowering annual clovers, for example, which may prove particularly important to drier, eastern farming areas, though their tolerance to clover root weevil will need to be assessed. However, New Zealand represents a small market, especially in these minor species, and so at present there are no plant improvement programmes locally. New Zealand needs to source these minor species from other countries.

New Zealand cannot rely on overseas sources of minor species forage seeds to continue indefinitely. Some public expenditure in overseas industries such as for Australian sub-clovers and annual top-flowering clovers is being withdrawn, and the current availability of material could change as a result. Also, the acceptability of plant material sources could become limited if overseas plant improvement programmes start to include genetically modified material. Because there are potentially 20-year time horizons involved in developing the opportunity, it is imperative to start sooner rather than later.

New plant breeding programmes for minor species are not without their challenges. For example, Caucasian clover seed production has ceased in New Zealand, and the demand particularly from high country farmers is no longer met. Arrowleaf and Persian clover cultivars are sourced from overseas. While there is potential for a niche seed market through selection of locally adapted forage legume germplasm, this has not been taken up by any of the commercial companies. Potential approaches to create a local supply could include grower co-ops or on-farm production by farmers for their own use. However, these are unlikely to gain traction without some over-arching co-ordination and direction from the sector. Central to this would be a decision pathway for determining whether the minor species was viable for commercial seed companies, or would require some other form of collaboration. A proposed pathway is shown below.



Actions:
Identify and develop a better understanding of key traits needed for future forage breeding objectives including environmental outcomes, and anticipated environmental stresses under climate change. Industry investment in this area will re-build and retain capability
Identify genetic markers associated with key forage traits, particularly in the major forage species
Coordinate collection missions for the Margot Forde Forage Germplasm Centre towards obtaining genetic material most likely to meet future requirements such as from regions which have environmental conditions likely to match the future New Zealand environment, and provide genetic diversity to plant breeders
Evaluate minor species for their importance to future New Zealand forage systems, and then develop strategies for sustainable sourcing of the most important species. Work with commercial seed companies to identify the best pathway for the introduction of minor species

Initiative 2.3 — New Plant Breeding Methods

Plant breeding is the art and science of changing the traits of plants to produce desired characteristics, and is pivotal to forage improvement. There are six steps:

1. Collection of genetic variation
2. Selection
3. Evaluation
4. Release
5. Multiplication
6. Distribution

In New Zealand the process is largely managed by commercial seed companies, and they are supported in this by the industries they service. The Margot Forde Forage Germplasm Centre plays a key role in obtaining, conserving, replenishing and distributing germplasm for research and development of new varieties. The farming sector, represented by levy-funded organisations, universities and CRIs also currently contribute to the research and development of improved plant breeding methods around selection and evaluation. They have also invested significantly through Pastoral Genomics in genetic technologies.

The purpose of this activity to support commercial plant breeding is to accelerate the rate of genetic improvement and create greater value for the pastoral farming sector. Three main directions can be pursued to this end:

- Hybridisation
- Genomic Selection
- Genetic Modification

Hybridisation:

Two benefits of hybridisation relevant to forage improvement are genetic variation and hybrid vigour. These represent separate strategies in plant improvement. The chief objective of hybridisation is to create genetic variation[63] by crossing two genotypically different plants. This enables the plant breeder to introduce new, useful traits. However, heterosis or hybrid vigour is also relevant and is commonly used to improve yield and fertility. The key to all successful hybrid breeding is resolving compatibility issues between genotypically different plants.

Hybrid ryegrasses (*Lolium x boucheanum* Kunth. Syn: *Lolium x hybridum* Hausskn.) are the most common interspecific hybrids used in New Zealand pastures. These are generally produced by plant breeders crossing Italian or annual ryegrass with perennial ryegrass. Depending upon the proportion of the parental species the result may be a long rotation ryegrass performing in a similar manner to perennial ryegrass or a short rotation ryegrass performing more like an Italian ryegrass. They provide better winter production than perennial, and in summer wet areas, most long rotation ryegrasses cultivars can persist for up to five years or more, while short rotation ryegrasses may last only two to three years. In summer-dry environments they may last much less than in moist conditions. Some hybrid cultivars are available with novel endophytes which enhances their insect resistance and persistence.

The short rotation hybrids were enabled by the historical collection of ryegrasses from the Mediterranean region, and the insight from New Zealand plant breeders about the potential for a valuable cross. It may be possible to have further success with grasses collected from other regions around the world, especially those with climates, soils and topographies that match New Zealand conditions. Also, perhaps more importantly, those regions whose current conditions more closely match what might be expected in a future, warmer New Zealand with climate change. The potential benefits arising from diverse plant collection are wider than just hybrid opportunities.

Possibilities for beneficial forage hybrids extend beyond ryegrasses. Current work on interspecific clover crosses is showing considerable promise, and may confer useful traits not available to breeders in the main clover species used in New Zealand. Regardless of the specific forage species, the key to a successful outcome is to have clear-cut objectives in making a cross, and to select parent plants to fulfil these objectives. The wider forage sector can be involved in setting the objectives.

A second approach for hybrids utilises heterosis which can increase crop yields by 15-50%. This has been successfully used in maize, where F1 hybrids have enabled quadrupling of production and dominate the global maize seed industry. Rice, canola, sorghum, sunflower and many other crops have also successfully used F1 hybrids to increase production. However, there are significant challenges to capturing heterosis in pasture species such as perennial ryegrass, mainly self-incompatibility and inbreeding depression.

Significantly, Dairy Bio in Australia has recently successfully developed a heterosis hybrid perennial ryegrass. This was achieved with a novel F1 hybrid breeding design that overcomes inbreeding and self-incompatibility issues. The F1 hybrid technology for ryegrass is now in the initial stages of being developed for commercial use in New Zealand.

Wider industry and research institute investment in hybrid breeding schemes and solving incompatibility issues is a necessary step. This investment creates the opportunity and greater certainty for commercial seed companies to then develop these improved hybrids for general use by pastoral farmers, which benefits the whole sector. Commercial seed companies are very unlikely to accept all the risk of pioneering these hybrid pre-breeding technologies themselves for the New Zealand market.

[63] This is premised on having genetic diversity in the first instance, which emphasises the importance of maintaining collections of germplasm such as the Margot Forde Centre.

Genomic Selection:

Genomic selection (GS) is an approach for improving quantitative traits in large plant breeding populations which uses whole genome molecular markers (high density markers and high throughput genotyping). Genomic prediction combines marker data with phenotypic and pedigree data when available to increase the accuracy of the prediction of breeding and genotypic values. It has significant advantages over traditional plant breeding programmes which rely mainly on phenotypes being evaluated in several environments with selection and recombination being based on the resulting data plus pedigree information, when available.

Genomic selection provides an attractive option for accelerating genetic gain in perennial ryegrass improvement by reducing the length of the breeding cycle. Recent modelling work suggests that the availability of genomic estimated breeding values (GEBVs) for productivity traits would permit a four-year reduction in cycle time, which could lead to at least a doubling and trebling of genetic gain for persistency and yield, respectively, versus the traditional programme[64]. However, there was also a higher rate of inbreeding per cycle among varieties for the genomic selection approach.

The next important step for the New Zealand forage sector will be developing the technology to validate these gains. This includes developing genomic estimated breeding values for the key traits involved. The Pastoral Genomics research consortium is now focused on this opportunity.

Genetic Modification:

Genetic modification has already received considerable attention in the previous sections, particularly in the coordination of regulations for forages. The potential benefits of genetically modified forages are stated here in the context that they cannot currently be used in New Zealand.

Conventional plant breeding in New Zealand has resulted in genetic gains of no more than 1% per annum, as measured in terms of yield, and there is limited evidence that this has led to equal improvements in animal nutrition. Genetically modified forage plants have potentially significant benefits including environmental outcomes, animal welfare and product attributes. Research on GM perennial ryegrass aims to incorporate traits with significant benefits that cannot be achieved through non-GM pathways. Some of these are potentially game-changing, although they have yet to be proven in field trials. A current business case for one of the GM traits indicates potential benefits of between $2 billion and $4 billion annually[65]. The benefit areas identified for the two main GM ryegrass technologies are described below:

Environmental Benefits	**Productivity Benefits**
Reduce greenhouse gas emissions (less methane production) Reduce greenhouse gas emissions (less nitrous oxide) Reduced nitrate losses (less nitrogen excreted in urine)	Potentially higher nutritional efficiency in animals Benefits to the plant in terms of pest resistance Yield increases Higher feed quality, especially metabolisable energy
Animal Welfare Benefits	**Product Attribute Benefits**
Reduced bloat and other animal health benefits including control of internal parasites	A more beneficial composition of meat products (less saturated fatty acids)

There is a calculated risk with investing in GM forages that consume research funding, but which may never be adopted in New Zealand. The GM forage traits developed in New Zealand have already required a significant investment of tens of millions of dollars. Not having the option to convert this into value for the primary sector is a source of frustration to the researchers involved and the industry. The Pastoral Genomics consortium has also withdrawn from further research in this area to focus on opportunities that can be implemented such as genomic selection.

[64] Genetic Gain and Inbreeding from Genomic Selection in a Simulated Commercial Breeding Program for Perennial Ryegrass; the plant genome; Lin et al; March 2016

[65] *Evaluating the Potential of Forages with Elevated Photosynthesis and Metabolisable Energy, 2016, AgResearch*

Actions:
Develop a New Zealand forage hybrid plan which identifies options for introducing key traits required in target species via hybridisation
Target the collection of novel germplasm for improved forage hybrids
Research investment to develop hybrid breeding schemes for selected forage species
Develop genomic estimated breeding values for ryegrass to enable genomic selection and accelerate genetic gain in perennial ryegrass cultivars
Implement genomic selection for ryegrass in commercial breeding programmes at proof of concept scale
Implement genomic selection for ryegrass in commercial breeding programmes at commercial scale, noting that the timeframe for release of improved cultivars is currently of the order eight to 10 years from starting
Complete offshore trials of GM forages to validate performance of new traits, with commercial development in New Zealand contingent on regulatory stance
Commercialise F1 hybrid perennial ryegrass in New Zealand

Initiative 2.4 — Symbionts

Forage improvement is not just about the plants. The performance of New Zealand forage species also depends on their symbiotic relationship with certain microbes. The two key symbionts which currently contribute to overall forage performance are fungal endophytes of perennial ryegrass and tall fescue, and bacterial rhizobia of legumes. Work with different endophytes in other plants is also occurring, but these are the most relevant.

Novel Endophyte Development

A naturally occurring fungal endophyte (*Epichloë*) infects most ryegrass in New Zealand pastures, and has been widely studied and used by farmers. The ryegrass endophyte grows between the cells of the host plant, drawing nutrients from it. The benefits from this symbiont arise because the endophyte produces chemical compounds within the host plant that confer resistance to insect pests. This in turn confers better persistence and drought tolerance. There are also some potential negative effects where these compounds can affect animal health, welfare and production. The initial research on endophytes was principally concerned with understanding the cause of ryegrass staggers in sheep, and the connection between this condition and ryegrass endophytes was only made in 1981[66]. One of the unique features of ryegrass endophytes is that they are found throughout the aerial parts of the plant, including infecting the ryegrass seed embryo. This means that the endophyte can persist in successive seed generations of ryegrass, along with successive generations of vegetative growth (tillering), making it particularly valuable in perennial pastures.

Since 1981, New Zealand has built a world-class fungal endophyte improvement programme mainly through AgResearch and its subsidiary Grasslanz. There is a long-standing joint venture between Grasslanz and one of the major seed companies, and so the other major seed companies also run their own endophyte programmes. Across these various programmes, New Zealand has an Endophyte Technical Committee (now a sub-committee of NZPBRA) which provides consistent and agreed endophyte evaluation procedures and information on endophyte efficacy. This group is chaired independently by DairyNZ.

A series of novel endophytes, as opposed to wild-type, standard or common-toxic endophytes, have been introduced to the New Zealand market. In the early 1990s, Endosafe was released, but has since been phased out. A significant advance was made with AR1 in 2001, then NEA2 and Endo5 were released in 2005, and AR37 in 2007. Other novel endophytes have also been released more recently, but these basically contain the same alkaloid compounds as previous types. AR37 was significant because it contains a unique group of alkaloid compounds that confer protection against a wide range of insect pests including Argentine stem weevil, black beetle, root aphid, pasture mealy bug and porina. However, AR37 is not effective against grass grub and has also been found to cause staggers under some conditions such as drought when the animals graze the lower part of the plant where the endophyte is more concentrated. Work is ongoing to develop endophytes that are effective against grass grub. However, since the release of AR37 in 2007, none of the more recent ryegrass endophytes has included any new compounds, despite the on-going investment in this area.

[66] An association of a Lolium endophyte with ryegrass staggers, Fletcher & Harvey. NZ Veterinary Journal, 1981

The development of novel endophytes begins with their isolation from cultivars collected from around the world, mostly Europe. These are identified and classified, and the spectrum of chemical compounds they produce is determined, along with the impact these have on important insect pests. Endophyte strains with a good range of insect tolerance are agronomically evaluated in a number of environments and various management styles. Endophytes that are agronomically as good or superior to standard endophytes are then subjected to intensive animal safety and performance testing. One of the complications is that endophyte activity can vary across different cultivars and types, hence the need to screen across a range of endophyte-cultivar combinations. The novel endophyte strains which prove superior to standard endophytes in these aspects of testing then become candidates for commercialisation. These pre-commercialisation steps in the process of novel endophyte development are shown below.

A current rate limiting step in endophyte development appears to be the screening for efficacy step where the endophyte's effectiveness versus insect pests is evaluated and the novel chemistry involved is investigated. The limiting factor in this is resources. As a general observation, all these steps are conducted by a relatively small group of expert scientists and technicians with a high reliance on manual procedures. There is a high degree of art as well as science in this process. Without undermining the world-class expertise that exists, there is likely potential for applying systematic process improvement. In other words, it is timely for a thorough examination of whether the process can be improved to increase the rate of discovery or alternately how to increase the resources employed in this area. There is also opportunity to look beyond the current rage of fungal endophytes of grasses to endophytes in other pasture plants.

Rhizobia

A key competitive advantage of New Zealand pastures is biological nitrogen fixation. This occurs through the symbiotic association of legumes, particularly clovers, with rhizobia bacteria.

Across New Zealand more than 11,400 farms use pastures containing forage legumes, mostly white clover, covering 7.88 million hectares[67]. This constitutes about 29% of the total land area and excludes hill country and tussock grasslands. Estimates of nitrogen input from legumes vary, however average at 185 kg N per ha per year for pastures with slope less than 12 degrees. Based on a recent average cost of urea fertiliser, the value of nitrogen fixation into New Zealand pastures is $1.8 billion per year; this is highly conservative as it does not encompass the value of increased forage quality, nitrogen fixation in extensive hill country systems, and reduced environmental costs.

Rhizobia strains vary extensively in their ability to form nodules with white clover, and their effectiveness at fixing nitrogen during symbiosis. Dedicated rhizobia strain selection and screening programmes have played a vital role in ensuring clover and other legume species are matched with an optimal rhizobia symbiont. These are most commonly delivered into farming systems as rhizobia-inoculated seed. However, in 2005 in New Zealand the inoculant industry replaced the strain of rhizobia for white clover (CC275e) with a new strain (TA1) apparently based on ease of production. A 2010 report then found that in white clover, strain CC275e fixes more nitrogen than strain TA1 and has greater persistence in soils[68]. This highlights the importance of aligning the selection and screening programmes for rhizobia strains with the objectives of the whole pastoral sector, particularly outcomes on-farm, and not just one commercial interest.

One of the further directions for research is to better understand genetic factors involved in the performance traits for rhizobia associated with white clover, including nitrogen fixation, saprophytic survival, and desiccation tolerance. This starts with screening strains for these traits. Genome sequencing and comparison of the main strains with closely related stains that differ in one or more phenotypes is also a potential pathway. This important area of work is currently being supported through an MBIE-funded programme. However, long-term funding is uncertain and there is concern that it could be overlooked in the future.

Also, it is difficult to maintain live rhizobia on coated clover seeds and some parties in the commercial seed industry are not convinced that inoculation of clover with new strains will be effective because rhizobia are already endemic in most soils. Field research is needed to validate the idea that improved rhizobia can be established effectively in New Zealand pastures.

[67] Genome sequence of the clover symbiont, Delestre et al, 2015
[68] White clover seed inoculation and coating in New Zealand. Kerr et al. 2011

Red clover, and more recently lucerne are significant forages in New Zealand. These are also candidates for rhizobia improvement. One of the complications arises from the difficulty and costs involved in importing new organisms to New Zealand. This means it relies entirely on pan-industry support, and currently this is not being considered.

Actions:
Re-engineer and improve the processes for the development of novel endophytes, with the goal of increasing the rate of discovery
Evaluate new approaches to forming genetic variation in endophytes
Introduce the same pan-industry governance and forage evaluation structures for forage legume-rhizobia selection as has been done for ryegrass and endophytes
Validate the usefulness of improved rhizobia-legume matches for New Zealand pastures with field trials such as that the improved rhizobia can supplant endemic strains
Develop genomic selection technologies for rhizobia and apply these to enhance selection of optimal rhizobia-legume matches for New Zealand pastures

Initiative 2.5 — Biological Controls

Previous sections have highlighted how New Zealand's forage base suffers from substantial pest, weed and disease pressure with annual losses to producers estimated at more than $2 billion each year. Major invertebrate pests in pastures include endemic insects that have adapted well to introduced pasture species as well as exotic invasive species. Weeds are also a major expense, with plants such as Californian thistle established across New Zealand and estimated to cost the pastoral sector as much as $700 million in lost farm revenue each year[69].

This discussion document has not focused specifically on pest and weed management. That is already covered with improved forages and forage systems being developed which are resistant to these pressures, the availability of agrichemicals for use in management of pests and weeds, and through a sector-wide approach to biosecurity. One area which still needs to be included is biological controls other than endophytes.

Biological control of endemic insects is aimed at exploiting natural enemies such as entomopathogens that can regulate populations while control of exotic insects relies on the identification, introduction and release of suitable biocontrol agents such as the parasitoid of clover root weevil. Self-sustaining, self-dispersing biological control agents are often the only practical method of suppressing pests over large areas of steep, relatively inaccessible farmland. Work on bio-pesticides such as microbes and bioactive compounds is also an emerging technology of increasing importance given the potential withdrawal of conventional pesticides.

AgResearch is the major provider of biological control research for pasture pests & nationally important programmes against pests. The Bio-Protection Research Centre (BPRC) also brings together New Zealand's leading experts in bio-protection for integrated and innovative research programmes from AgResearch, Lincoln University, Massey University, Plant & Food Research and Scion[70]. However, the work conducted by this group on biological protection solutions for the primary sectors is relatively weighted towards the horticulture sector.

The process of developing effective biological controls is challenging for a number of reasons. In the first instance, it can be difficult to identify and validate a suitable bio-control candidate that will adapt to New Zealand conditions. Methods for breeding the bio-control candidate in containment must be developed, and testing conducted to gain legislative approval for release in New Zealand, taking into account possible unintended consequences. The main risk that requires assessment is potential off-farm negative impacts on biodiversity through predation, parasitism, pathogenicity, competition, hybridisation and other possible negative effects on non-target species including native species. Once biological control agents are released, funding for ongoing monitoring is often withdrawn. There is a risk in the long term of failure of the biological control agent as appears to be the case with Argentine stem weevil[71]. Reliance on a single agent as the sole means of control as is the case for clover root weevil is particularly concerning, and once such a control is in place there is a reluctance to invest in further research.

[69] On the economics of invasive plant: The case of Californian thistle in New Zealand, Bourdot et al,
[70] Formed in 2003. TEC funded for fundamental research.
[71] Biological control against invasive species in simplified ecosystems: its triumphs and emerging threats. Goldson, Tomasetto and Popay; Current Opinion in Insect Science (2014).

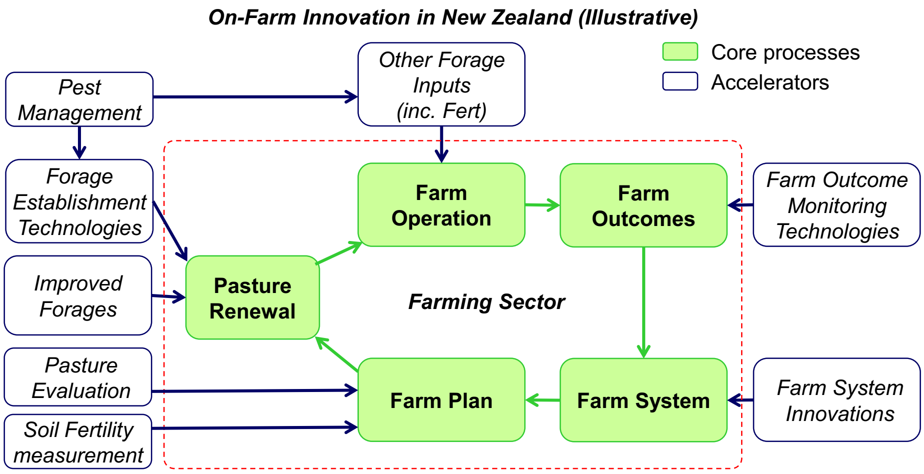
A further complication is the continued reliance of the agricultural sector on various biocides that tend be as effective against the biocontrol as the intended target. There is a natural conflict between the interests of agrichemical supply companies and advocates of biological controls. Biological control research and discovery thus need to be proactively supported by the potential beneficiaries, that is the pastoral sector. Biocontrol also needs a clear understanding of the ecosystem in which the agents will act, requiring more fundamental research than agrichemical approaches. The solutions then need to be included within an integrated pest management solution, and supported with accurate technical advice to the pastoral sector. The challenge of implementing effective biological controls increases as new pastoral pests invade New Zealand and add complexity to pasture ecosystems.

Actions:
The pastoral sector must actively support the development of biological controls, and research that maximises their effectiveness, to build greater involvement and expertise directed towards the pastoral forage sector

6.4 On Farm Innovation

Objective: Facilitate the rapid adoption of improved forages

Forage improvement only benefits New Zealand's pastoral sector when the improved forages are established in the pastures and forage crops of commercial farming operations. A high rate of pasture renewal using improved forages, and good management of pastures, is critical to achieving the desired productivity improvements in the sector. Simplistically, the process starts on each individual farm with decisions about the type of farm system, and what forage system innovations such as cropping to include. From this strategic perspective, a farm plan is then developed. The farm plan, potentially together with evaluation of existing pastures and soil fertility, then determines what pasture renewal is required as well as other investments such as fertiliser. These are then integrated in the farm operation. The performance of the farm system, contingent on measurement of the outcomes, then provides feedback for further farm system innovations[72]. The system is illustrated below.



This diagram highlights in blue the key points of intervention and support for the farming sector which are relevant to forages. Farm system innovations provide farmers with options they can choose to implement on their farm. These might include new cultivars, new forage species, or crops, each of which can impact on the management of the whole farm system. It might also include different cultivation and seed sowing techniques such as direct drilling, or some other aspect of forage management. A change in stock management can change the overall balance of the forage system. The key point is farm system innovations are an integral part of adopting improved forages.

The effectiveness of the farm plan, based on the farm system context, depends on good knowledge of the farm's natural resources and pastures. In most cases, incorporating cropping into the farm system is what currently drives pasture renewal, with new pastures being established after the crop. Pasture evaluation and soil fertility measurement is particularly critical in determining which paddocks are under-performing and hence where pasture renewal will be most effective.

[72] *One of the key insight from the Red Meat Profit Partnership has been how the most successful sheep and beef farmers will typically trial farm system innovations on a small scale (eg 5% of the farm), and then evaluate before deciding whether to adopt or reject the new approach.*

The process of pasture renewal depends on the context. Crops are limited to cultivatable land, and the cropping process will typically provide a well-prepared seed bed clear of weeds for pastures to be established. However, there is a need for pasture renewal beyond just the cultivated areas to maximise the benefits of forage improvement. This can be more challenging with slope, aspect and moisture issues as well as in situations where existing vegetation is competing with the new plants. Farmers need effective options for establishing improved forages on non-cultivated land. Fundamentally, farmers also need to be confident that the improved forages being established will outperform the previous forages. In any case, there is a practical limit to the rate of pasture renewal and the use of crops on an extensively grazed farm as it takes the land out of production and requires investment.

The performance of new forages depends on both establishment and management. The management aspect is really a broader issue of farm system management and hence beyond the scope of this discussion document. Exceptions include pest management and soil fertility management and the associated inputs. The agrichemical and fertiliser industries share some characteristics with the seed industry of having embedded technologies, being led by commercial companies and having business models dependent on sales of fertiliser. Likewise, while the interests of the fertiliser and farming sectors are broadly aligned they are not necessarily the same and commercial fertiliser companies will tend to focus efforts where there are greater sales opportunities. Hence there is scope for industry good organisations to play a role in creating better alignment, especially at the further ends of the spectrum.

The process of on-farm innovation also includes monitoring outcomes. While monitoring financial and animal outcomes for a season might be relatively straightforward, many forage outcomes are more challenging to assess. This is especially true on sheep and beef operations where properties are larger and stock performance might only be assessed at the end of a season, compared with a dairy operation where production is monitored daily. This uncertainty of knowledge makes grazing management, which is crucial to achieving optimal pasture production, more difficult.

In terms of farm outcomes, the forage sector is also having to come to terms with requirements for environmental outcomes in terms of emissions, water quality and soil health. There are still challenges in monitoring these outcomes, and a heavy reliance on modelling. Increasingly, these requirements must be incorporated as objectives within the farm plan. Meeting these objectives requires farm system innovations, and changes to farm plans. Farmers will need confidence that farm system innovations intended to improve environmental outcomes are both effective and feasible, and ideally that they are validated through monitoring.

This discussion document recommends three main areas of focus to prove, show and enable the adoption of forage system innovations:

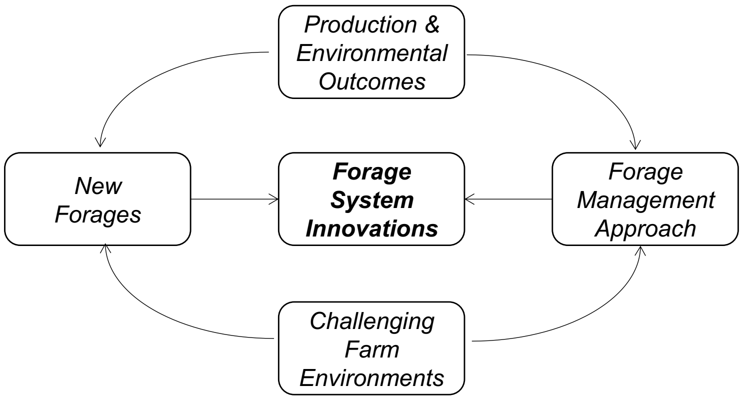
1. *Forage System Innovations:* Development and validation of forage systems that enable value opportunities and/or solve farm systems problems (Prove)
2. *Forage System Demonstration and Extension:* Demonstration of forage system solutions to build confidence and know-how with farmers and rural professionals. Includes extension activities aimed at increasing the rate of adoption (Show)
3. *Forage Technology Packages:* Development of forage technologies with supporting information and industry capability for successful implementation on farms. Includes existing technologies (Enable)

Further to this, there is a need for greater industry focus on pasture evaluation and soil fertility measurement to enable more effective farm planning. This could potentially overlap with innovations for more frequent and accurate pasture monitoring in terms of managing farm outcomes. These investments by the farming sector can then provide the impetus for commercial agribusiness to invest and create a virtuous cycle of improvement.

Initiative 3.1 — Forage System Innovations

Farm system innovations provide farmers with options they can choose to implement on their farm. These might include new cultivars, new forage species, or crops, each of which can affect the management of the whole farm system. It might also include alternate seed establishment techniques such as direct drilling, or some other aspect of forage management. Even changing stocking rate, mobs, and rotations can change the overall balance of the forage system. The key point is that farm system innovations are an integral part of adopting improved forages.

Fundamental drivers of forage system innovations are a desire for better productivity[73] and environmental outcomes, and challenging farm environments where existing systems are not effective. Forage solutions to these challenges are not simple, as they need to be integrated into a system with multiple inter-dependencies. A new forage will generally need a new management approach to be successful. The main drivers and components of forage management approaches is represented schematically in the figure below.



New Zealand's farm sector is continuously researching and developing forage system innovations. Recent examples of this are:

- Annual clovers for steep hill country with low rainfall[74]
- Red clover and plantain systems in hill country with high rainfall[75]
- Southern Wintering Systems[76]
- Northland Agricultural Research Farm

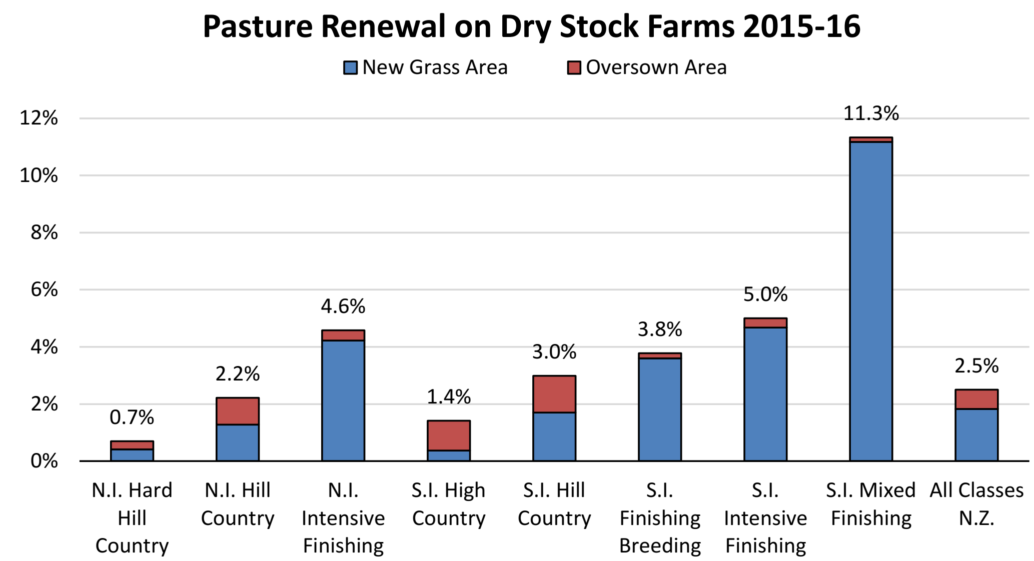
The point of this research is to identify and validate useful forage system innovations. Identification of solutions and/or components is often done by farmers themselves as they experiment with ideas. Ideally, as with the above cases, farmers and researchers work together on commercial-scale farm systems over multiple seasons. Researchers contribute scientific method and credibility, and together the parties learn about and refine the system innovation.

For a forage system innovation to have value it needs to have impact, which requires both relevance and scale. Relevance means being able to significantly improve outcomes for a New Zealand farm system. Scale means that it is suitable for adoption across a significant number of farms. For example, in the case of the Erect Annual Clover innovation, there are 1,200 dry hard hill country farms occupying 1.5 million hectares in New Zealand (especially eastern areas), currently characterised by low soil fertility, low legume content and a low-productivity grasses. Plot trials using annual clovers have demonstrated a 300% increase in total spring dry matter, and improvements in soil nitrogen. The current focus is on proving that annual clovers can provide a sustainable and profitable forage system innovation within a whole farm system. A further reason for investigating this innovation is the implications of climate change which are predicted to further increase temperatures and reduce rainfall in eastern areas of New Zealand.

The Northland Agricultural Research Farm has similar relevance for the future of the forage industry. Although Northland comprises only 6% of New Zealand's dairy production it is unique as a subtropical zone with the subtropical grass species kikuyu. Research into effective dairying systems in the Northland climate may be increasingly useful for regions such as the Waikato and Bay of Plenty which are already experiencing invasive tropical grasses and heavy insect pressure.

[73] 'Productivity' incorporates improvements in both production outputs and inputs
[74] 'Erect Annual Clovers – A Game Changer for Dryland Hill Country', Paul Muir, On-Farm Research
[75] 'Forage Use in a High Performance Sheep System', Beef + Lamb New Zealand
[76] 'Evaluating Dairy Wintering Systems in Southern New Zealand, Pinxterhuis et al, Extension Farming Systems J. v9n1

One of the other essential forage innovations is around effective and economic systems for pastoral renewal on hill country. Pasture renewal as part of cropping, which is currently most of pasture renewal, on cultivatable land doesn't provide a feasible mechanism for getting improved forages into hill country. As a result, hill country has very low reported levels of pasture renewal, as shown in the figure below, and a high proportion of low-productivity plant species such as browntop. The analysis is also based on Beef + Lamb New Zealand farm classes, and it is highly likely that the small proportion of pasture renewal that does occur in hill country is actually on the small areas of cultivatable land that are part of each farm.



A paper presented at the 2016 Hill Country Symposium highlighted steep, non-cultivatable hill country below 1,000 metres elevation comprises about 40% of New Zealand farms. In a review of existing literature, several key areas for research were identified[77]:

- *Pre-sowing management*: including strategies to reduce seedling desiccation, optimal herbicide application and weed control, annual legume management and forage herb establishment
- *Sowing management*: including sowing sequence strategies to enhance legume establishment, aerial establishment, and seed dissemination
- *Post-sowing management*: including herbicide use

Actions:
The sector must actively identify and prioritise forage system innovations for investment. Industry good organisations will take a leadership role in their respective farming areas. The suggested criteria for investment are relevance and scale, and validating this for each should be the first step
Prioritise investment into systems for pasture renewal and establishment in hill country as an area of immediate relevance and scale
Farm system research expertise must be actively developed through investing levies and public money in relevant forage-related initiatives
Forage system innovation must be approached as a co-innovation initiative, with innovations validated on commercial farm-scale operations

[77] *Pasture establishment on non-cultivatable hill country: a review of the New Zealand literature, Tozer et al, 2016*

Initiative 3.2 — Forage System Demonstration and Extension

Once forage system innovations have been developed and proven to work, they still need to be demonstrated and actively promoted to farmers within the relevant regions for adoption. The workshops conducted in the forage review revealed considerable barriers to adoption arising largely from uncertainty, risk aversion, and a lack of confidence in the outcome.

The problem is compounded on hill country farms due to seasonal uncertainty and the potential for events beyond the ability of the farmer to manage. It is less problematic on cultivatable land, and especially where irrigation means there is much greater certainty around soil moisture availability. Another differentiating factor is the financial readiness of farmers where historically higher returns to dairy farming have enabled greater investment and a higher appetite for financial risk. Hill country farmers appeared to be inherently more conservative, preferring a lower level of financial leverage.

This discussion document cannot change the fundamental uncertainty associated with weather, but it must address the uncertainty in knowledge which prevents adoption of forage innovations. Farmers gain confidence in forage system innovations when they can see them operating. Generally, this will be most effective when the demonstration is in their region, and in similar conditions to their own farm. Farm system demonstration is not a national initiative where one demonstration farm location can be used for the whole country.

Forage system demonstration also needs to be supported with resources and expertise, as with all farm demonstration. One of the most successful extension initiatives in the dairy industry was the Dairy Push initiative that first ran from 2007-2010 in South Waikato and has led to similar initiatives in multiple areas. The Dairy Push programme was a hybrid mix of traditional extension methods, including a demonstration farm, regional benchmarking with 50 participating farms and one-to-one farmer engagement with supporting consultants. This more intensive support model was instrumental in achieving more effective behavioural change and knowledge transfer, the results of which are shown in the table below. The critical feature of this support was how it assisted each farmer to make changes to their own system. Given the potential complexity of implementing forage innovations within various farm systems there could be merit in a Forage Push farm demonstration approach supported by farm consultants giving one-on-one advice.

Group	2006-07	2007-08	2008-09	2009-10
Dairy Push Owner Operator	$707	$1,721	$663	$1,889
Average Waikato Owner Operator	$1,236	$2,656	$747	$1,846
Performance Gap	-$529	-$935	-$84	$43

Extension support using farm consultants can be relatively expensive. In the Dairy Push example, it required a direct investment of $1,500 per participant, which was 50% of the total programme cost. New Zealand pastoral farmers themselves have historically been reluctant to pay for this type of advice, notwithstanding evidence that it can benefit them substantially. In this case, it comes down to the capacity and ingenuity of each farming sector in finding a means of providing this support, which is beyond the scope of this document to specify.

An alternative extension recommendation to be considered is for pasture renewal activity to be supported with a project manager, who could work directly with farmers. This role could potentially also have some commercial funding, especially in regions or systems where pasture renewal rates are low.

Actions:
Proven forage system innovations with a high potential for enhancing farm system profitability and sustainability must be demonstrated in relevant regions. This demonstration must be planned as a follow-on from forage system innovation research as part of the overall programme
Forage system demonstration must be supported with extension activities. Where there is a degree of complexity involved, this will ideally include one-on-one support

Initiative 3.3 — Forage Technology Packages

The most successful and rapid adoption of new forage system innovations seems to occur when the innovation is presented as a technology package that can be readily integrated within the existing farm system. Five key success factors for forage system innovations have been identified:

1. Compelling value proposition: the innovation addresses an existing need, and the expected benefits to the farm operation are clearly articulated
2. Clear extension message: the wider industry supports the proposition and recommends farmers to consider adoption in the farm systems
3. Technology Package: the system for agronomy and professional support has been developed and proven on New Zealand farms
4. Commercial Support: The relevant agribusiness sectors have embraced the innovation, and made it part of their offering to farmers
5. Champion: One or more credible individuals with a high profile in the industry champion the innovation, through seminars, articles and other methods

Historically, one of the most obvious technology packages is maize, where technical data, seed selection tools, performance calculators and professional support and advice are all available to farmers. More recently, two new forage innovations – Fodder Beet and Lucerne - have achieved significance in the sector. These are shown in the following table, with their key success factors:

Key Success factors	Fodder Beet	Lucerne
Compelling value proposition	✓ feed value	✓ drought tolerance
Clear extension message	✓ supported by industry	✓ supported by industry
Technology Package	✓ systems for agronomy, and professional support	✓ systems for agronomy, and professional support
Commercial Support	✓ seed companies	✓ seed companies
Champion (farmer / academic)	✓ Jim Gibbs	✓ Derrick Moot ✓ Doug Avery

These forage species are not new. They have both been available for many years without being widely adopted because one or more of these factors was missing. In both cases Lincoln University provided the initial impetus possibly because they had greater freedom to operate than Crown Research Institutes. Once the innovation was established, commercial companies picked up the messages and reinforced them.

One of the important factors to consider is that the value proposition for farmers may be different to that for seed companies. Farmers will probably evaluate the forage innovation in terms of its yield, and whether it solves a feed deficit or some other need on their farm. They will also consider the complexity and what trade-offs they will have to make if they adopt it. Each farmer is only concerned with their own farm. However, seed companies will be concerned with overall market size and the practicalities of commercialisation such as seed multiplication. There is a potential catch-22 where until the innovation is properly marketed as a technology package, the market size is not apparent, and it won't seem worthwhile to overcome barriers. Unless a conscious effort is made, good ideas can languish or be lost.

Champions can't be manufactured. Individuals with good ideas might come from farming, universities, CRIs, or the private sector. However, emerging champions can be assisted where an idea has merit. The forage sector can invest in providing extension support and developing the technology package. This may be achieved in conjunction with the recommendations of the previous section around development of the forage system innovation and its demonstration. Doing this should be an accelerator of adoption.

Actions:
Invest in technology packages to enable the rapid adoption of forage system innovations

Ready and Responsible

Objective: Proactive development of tools and processes to protect and enhance the reputation of forage-based farming sectors

The ready and responsible theme is in many ways a logical extension of the preceding themes. The difference is that it deals exclusively with the challenges that are still emerging in the forage sector, or whose full impact has not yet been felt. In particular, it deals with future challenges that could threaten the reputation of the forage sector and undermine other progress. It includes coordinated efforts to manage the reputation of the forage sector as a responsible industry. It incorporates environmental outcomes, the integrity of the forage-based food production system, and proactive actions to develop appropriate forage management practices.

The first challenges arise from forage system innovations themselves. New cultivars and symbionts, new species, and new forage systems all carry the potential risk of unexpected consequences. The forage sector must be concerned with how these might change product integrity as it affects human health and wellbeing. The forage sector must also be concerned with how they might affect the health and welfare of grazing animals.

Additional challenges can be anticipated with technologies deployed in forage systems, and how these affect environmental outcomes. The area of soil health and land-use sustainability is of particular concern, as is the permitted use of agrichemicals. The forage sector needs to anticipate any restraints that might be applied, and develop feasible alternatives for when they are needed.

The following strategic initiatives are proposed:

- *Product Integrity:* A coordinated forage industry programme to proactively evaluate and manage the integrity of products from New Zealand's forage-based farm sectors, particularly where new forages or approaches are introduced
- *Animal Health and Welfare:* A coordinated forage industry programme to proactively evaluate and manage animal health and welfare outcomes arising from new forage systems
- *Responsible Forage Management Practices:* Proactive development and promotion of responsible farm practices anticipating potential threats from future constraints such as those which might apply to cultivation practices. This can also identify new opportunities for the forage sector to be market ready

Initiative 4.1 — Product Integrity

The forage system is one element in producing food for human consumption. Although forages are metabolised, the composition of the forage plant and the overall diet of the animal can affect the composition of the meat and milk produced. Generally, any forage system innovation can affect the integrity of the product. It is vital that forage innovations are not just assessed on the basis of meeting targets for production and environmental outcomes. They must also ensure that the final product integrity is retained.

This means that farm system trials of new forage innovations need to include testing of animal products for any composition changes and other characteristics. This initiative would likely need to include testing of the forage composition as well, particularly to identify any components of importance. It is particularly important where the animals' diet will include a large proportion of the new feed.

Individual processing and export marketing companies already engage in this testing. However, it is neither mandatory nor universal. There is a risk to the reputation of the whole industry, either from an exporter who does not pick up an issue in testing or where the feed innovation is adopted rapidly and moves ahead of the testing regime.

Actions:
The farming sector must work with processing and market companies to develop New Zealand-wide protocols for product testing, and include this in the research and development programmes for new forage innovations

The industry must keep a watching brief on feeding practices, and forage innovations that are made on-farm, without the involvement of the rest of the sector, in order to identify the need for testing before the product reaches the market. This will need the involvement of the processing and marketing sector, whose reputation it is designed to protect.

Initiative 4.2 — Animal Health and Welfare

As with the previous initiative, new forage innovations can have implications for animal health and welfare. This is particularly the case when animals transition from one feed to another. Five specific issues are already well understood by the sector, and illustrate the variety of possible ailments:

Ryegrass staggers: Ryegrass staggers occur because of toxins in ryegrass pastures created by endophytes. Endophytes are symbiotic fungi that occur in perennial ryegrass and can protect the plant with specific toxins such as peramine which is effective against Argentine stem weevil. However, endophytes can produce several toxins, one being lolitrem B which is the major toxin associated with ryegrass staggers. The newer ryegrass cultivars have endophytes which are of low or zero risk for ryegrass staggers in animals.

Bloat: Bloat is a very rapid build-up of digestive gas in the rumen which can occur when cattle feed on pastures containing significant levels of clover. Under normal circumstances cattle belch up surplus gas as they chew their cud. Clover has high levels of foaming agents, which assist the rumen gas to form numerous small gas bubbles in the rumen as the digestion occurs. These can make it difficult for the animal to belch so instead the gas continues to build up in the rumen. As this process continues the rumen expands, putting significant pressure on the diaphragm. This makes breathing more and more difficult for the animal and eventually causes death by asphyxiation and heart failure.

Rumen Acidosis: Rumen acidosis is a metabolic disease of ruminant animals, the primary cause of which is feeding a high level of rapidly digestible carbohydrate. Acidosis occurs when the pH of the rumen falls to less than 5.5 and the rumen stops moving, becoming atonic. This depresses appetite and production. The change in acidity then changes the rumen flora, with acid-producing bacteria taking over. They produce more acid, making the acidosis worse. The increased acid is then absorbed through the rumen wall, causing metabolic acidosis, which in severe cases can lead to shock and death. This can also occur at sub-clinical levels which are hard to detect.

Nitrate Poisoning: Short-term ryegrasses, oats, brassicas and occasionally other new pastures can all end up with potentially dangerous levels of nitrate in their leaves, particularly when rapidly growing plants are affected by cold frosty weather. This happens when the plant's uptake of nitrogen from the soil is greater than its ability to utilise that nitrogen through its roots, so the surplus gets stored in the leaves. The onset of symptoms is rapid and can include animals appearing weak and staggering, animals gasping for breath and rapid deterioration leading to death.

Facial Eczema: Facial eczema is caused by a toxin produced by the spores of a fungus that grows in the leaf litter at the base of pasture in warm moist conditions. When ingested by livestock it damages the liver and bile ducts, ultimately leading to the visible skin inflammation. It also causes a decline in sheep and cattle fertility and depressed growth rates, estimated to cost the New Zealand meat industry between $80 and $400 million annually[78]. Some forage species are much less prone than others to high spore counts.

New Zealand's pastoral farming sector depends on its reputation in export markets, and part of this is acceptable animal welfare practices. Accordingly, one of the key objectives set out in the Strategy for Sustainable Dairy Farming 2013-2020 is farming to high standards of animal health, welfare and well-being. The sector therefore has a mandate to ensure that new forage innovations[79] do not adversely affect the health and welfare of animals.

Actions:
The farming sector must conduct research trials to develop protocols for the use of new forage innovations to protect animal health and welfare
Any protocols for new forage innovations that are necessary to protect the health and welfare of animals must be included in the extension and demonstration efforts to promote the innovation

[78] AgResearch Grasslands 1998

[79] *It is beyond the scope of this discussion document to include research and extension on existing animal welfare issues*

Initiative 4.3 — Responsible Forage Management Practices

The Forage sector anticipates some current technologies deployed on farms may not be permitted in future. The first area of concern is soil health and land-use sustainability, where some forms of cultivation could be restricted. There may also be restrictions or bans applied to some agrichemicals in common use today. The forage sector needs to anticipate any restraints that might be applied, and develop feasible alternatives for when they are needed.

Soil is a finite resource on which all agriculture depends. Currently, the pastoral sector uses various methods of cultivation as an essential tool in cropping and pasture renewal. Cultivation is used to remove existing vegetation, reduce pest populations and prepare the soil for planting. However, it is also linked to issues with degraded soil structure and potential loss of topsoil particularly where land use has not been well matched to the inherent capability of the soil. An MPI report on "Future requirements for soil management in New Zealand", prepared by the National Land Resource Centre, was published in December 2014. Some regions in New Zealand are also planning to implement rules that restrict cultivation or cropping on pastoral farms to a maximum allowed area per year. In light of possible restrictions being imposed, the sector should consider research on alternative sustainable methods for pasture renewal.

The work of the forage review has also identified a disconnection between public sector spatial information on soils and land-use capability (LUC) in New Zealand, and the information and data structures used in the forage sector. It has proved too difficult to align LUC data with actual industry definitions of land use and farm class. Furthermore, the most detailed information on soil fertility is held by the fertiliser companies but is mainly limited to the most fertile, cultivatable land where farmers have been willing to pay for soil tests and so the majority of hill country farms are not included. It is timely for the forage sector to consider obtaining better information about the state of New Zealand's soil resources, and their suitability for cultivation.

Recommendations:

- Invest in developing sustainable techniques for pasture renewal and cultivation.
- Develop and coordinate the population of a soils database aligned with the pastoral sector and other land users.

Actions:
Develop and validate a portfolio of techniques for sustainable pasture renewal and cultivation
Specific sectors to invest in soil sampling of under-represented farm classes to build a more complete picture of soil status
Develop and coordinate the population of a comprehensive soils database aligned with the pastoral sector and other land users

ATTACHMENT 1: SUMMARY OF STRATEGIC ACTIONS

Working Together

Actions:
Formalise the role of the Pastoral Industry Forage Steering Group as the facilitating body across all stakeholders, collaborations and consortiums
Collate a more complete and accurate view of forage sector investment in New Zealand, accounting for the multiple interests and related parties. Appropriate understandings still need to be negotiated for this information to be shared, building on the work already completed in this report
The Pastoral Industry Forage Steering Group to convene a Forage Science and Agriculture Advisory Group to coordinate with government and other investors on funding priorities for forage-related research and development
Identify common interests with the Australian pastoral sector and initiate discussions around joint investment in research and development
Convene the Science and Agronomy Advisory Group to develop the overarching brief for the forage-related biosecurity plan, and effectively pre-empt the inevitable operational agreements to be formed under the GIA plan
Develop an over-arching New Zealand Forage Sector biosecurity plan in partnership with all forage sector stakeholders. This will complement the GIA arrangements and establish the context for Operational Agreements to be negotiated under the GIA
Develop a specific initiative to set standards for agricultural contractors and machine operators to better manage the containment of forage pests and diseases. This will be a consultative process
Engage with the New Zealand Story to ensure that pastoral agriculture is not left behind, and the kaitiaki, integrity and resourcefulness of New Zealand's forage-based farming sector is better promoted
Establish the business case for a New Zealand grass-fed minimum standard supported by scientific and marketing evidence, and develop this standard for adoption in both the red meat and dairy sectors
Industry groups to maintain a watching brief on new forage and feeding practices in conjunction with the export marketing companies
The forage sector needs to work collectively with government to ensure the GMO regulations which apply to GM forages continue to be consistent and workable as the technology evolves
The forage sector will engage with AGCARM to include them in the science and agronomy advisory group as it considers agrichemicals
Conduct a joint review of agrichemical use and alternatives in New Zealand, and the assessment and re-registration process, to clarify the potential implications and outcomes for the sector
Identify funding options and re-commence research into forages and feeding regimes for reduced greenhouse gas emissions
Work collaboratively to inform policy and investment affecting the exposure of the sector to risks from both inclusions in the ETS and non-tariff trade barriers related to emissions
Work with stakeholders and policy makers to enable the introduction of new forage species where this is justified

Forage Improvement

Actions:
Extend the current Forage Value Index to include new traits, including quality and persistence, underway in a partnership between DairyNZ & NZPBRA
Validate the current Forage Value Index using a three to five-year strain trial
Beef + Lamb New Zealand, NZPBRA and DairyNZ partner to evaluate the opportunity and costs for extending FVI to other species and systems, and identify a suitable funding model where the effort is justified
Contingent on a valid business case and viable funding model, develop a version of the Forage Value Index methodology suitable for sheep and beef farm systems, and re-evaluate cultivars accordingly
Contingent on a valid business case and viable funding model, develop a Forage Value Index to include additional forage species
Identify and develop a better understanding of key traits needed for future forage breeding objectives including environmental outcomes, and anticipated environmental stresses under climate change. Industry investment in this area will re-build and retain capability
Identify genetic markers associated with key forage traits, particularly in the major forage species
Coordinate collection missions for the Margot Forde Forage Germplasm Centre towards obtaining genetic material most likely to meet future requirements such as from regions which have environmental conditions likely to match the future New Zealand environment, and provide genetic diversity to plant breeders
Evaluate minor species for their importance to future New Zealand forage systems, and then develop strategies for sustainable sourcing of the most important species. Work with commercial seed companies to identify the best pathway for the introduction of minor species
Develop a New Zealand forage hybrid plan which identifies options for introducing key traits required in target species via hybridisation
Target the collection of novel germplasm for improved forage hybrids
Research investment to develop hybrid breeding schemes for selected forage species
Develop genomic estimated breeding values for ryegrass to enable genomic selection and accelerate genetic gain in perennial ryegrass cultivars
Implement genomic selection for ryegrass in commercial breeding programmes at proof of concept scale
Implement genomic selection for ryegrass in commercial breeding programmes at commercial scale, noting that the timeframe for release of improved cultivars is currently of the order eight to 10 years from starting
Complete offshore trials of GM forages to validate performance of new traits, with commercial development in New Zealand contingent on regulatory stance
Commercialise F1 hybrid perennial ryegrass in New Zealand
Re-engineer and improve the processes for the development of novel endophytes, with the goal of increasing the rate of discovery
Evaluate new approaches to forming genetic variation in endophytes
Introduce the same pan-industry governance and forage evaluation structures for forage legume-rhizobia selection as has been done for ryegrass and endophytes
Validate the usefulness of improved rhizobia-legume matches for New Zealand pastures with field trials such as that the improved rhizobia can supplant endemic strains
Develop genomic selection technologies for rhizobia and apply these to enhance selection of optimal rhizobia-legume matches for New Zealand pastures
The pastoral sector must actively support the development of biological controls, and research that maximises their effectiveness, to build greater involvement and expertise directed towards the pastoral forage sector

On Farm Innovation

Actions:
The sector must actively identify and prioritise forage system innovations for investment. Industry good organisations will take a leadership role in their respective farming areas. The suggested criteria for investment are relevance and scale, and validating this for each should be the first step
Prioritise investment into systems for pasture renewal/establishment in hill country as an area of immediate relevance and scale
Farm system research expertise must be actively developed through investment of levies and public monies in relevant forage-related initiatives
Forage System Innovation must be approached as a co-innovation initiative, with innovations validated on commercial farm-scale operations
Proven forage system innovations with a high potential for enhancing farm system profitability and sustainability must be demonstrated in relevant regions. This demonstration must be planned as a follow-on from forage system innovation research as part of the overall programme
Forage system demonstration must be supported with extension activities. Where there is a degree of complexity involved this will ideally include one-on-one support
Invest in technology packages to enable the rapid adoption of forage system innovations

Ready and Responsible

Actions:
The farming sector must work with processing and market companies to develop New Zealand-wide protocols for product testing, and include this in the research and development programmes for new forage innovations
The farming sector must conduct research trials to develop protocols for the use of new forage innovations to protect animal health and welfare
Any protocols for new forage innovations necessary to protect the health and welfare of animals must be included in the extension and demonstration efforts to promote the innovation
Develop and validate a portfolio of techniques for sustainable pasture renewal and cultivation
Specific sectors to invest in soil sampling of under-represented farm classes to build a more complete picture of soil status
Develop and coordinate the population of a comprehensive soils database aligned with the pastoral sector and other land users

ATTACHMENT 2: NEW ZEALAND SEED MARKET IN 2014

The following outlines the sales of forage seed in New Zealand, and estimates the area sown[80].

Sales of Grass and Herb Seed for Pasture

Plant Species	Seeding Rates kg/ha	Seed Sales MT sold	Area sown 000 ha
Perennial Ryegrass	20	6,330	317
Italian Ryegrass	20	2,707	135
Annual Ryegrass	25	1,912	76
Hybrid Ryegrass	20	1,004	50
Tall fescue	25	215	9
Cocksfoot	2-8	154	31
Chicory in Pasture mix	0.5	15	3
Plantain in pasture mix	1	80	16

Sales of Legume Seed for Pasture

Plant Species	Seeding Rates kg/ha	Seed Sales MT sold	Area sown 000 ha
White Clover	4	960	240
Red clover	3	360	120
Lucerne	10	184	18
Lotus	2	10	5
sub-clover	5	35	7

Sales of Crop Seed for Forage

Plant Species	Seeding Rates kg/ha	Seed Sales MT sold	Area sown 000 ha
Brassicas	3	1200	400
Fodder Beet	2.32	142	61
Chicory as crop	8	185	23
Plantain as crop	10	200	20
Maize	30	2400	80

80 Seed Sales data sourced from NZPBRA and discussions with seed company executives.

ATTACHMENT 3: FORAGE STEERING COMMITTEE

The Forage Review Group comprised the following members, including alternates:

- Richard Green (Chair), representing FAR
- Murray Willocks, representing the NZPBRA
- Bruce Thorrold, representing DairyNZ
- James Parsons, representing Beef + Lamb New Zealand
- Richard Wakelin, representing Beef + Lamb New Zealand
- Philip Mladenov, representing the Fertiliser Association of New Zealand
- Mike Manning, representing the Fertiliser Association of New Zealand
- Greg Murison, representing AgResearch
- Ministry for Primary Industries
- James Morrison (consultant)