Diverse Species Pasture

On Farm Impact Monitoring Project (2019-2022)

Contents

		Page
1	**Introduction**	**3**
1.1	Project Purpose	3
1.2	Description	3
1.3	Explanation	3
2	**Methods and analysis for diverse species pasture**	**4**
2.1	Management of the project	4
2.2	Sodium thiocyanate	4
2.3	Milk production	4
2.4	Pasture root penetration	4
2.5	Soil carbon/Soil biology	4
2.6	Pasture Composition	4
2.7	Cow behaviour	5
3	**Results**	**6**
3.1	Pasture diversity/composition	6
3.2	Rooting depth	8
3.3	Soil carbon	8
3.4	Milk production and cow behaviour	8
3.5	Sodium thiocyanate (NaSCN)	8
3.6	Soil biology	9
4	**Conclusions**	**11**
5	**Practical Guidelines for Farmers**	**11**

1 Introduction

1.1 Project purpose:

The project aimed to monitor the impact of highly diverse pasture (19+ species in each individual mix – see Table 1) on milk quality, soil root penetration, animal behaviour, pasture composition and soil organic matter/soil biology over the three-year life of the project.

1.2 Description

The project involved the drilling of the highly diverse pasture mixtures (as high as 23 different species – see Table 1) into 5 different sites across four different dairy farming properties in the North Otago/South Canterbury regions of the South Island. There were three different diverse mixtures utilised. There was no intention to differentiate performance between the different mixes as they were all quite similar and this was not the focus of the project. An additional site of highly diverse pasture, already existed one of the participating but was unfortunately lost to the project as a result of a contractors mistakenly spraying out of the wrong paddock.

The aim was to determine if the grazing of diverse mixtures would produce milk with lower levels of sodium thiocyanate (NaSCN) and to identify other benefits arising from the implementation and utilisation of highly diverse pastures.

1.3 Explanation

All milk contains sodium thiocyanate (ST) which can be toxic to humans in high quantities. Milk produced in New Zealand does not contain dangerous levels, but a recent study which tested ST levels in milk samples from New Zealand, The Netherlands and China found that New Zealand milk had the highest ST levels, at just over 10mg/kg.

Oceania Dairy is a large South Island dairy company which produces UHT milk through sourcing milk with low ST levels. It strictly adheres to its policy of only taking milk with ST levels 9mg/kg or lower for the production of UHT milk. Some South Canterbury/North Otago farms have pastures with high clover populations. Oceania milk testing, a thorough literature review and an earlier small research project clearly demonstrated that high clover diets produce high ST levels in milk. This works against farmers who seek to reduce their use of synthetic nitrogen fertiliser inputs (and therefore nitrate leaching) by utilising biological sources of nitrogen (i.e. clover) in order to deliver superior environmental performance.

This study looked at an alternative pasture mix which is highly diverse (between 19 and 23 different species), as opposed to the traditional ryegrass / clover mix, to see if grazing a diverse pasture mix lowers ST levels in milk. The programme took place over three years on five farms in North Otago and South Canterbury- this was reduced to four farms as a result of an accidental spraying out of one mixed pasture site.

The study also looked at other impacts of highly diverse pastures, including animal behaviour (welfare), root penetration (deeper root penetration is associated with lower nutrient loss and improved soil organic matter levels), pasture establishment and performance, soil organic matter/soil biology (important soil productivity and carbon sequestration factors), and farm productivity (milk production).

The view was that the study could lead to an additional market opportunity for many South Canterbury dairy farmers and Oceania Dairy, creating the opportunity for UHT from local suppliers. It could also assist with making on-farm management changes that deliver improved environmental outcomes (reduced synthetic nitrogen use, increased soil organic matter/soil biology etc.)

2 Methods and Analysis for diverse species pasture (Methodology)

2.1 Management of the project.

Monitoring and recording information for key variables – sodium thiocyanate levels (via the milk processor, Oceania Dairy), pasture root penetration, soil carbon/biology (core soil samples), cow behaviour and pasture composition (pasture quadrat evaluation).

2.2 Sodium thiocyanate levels

Sodium thiocyanate is measured from the farm vat sample by Oceania Dairy as part of their overall regular milk quality assurance testing systems using the internationally validated sodium thiocyanate test method whereby the aqueous phase is extracted from the milk using acetonitrile, followed by defatting using a reverse- phase column. Sample aliquots and reference solution of sodium thiocyanate are separately measured using ion chromatograph. The principle of ion chromatographic method: The protein in the milk sample is precipitated using solvent (acetonitrile), the extract goes through a clean-up process and is separated by an ion exchange column using potassium hydroxide as an eluent and conductance detector. The result is quantified by an external standard.

Sodium thiocyanate is measured for every daily vat collection, so, milk sodium thiocyanate levels can be directly linked to the time cows are grazing on mixed species pastures, and times that they are grazing on the farmers standard pastures. Sodium thiocyanate levels were compared during the days cows were grazing on the mixed pasture with grazing days on the standard pasture.

The multiple sampling periods depended upon the dates for each time the cows move into a mixed species pasture paddock, being supplied to Oceania Dairy. Sampling was over the life of the trial. Data was analysed for average sodium thiocyanate difference between the two pasture types across all farms, all years, and all sampling dates. The data was analysed, for differences between individual farms, for seasonal effects and any other patterns.

2.3 Milk production

Differences in milk production was pursued through the Oceania Dairy milk testing and also participant farmer interviews. The analysis was also the same as for sodium thiocyanate, in that production while on mixed pastures was compared with production while cows are on standard pastures, and, the data analysed for farm to farm, season to season etc., differences and patterns, as for the sodium thiocyanate comparisons.

2.4 Pasture root penetration

Pasture root penetration was undertaken by digging inspection pits in the mixed species pasture paddock and in a next-door standard pasture paddock, as close together as practical and choosing sites that appear as physically similar, i.e., both flat, or both on the same slope. The maximum rooting depth of the pasture was measured to a maximum of one meter and then a visual assessment of rooting density was made. This was done on each monitoring visit for all five sites. Each farm was treated as replicates and the maximum rooting depth and rooting density analysed.

2.5 Soil carbon/Soil biology

Soil carbon and soil biology was measured by taking 15 cm deep soil cores, as per standard soil sampling for soil nutrient tests, on both mixed and standard pastures, on each farm. Soil samples were sent to Hill Laboratories for determination of soil carbon percentages, soil organic matter and soil biology levels. Soil biology was measured using the Hot Water Extractable Carbon method. Statistical comparisons were made across all farms over the life of the project and for farm to farm variations.

2.6 Pasture composition

Pasture composition was measured each year, on all farms, in one mixed (two in the case of Farm 1) and one standard pasture, in paddocks next to each other and in areas within areas of the paddocks that are comparable, i.e., both flat, or both on slopes with similar compass orientation, as per soil measurements. On each field a 0.25 m^2 quadrat was randomly placed in four different locations within the chosen sample areas in the paddocks, and the pasture composition assessed by simple counts of plants and totalled to give a count per square meter. It was not aways possible to identify all plants down to species levels, e.g., grasses can be very difficult to differentiate when they are not flowering, and, some legumes are also very similar when small. Every attempt was made to identify all plants down to species level but that was not possible in the case of individual grasses. The results were analysed to compare each pair of pastures on each farm at each sampling year, and then also analyse the total averages across all the farms, as well as farm to farm and year to year variation, and any other patterns that can be identified.

2.7 Cow behaviour.

Cow behaviour on both mixed and standard pastures was monitored by the farm operators. Data collection was observational, such as how much cows move around on initial turn out, i.e., assessing the pasture and looking for parts they wish to eat, which correlates with how much the pasture is meeting their nutritional needs, how long the cows eat, before they sit down to chew the cud etc.

This applied on all 5 sites throughout the grazing season.

Table 1. Mixed species pasture composition for Mixes I, II and III.

	Mix I	Kg/ha	Mix II	Kg/ha	Mix III	Kg/ha
1	Cocksfoot	4.19	Cocksfoot	0.5	Cocksfoot	0.5
2	Plantain	0.5	Plantain	0.5	Plantain	0.5
3	Chicory	1	Chicory	0.5	Chicory	1
4	Timothy	2.09	Timothy	1	Timothy	2
5	White clover - large	0.5	White Clover	1.5	White clover - large	1
6	White clover - medium	0.5	Balensa Clover	0.5	White clover - medium	0.5
7	White clover - small	0.5	Strawberry Clover	1	White clover - small	0.5
8	Alsike clover	1	Arrowtas Clover	0.3	Alsike clover	0.5
9	Red clover	1	Red Clover	1.5	Red clover	1.5
10	Brome	2.19	Brome	3	Brome	2.5
11	Prairie Grass	2.19	Prairie Grass	3	Prairie Grass	2.5
12	Parsley	0.8	Black Oats	3	Vetch	2
13	Lucerne	1	Lucerne	2	Lucerne	2
14	Birdsfoot Trefoil	0.5	Vetch	2	Birdsfoot Trefoil	0.5
15	Sheeps Burnett	0.4	Sheeps Burnett	0.5	Sheeps Burnett	0.5
16	Yarrow	0.3	Phacelia	0.2	Phacelia	0.2
17	Tall Fescue	4.09	Fescue	4	Tall Fescue	4
18	Red Fescue	4.09	Festulolium	2	Red Fescue	4
19	Meadow Fescue	4.09	Ryegrass	2	Meadow Fescue	4
20		30.93	Perennial Ryegrass	4	Festulolium	2
21			Buckwheat	1	Buckwheat	1
22				34.00	Arrowtas Clover	0.3
23					Strawberry Clover	0.5
						34.00
5	Clovers	3.5	5	4.8	7	4.8
2	Other legumes	1.5	2	2	3	2.5

3 Results

3.1 Pasture diversity/composition

Superior diversity of the mixed pasture vs. the standard pasture, was maintained across all sites, even the site which ‘failed’ in terms of drilling and establishment.

The level of weeds was also consistently lower across the board (except failed site 5) for the mixed species pastures across all the established locations, relative to the weed levels of the ‘standard’ mixes.

The diversity of mixtures was not however maintained in terms of all of the different species originally represented in the diverse mixes. Key additional species such as chicory and plantain were comfortably the most dominant ‘alternate’ species present in the diverse mix, over the life of the project, after the grasses.
The reason for the presence and/or lack of particular species, is speculated to be a result of the drilling (successful or otherwise), establishment following drilling and then the nature of the on-going grazing management (including fertiliser use).

See Table 1.

Table 1. Mixed species pasture composition on all 5 sites, average of four 0.25 m^2 quadrats.

	Jul-20		Nov-20		Dec-21			
Site 1	**Mix I**	**Standard Mix**	**Mix I**	**Standard Mix**	**Mix I**	**Standard Mix**	**Mix I Average**	**Standard Mix Average**
All grasses	42.90%	81.90%	30.00%	65.00%	46.25%	43.75%	39.72%	63.55%
Plantain	33.90%	0.00%	16.25%	0.00%	7.50%	0.00%	19.22%	0.00%
Chicory	0.00%	0.00%	21.25%	0.00%	17.50%	0.00%	12.92%	0.00%
Clover	10.10%	10.60%	13.75%	25.00%	15.00%	37.50%	12.95%	24.37%
Sheep's Burnett	0.00%	0.00%	9.38%	0.00%	2.50%	0.00%	3.96%	0.00%
Yarrow	10.60%	0.00%	9.38%	0.00%	11.25%	0.00%	10.41%	0.00%
Docks	2.50%	0.00%	0.00%	6.25%	0.00%	6.25%	0.83%	4.17%
Nettle	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Unknown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Weeds	0.00%	7.50%	0.00%	3.75%	0.00%	12.50%	0.00%	7.92%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

	Jul-20		Nov-20		Dec-21			
Site 2	**Mix II**	**Standard Mix**	**Mix II**	**Standard Mix**	**Mix II**	**Standard Mix**	**Mix II Average**	**Standard Mix Average**
All grasses	63.80%	81.90%	42.50%	65.00%	42.50%	43.75%	49.60%	63.55%
Plantain	6.30%	0.00%	26.25%	0.00%	7.50%	0.00%	13.35%	0.00%
Chicory	0.00%	0.00%	10.00%	0.00%	7.50%	0.00%	5.83%	0.00%
Clover	24.90%	10.60%	20.00%	25.00%	23.75%	37.50%	22.88%	24.37%
Sheep's Burnett	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Yarrow	0.00%	0.00%	0.00%	0.00%	11.25%	0.00%	3.75%	0.00%
Docks	5.00%	0.00%	0.00%	6.25%	5.00%	6.25%	3.33%	4.17%
Nettle	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Unknown	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Weeds	0.00%	7.50%	1.25%	3.75%	2.50%	12.50%	1.25%	7.92%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

	Jul-20		Nov-20		Dec-21			
Site 3	**Mix III (Site 3)**	**Standard Mix (Site 3)**	**Mix III (Site 3)**	**Standard Mix (Site 3)**	**Site 3 Mix III**	**Standard**	**Mix III Average**	**Standard Mix Average**
All grasses	51.30%	97.50%	31.50%	86.25%	33.75%	48.75%	38.85%	77.50%
Plantain	30.00%	0.00%	17.88%	0.00%	**17.50%**	0.00%	21.79%	0.00%
Chicory	6.90%	0.00%	20.94%	0.00%	**20.00%**	0.00%	15.95%	0.00%
Clover	5.60%	2.50%	18.44%	12.50%	22.50%	33.75%	15.51%	16.25%
Sheep's Burnett	1.30%	0.00%	6.88%	0.00%	0.00%	0.00%	2.73%	0.00%
Yarrow	0.00%	0.00%	0.00%	0.00%	5.00%	0.00%	1.67%	0.00%
Docks	0.00%	0.00%	0.00%	0.00%	1.25%	16.25%	0.42%	5.42%
Nettle	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Unknown	5.00%	0.00%	0.00%	0.00%	0.00%	0.00%	1.67%	0.00%
Weeds	0.00%	0.00%	5.06%	1.25%	0.00%	1.25%	1.69%	0.83%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

	Jul-20		Nov-20		Dec-21			
Site 4	**Mix I (Site 4)**	**Standard Mix (Site 4)**	**Mix I (Site 4)**	**Standard Mix (Site 4)**	**Site 4 Mix I**	**Standard**	**Mix I Average**	**Standard Mix Average**
All grasses	29.10%	82.50%	26.63%	52.19%	60.00%	78.75%	38.58%	71.15%
Plantain	24.90%	0.00%	26.56%	11.56%	13.75%	0.00%	21.74%	3.85%
Chicory	1.30%	0.00%	18.69%	0.00%	5.00%	0.00%	8.33%	0.00%
Clover	32.60%	1.30%	11.25%	19.69%	8.75%	3.75%	17.53%	8.25%
Sheep's Burnett	0.30%	0.00%	9.94%	0.00%	0.00%	0.00%	3.41%	0.00%
Yarrow	8.80%	0.00%	2.56%	0.00%	8.75%	0.00%	6.70%	0.00%
Docks	0.00%	5.00%	1.56%	9.38%	0.00%	13.75%	0.52%	9.38%
Nettle	0.00%	9.40%	0.00%	0.00%	0.00%	0.00%	0.00%	3.13%
Unknown brassica	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Weeds	3.10%	1.90%	2.81%	7.19%	3.75%	3.75%	3.22%	4.28%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

	Jul-20		Nov-20		Dec-21			
Site 5	**Mix 1 (Site 5)**	**Standard Mix (Site 5)**	**Mix 1 (Site 5)**	**Standard Mix (Site 5)**	**Site 5 Mix I**	**Standard**	**Mix I Average**	**Standard Mix Average**
All grasses	66.30%	77.90%	60.00%	90.31%	61.30%	63.75%	62.53%	77.32%
Plantain	8.80%	0.00%	8.13%	0.00%	11.25%	0.00%	9.39%	0.00%
Chicory	0.00%	0.00%	10.00%	0.00%	0.00%	0.00%	3.33%	0.00%
Clover	0.00%	11.90%	0.00%	2.50%	3.75%	7.50%	1.25%	7.30%
Sheep's Burnett	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Yarrow	0.00%	0.30%	0.00%	1.56%	0.00%	0.00%	0.00%	0.62%
Docks	7.50%	1.90%	11.25%	2.50%	13.75%	3.75%	10.83%	2.72%
Nettle	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Unknown brassica	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Weeds	17.50%	8.10%	10.63%	3.13%	10.00%	25.00%	12.71%	12.08%
	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

3.2 Rooting Depth

The photographs presented in the milestone reports, generated post monitoring visits, ultimately demonstrated the superiority of the diverse mixture vs the standard mixture, in terms of rooting depth (see example photos below). This was the case even where the standard mix was a long-established pasture. An example of the diverse pasture mix compared to the standard mix is presented in the photographs below.

Photo 1
Diverse Pasture Mix

Photo 2
Standard Pasture Mix

The primary and most visibly identifiable example of the difference in rooting depth was demonstrated through the deep chicory taproot which had extended below spade depth in all those paddocks that were able to be evaluated (as seen in photo 1 on the left above).

3.3 Soil carbon

Soil carbon itself is difficult to identify changes in over such relatively short time spans (3 years). The organic matter figures recorded are in effect soil carbon and these were superior (some significantly at 63%) on all sites except for Site 2, where Mix II was an identifiable outlier in term of its organic matter underperformance vs. the standard pasture. See Table 2.

3.4 Milk production and cow behaviour

The farmers observation of milk production did not produce any identifiable difference between standard and diverse mix grazing. This was consistent with the limited data available through the milk processor, primarily due to the short grazing periods (on diverse pasture). The short period of actual diverse pasture grazing meant this measure was difficult to identify and quite likely the grazing time on the diverse mix was insufficient to create identifiable difference in milk production.

It was noted by several farmers that the animals seemed to enjoy the diverse mix and were enthusiastic about getting in to graze it.

3.5 Sodium thiocyanate (NaSCN)

The limited data availability and short periods of animal grazing on the diverse mixture, relative to the periods of time grazing the standard pasture mixes on properties, meant there was insufficient hard data generated and insufficient time (length of grazing) to make a definitive statement vis a vis diverse mixtures and NaSCN.

An earlier study and overwhelmingly the literature review, indicated a material difference in NaSCN levels, primarily as a result of small leaf clover, which is identified as the primary source of higher, pasture grazed NaSCN levels in milk.

The other notable variable is climate. In a warm and sunny season where ‘clover did well’ in all mixes, this created a high NaSCN impact, whereas ‘normal’ and cooler seasons did not see as strong expression of NaSCN in any mix.

3.6 Soil biology

Arguably the most striking figures to emerge from the study are for soil biology.
In all but one case (Mix II) the diverse mixtures outperformed the standard mixes and in some cases by significant amounts (63%).

This in itself is very interesting as it suggests pasture diversity, regardless of any management actions, will have a positive impact on the soil biology.

Soil biology is linked to carbon sequestration, GHG emissions, productivity, resilience and more broadly, soil health.

While further work is necessary, these findings in and of themselves are of material relevance from both a practical faming and an environmental performance perspective.

See below in Table 2, the results for N, Organic Matter and Soil Biology.

Table 2. Total Soil Analysis	Site 1					
	Mix I		**Standard**			
	Jul-20	**Nov-20**	**Jul-20**	**Nov-20**	**M I v ST 7/20**	**M I v ST 11/20**
Potentially Available Nitrogen	143	264	135	234	6%	13%
Organic Matter	6.6	7.9	6	7.8	10%	1%
Hot Water Extractable Carbon (Soil Biology)	1659	2438	1756	2195	-6%	11%
	Site 2					
	Mix II		**Standard**			
	Jul-20	**Nov-20**	**Jul-20**	**Nov-20**	**M II v ST July/20**	**M II v ST Nov/20**
Potentially Available Nitrogen	189	286	135	234	40%	22%
Organic Matter	4.8	6.2	6	7.8	-20%	-21%
Hot Water Extractable Carbon (Soil Biology)	1599	2017	1756	2195	-9%	-8%
	Site 3					
	Mix III		**Standard**			
	Jul-20	**Nov-20**	**Jul-20**	**Nov-20**	**M I v ST 7/20**	**M I v ST 11/20**
Potentially Available Nitrogen	230	311	136	226	69%	38%
Organic Matter	9.3	8	5.7	6.4	63%	25%
Hot Water Extractable Carbon (Soil Biology)	2492	2446	1531	2037	63%	20%
	Site 4					
	Mix I		**Standard**			
	Jul-20	**Nov-20**	**Jul-20**	**Nov-20**	**M I v ST 7/20**	**M I v ST 11/20**
Potentially Available Nitrogen	251	380	205	377	22%	1%
Organic Matter	8.9	8.4	8.3	7.9	7%	6%
Hot Water Extractable Carbon (Soil Biology)	2363	2672	1856	1905	27%	40%
	Site 5					
	Mix I		**Standard**			
	Jul-20	**Nov-20**	**Jul-20**	**Nov-20**	**M I v ST 7/20**	**M I v ST 11/20**
Potentially Available Nitrogen	166	351	235	282	-29%	24%
Organic Matter	7.3	6.7	7.5	6	-3%	12%
Hot Water Extractable Carbon (Soil Biology)	1933	2317	1513	2042	28%	13%

4 Conclusions

- Small leaf clover is the main driver of Sodium thiocyanate (NaSCN) levels in milk from pasture grazing systems
- Climate is a key determinant of NaSCN levels in milk from pasture-based systems.
- Diverse pasture mixes would benefit and perform more optimally, from the implementation of a specifically designed (fit for purpose) management approach, rather than being managed as if they were exactly the same as simple ryegrass or ryegrass/clover mixes.
- Plantain and chicory are the most persistent, prevalent and well performed species seen in the diverse mixtures utilised in this trial
  - Plantain was number one, chicory performed well in the summer but was less visible during winter
- Diverse mixtures were deeper rooting, primarily and most visually apparent, through the presence of chicory
- Potentially available nitrogen was superior under the diverse pastures
- Organic Matter was largely superior under the diverse grazing mixtures, at times significantly (63%)
- Soil Biology was consistently superior under the diverse mixtures, except in the case of Mix II and in general this was by a material amount.
- The superiority of soil biology may result in superior productive and environmental performance and is supportive of further study to identify and evaluate actual benefits arising from this identified advantage.

5 Practical Guidelines for Farmers

Practical guidelines with respect to diverse species pasture, as identified over the course of this research project are presented as an insight for farmers to utilise and consider in the context of their own situation and how such mixtures may fit within their system.

5.1 Attitude

The farmers attitude to the inclusion and utilisation of diverse pasture mixes is fundamental to the success of any intended programme. This commences right from the moment of making the decision to introduce such pastures into any farming system and critical that a positive attitude is in place prior to drilling.

Determine and be very clear on why you are doing it and be committed to making it a success.

5.2 Drilling/Establishment

Success will be determined at the point of drilling and how the pasture establishes. Any setback at this point, whilst not necessarily fatal as a whole, will be limiting in terms of the actual range of species represented within the diverse mix, that are able to be established.

Timing in terms of season and climate will be key, along with utilisation of any irrigation etc. Paddock selection (soil type, slope, position, nutrient levels, pH etc.) will also play a role in determining the success of establishment.

The better the establishment, the more value will be obtained from the pasture.

5.3 Management

Management is extremely important in terms of generating optimal results from a diverse pasture mix.

The first point to recognise is that a diverse species pasture is not ryegrass and white clover and will not deliver optimal results if it is managed as such. It can function quite effectively if managed as an alternative form of ryegrass or ryegrass/white clover pasture but it will not deliver optimal results or fulfil its true potential performance impact.

A diverse species pasture is likely to have a significant proportion and variety of legumes. As a result of this feature, farms need to consider what if any synthetic nitrogen (N) is required to support these pastures, when so much N is being biologically fixed by the pasture itself. If synthetic N is being used, what is the best time to apply it? – likely at the 'shoulders' of the season and possibly as a boost at establishment, although too much soluble N at this point in the process may be detrimental for legume establishment.

It is very likely that paddocks with diverse species pasture will benefit from operating longer covers and therefore in running longer grazing rotations. Farmers will need to consider how this can be managed in the context of the whole farm system i.e. if a smaller % is diverse pasture and the majority is a monoculture or low diversity mixture such as ryegrass/white clover. Whilst it will take a degree of consideration and organisation it is quite achievable and has been successfully managed by farmers in NZ. Inevitably it will need to be managed whether the introduction is for a small/pilot area of the farm or part of a staged progression of the whole farm to a diverse pasture based grazing system.

5.4 External Input

In terms of deciding what the make-up of any diverse pasture mix is, farmers should consult with a relevant seed merchant. This may not be their usual seed adviser/provider but one with some track record in diverse mixtures and ideally in the farmers area, so as to have some insight into the soil and climatic characteristics of the farmers area which will influence species selection and therefore the likelihood of success.

It may also be that farmers wish, at least initially to utilise some external advisory/consultancy input with respect to the appropriate grazing management of diverse pasture mixes. External groups such as Quorum Sense (www.quorumsense.org.nz), with their very active social media community, with nearly 4000 members is also worth exploring and participating in.

The age-old device of looking at what grows well naturally in a farmer's region is also a useful and inexpensive tool to inform of what species may work in their farming situation.

5.5 Record, Review, Report

Record the diverse pasture over time.

As an example, taking photos of the paddock before drilling, at various stages of establishment, first grazing (before/after), seasonal intervals and then repeating this annually, will build up a robust record of historical progress/change etc. which will be informative in terms of understanding the wider 'story' of the pasture and its performance.

Recording pasture cover, species identified, animal health/performance (e.g. milk production), animal behaviour, comparison with the standard farm mixture, particularly at times of stress e.g. drought is extremely valuable. Capturing this 'data' even if observational and based on judgement, rather than hard empirical information, will provide you with a record of the process and performance of the pasture, of decisions made and actions taken and why and the consequences.

It may also be that there are opportunities to undertake or participate in associated hard data capture, covering themes such as water quality, biodiversity and soil carbon sequestration etc. in the future or through wider sector collaboration.