To investigate the incorporation of multi-species swards on ruminant grazing systems

Operational Group:	Multi-Species Swards for Beef and Sheep
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Abstract

Farmers in Northern Ireland (NI) are increasingly facing financial, production and environmental challenges. With grassland being the predominant crop across Northern Ireland, there is a growing body of evidence to suggest that increasing the diversity of plant species via the incorporation of multi-species swards (MSS) can meet many of these challenges; delivering a wide range of ecosystem services, reducing costs and positively influencing livestock production. There is therefore increasing interest within the NI agri-food industry but success will be dependent on uptake. Acknowledging knowledge gaps, this farmer-led project investigated the feasibility and practicality of incorporating multi-species swards on Northern Ireland commercial beef and sheep farms.

MSS was established on six farms in 2021 with animal performance and management requirements monitored over the following two years. The study has provided initial insight into MSS utilisation and the project results were largely positive regarding establishment, management and performance of MSS on the farms involved. Project findings indicate that MSS swards can maintain or enhance animal performance compared to grass-only or grass-clover swards in terms of daily weight gain and age at slaughter, albeit switching swards in a rotation was found to be counter-productive. Sward establishment methods did vary across the farms and weather patterns were erratic during the two years of the study. Despite this, farmers successfully established swards with herbs and clover present along with grass. Although the seed mixtures used varied considerably on each farm, there was continuity in the main species present at the end of the project. The on-farm experiences of this project would very much concur with the findings of the literature review of the scientific data regarding MSS.

It Is clear from the level of interest in the project and the number of people attending the project associated workshops, webinars, meetings and farm walks that there is a definite industry interest in MSS going forward. The project has significantly increased the knowledge of multi-species sward establishment, management and use specific to Northern Ireland as well as its impact on animal performance (profitability) and wider environmental benefit. The project has overall highlighted the need for additional research in a number of key areas such as establishment, species persistency and grazing animal performance.

Contents

Project Aims

Farmers in Northern Ireland (NI) are increasingly facing financial, production and environmental challenges. Low profitability in beef and sheep production enterprises in particular is a real threat to the viability of the NI livestock sector. Finding a suitable balance between maintaining profitable and sustainable livestock performance from grassland and improving farm ecosystem service provision is therefore critical to sustaining farm businesses and the wider industry for the future. There is a growing body of evidence to suggest that increasing the diversity of plant species within grasslands can meet many of these challenges; delivering a wide range of ecosystem services, reducing management costs and positively influencing livestock production.

Multi-species swards (also referred to as herbal leys or species-rich/diverse grasslands) are communities comprised of grass, legume and herb species. Incorporating a wide variety of plant forms, with a range of rooting strategies, can improve biomass productivity both above and below ground. This not only improves soil health but can also reduce the need for fertiliser input. Previous research is limited but has shown that yields from multi-species grasslands with low or no fertiliser input, are comparable to yields from low diversity, high fertiliser input systems (EU Multisward, 2014). In addition, research has also demonstrated that multi-species swards can have an anthelmintic effect. This will improve animal performance whilst reducing medicinal use, further improving the potential for efficiency gains on farm (Ungemach et al. 2006). With regards wider ecosystem service provision multi-species swards may also positively contribute to climate mitigation and adaptation, improving carbon storage potential and reducing on farm GHG emissions. Improved water quality, flow and resilience may also be a feature (EU MultiSward, 2014).

With grassland being the predominant crop across Northern Ireland, incorporation of multi-species swards presents a significant opportunity for the livestock sector. Success will, however, be dependent on uptake, and whilst the potential benefits of multi-species swards are numerous there is a distinct lack of information on their use on Northern Ireland commercial Beef and Sheep farms. There is increasing interest from industry in the evaluation of MSS, to establish not only the sward and animal performance figures but also to develop practical management guidelines for such swards regarding seed mixtures, establishment methods and grazing management. The objective of this EIP-funded project was to evaluate the use of MSS on a group of commercial farms in NI.

This project therefore aimed to bring together a group of individuals with complementary knowledge and experience (both farmers and researchers) to investigate the feasibility and practicality of incorporating multi-species swards on Northern Ireland commercial beef and sheep farms. The project will significantly increase the knowledge of multi-species sward establishment, management and use specific to Northern Ireland as well as its impact on animal performance (profitability) and wider environmental benefit.

Specific objectives of the project were to:

- Establish multi-species swards on participant farms
- Assess the impact of multi-species incorporation on animal performance
- Assess the management requirements of multi-species incorporation
- Assess the impact of multi-species incorporation on Biodiversity and Soil Carbon
- Determine prospects for success of multi-species incorporation on commercial NI farms
- Disseminate project activity and results

The Operational Group

Following participation in a H2020 SUPER-G funded ‘Ecosward’ on-farm research project a number of the farmers involved had increased interest in multi-species swards (MSS) but were unsure as to how they would incorporate it into their farms outside a pre-ordained research protocol.

When funding became available under the European Innovation Partnership initiative the Multi-Species Swards for Beef and Sheep Operational Group was formed to address the questions surrounding MSS utilisation on NI beef and sheep farms.

Having facilitated the EcoSward project AgriSearch brought together the five beef and sheep farmers who had taken part in the EcoSward project, plus one additional organic farmer who was familiar with MSS and low input systems, alongside expertise from the Agri-Food and Biosciences Institute (AFBI) and Queens University Belfast (QUB).

The members of the Operational Group are:

- Andrew Clarke (on behalf of Wayne Acheson) – Cookstown, Co. Tyrone
- Dale Orr – Strangford, Co. Down
- Crosby Cleland – Saintfield, Co. Down
- Paul Turley – Downpatrick, Co. Down
- Roger Bell, Kells, Co. Antrim
- Sam Chesney – Kircubbin, Co. Down
- Dr Denise Lowe – AFBI (left March 2022)
- Dr David Patterson – AFBI (joined March 2022)
- Prof Nigel Scollan – QUB
- Jason Rankin – AgriSearch (Lead Partner)

Members of the Multi-Species Swards for Beef and Sheep on a study tour to MSS sites in Republic of Ireland

Dr Denise Lowe and Dr David Patterson at AFBI's livestock branch took on the role of scientific lead in the project having previous experience of grassland focused on-farm ruminant research. The group was administered by AgriSearch who took on the role of project lead and provided an innovation broker to support the delivery of the project aims and objectives. AgriSearch also led on all dissemination activity for the project.

Members signed a partnership agreement declaring their intentions to work cohesively to deliver the objectives listed in the project action plan. Each member contributed to the compilation of the action plan and its delivery. Roles and responsibilities were assigned to each member to ensure clarity regarding their expected input. The group met on a regular basis to plan activity, discuss progress and report results.

The majority of the farmer group members had previously worked with AgriSearch and AFBI on prior on-farm research projects which was beneficial to the dynamic of the group.

Project Details

To meet the aims of the project a number of actions were planned and undertaken for the delivery of individual objectives.

Objective 1: Establish multi-species swards on participant farms

Before establishment of multi-species swards on farm could take place each participant farmer had to first determine which fields were going to be committed to the project and what species mix was going to be sown in each. To help them to make those decisions soil sampling for pH, P, K and a range of trace elements was conducted in January 2021 on the fields being considered. A meeting was also set up with a representative from a seed merchant to discuss MSS, the different species mixes available and their different requirements.

At the same time a literature review (see *appendix 4*) was conducted by Dr Denise Lowe at AFBI to review the use of MSS elsewhere to determine what might be expected on farm following establishment.

All establishment on farm took place in the spring and summer of 2021 with each farm determining and implementing their own grazing and management strategy thereafter informed by the literature review and in consultation with other group members. The seed mixtures chosen varied from farm to farm (see *appendix 5*), but the common seed mixture components were typically: perennial ryegrass; timothy; white clover; red clover; chicory; and plantain. These were assessed alongside existing and/or reseeded grass-only (GO) and grass/white clover (GWC) swards on each farm.

Objective 2: Assess the impact of multi-species incorporation on animal performance

Once the sward was established each farm was requested to record, where possible, animal performance information for individuals grazing the established MSS such as live-weight gain, health/performance information and anthelmintic use.

A number of the farms established a suitable area of MSS to enable batches of stock to be grazed exclusively on the MSS but the remainder utilised the MSS as part of a wider grazing rotation which included perennial ryegrass (PRG) only and/or PRG & White Clover (WC) swards. On the farms where stock were able to be exclusively grazed on MSS, additional data was collected. Two were provided with FECPAK^{G2} kits to undertake on farm faecal egg count monitoring of stock grazing the MSS and stock grazing PRG/WC swards. Blood sampling was also carried on a small subsample of the batches grazing MSS and PRG/WC to assess nutritional effect on Copper, Selenium and Iodine levels.

Objective 3: Assess the management requirements of multi-species incorporation

Once established each farm was also requested to record, where possible, sward management information such as fertiliser use and weed burden. To supplement this information botanical composition was assessed in autumn 2022 across all farms, using hand separations of herbage samples into herbs, clover, grass and weed fractions. Soil samples were also repeated in January 2023 to investigate any impact of management change on soil health.

Objective 4: Assess the impact of multi-species incorporation on Biodiversity and Soil

Soil Carbon sampling was undertaken in each established MSS field in autumn 2022. Samples were taken at 10cm and 30cm depth. Soil carbon samples were also taken in one nearby PRG or PRG/WC clover field at each farm location. Ideally soil carbon sampling would have been undertaken pre-establishment and repeated two years later as occurred with the standard soil sampling but there were limited soil carbon sampling protocols available in early 2021 and establishment could not be delayed due to the short duration (<3 years) of this project.

Biodiversity sampling was scheduled to take place in May/June 2023 using new technology (Agrisound Polly Sensors) to assess presence and abundance of pollinator species. However, due to resource limitations at Queen's University Belfast and the strict time limitations of this project this activity was unfortunately not completed. It is the intention the activity will take place but no will no longer form an output of the EIP project. Anecdotal evidence of biodiversity presence and abundance was however noted by the farmer participants throughout the project.

Objective 5: Determine prospects for success of multi-species incorporation on commercial NI farms

Following completion of on-farm activity at the end of the 2022 grazing season the results were compiled and analysed by operational group members at AFBI and the prospects for increased uptake of MSS on NI beef and sheep farms considered. To supplement this information the participant farmers were also surveyed regarding their thoughts on both their own experience as part of the project and wider applicability of MSS in the NI agricultural context.

One argument for increased MSS utilisation in NI was improved ecosystem service provision including positive impact on farm carbon footprints. To understand the impact of MSS on carbon footprints, AgreCalc conducted a revised whole farm carbon report for one of the participant farmers who had previously conducted his original report in 2020 before the EIP project had commenced. The impact of increased MSS on farm was reviewed and future farm scenarios assessed.

Objective 6: Disseminate project activity and results

A suite of dissemination activity was planned and undertaken throughout the course of the project to share information on MSS, it's establishment and management as well as project activity and outcomes as they arose.

Project Funding

This delivery of this project was supported via the European Innovation Partnership (EIP) Scheme in Northern Ireland which is jointly funded by the European Agricultural Fund for Rural Development (EAFRD) and the Department of Agriculture, Environment and Rural Affairs (DAERA).

Each project had a maximum budget of £120,000 available for planned activity over the duration of the project.

Total budgeted and claimed costs – £95614 TBC

Approximately 31% of funding was allocated to project dissemination and promotion and 22% allocated to project administration. The remainder was allocated to direct activity in the delivery of the project. Total spend would have been higher if the biodiversity component of the project had been able to be completed within the project duration.

No capital funding was obtained for this EIP project via the available channels.

Any additional or ineligible activity was funded by AgriSearch, the lead partner within the Multi-species Swards for Beef and Sheep Operational Group.

Project Results and Outcomes

Objective 1: Establish multi-species swards on participant farms

Literature Review

Following a review of the literature, available in full in *appendix 4*, it was concluded that there is potential for MSS to build resilience into beef and sheep systems. There is, however, a lack of evidence for establishment and management of MSS under NI conditions of soils and climate.

With regard to results from previous research conducted elsewhere, there is evidence of many positive aspects of incorporating MSS in beef and sheep systems. MSS can provide an opportunity to increase sward diversity whilst producing similar herbage yields to PRG swards, but with less nitrogen fertiliser/ha/year, thus increasing nitrogen use efficiency. In addition herb species such as plantain and cocksfoot are characterised by their deep root system, which can assist in drought resistance and resource utilisation from deeper soil layers. Herb and legume swards have also been shown to have a higher feeding value for ruminants than PRG swards. These swards can contribute to rumen health, provide a higher feeding value for ruminant species, while improving biodiversity and mitigating environmental concerns by reducing the need for fertiliser and nitrogen leaching risks.

However, research on the effect of grazing MSS on animal performance is often conflicting and a focus on beef cattle in particular is limited. Many of the research outcomes vary especially in regards to animal performance, endo-parasite control and environmental impacts. This is likely as a consequence of different research methodologies and different sward species combinations (which have different nutritional properties). Additionally, MSS have often been found to be harder to manage than PRG swards and there are often problems with persistency in the sward over the medium to long-term.

MSS Establishment

A total of 20 fields, totalling approx. 36.8ha, were established in MSS across the six farms participating in the EIP project as listed in *Table 1*. The lowest pH in any of the fields prior to establishment established was 5.8 but the remainder had a pH of at least 6.2.

Each participant farm chose their own preferred means of establishment and species mix. Species mixes ranged from simple 6 species (PRG, Timothy, Red Clover, White Clover, Plantain and Chicory) to an 18 Species mix (full details available in *appendix 5*).

Table 1 – Fields established in MSS as a result of the EIP project

Farm	Fields Established	Total Ha
Andrew Clarke/Wayne Acheson	3	8.8
Dale Orr	3	5.9
Crosby Cleland	5	7.8
Paul Turley	7	9.6
Roger Bell	1	2.8
Sam Chesney	1	1.9
Total	**20**	**36.8**

Establishment at the farm of operational group member Paul Turley in spring 2021

Establishment methods ranged from the use of a stale seed bed technique to stitching in (see *Table 2*) and were chosen depending on soil type, weather considerations and farm preference. Despite the inherent variation in these farm situations, in general at least some form of soil disturbance and cultivation is required for successful germination and establishment of MSS mixtures. On the one participant farm that did not cultivate and instead stitched in directly to an existing PRG sward, establishment was less successful with herb presence reducing significantly within the 2 years of the project. Previous fields established using this method but having sprayed off the PRG were more successful indicating there are more factors than just establishment method that affect it's success. One such factor is time of establishment with spring/early summer establishment found to be more successful across the fields established allowing sufficient time for new seedlings to fully establish during the first year.

Table 2 – Range of MSS establishment methods used within the EIP project

Method 1	• Plough, lift surface stones, then harrow until well consolidated. • Roll, sow at surface, then final roll.
Method 2	• Spread farm-yard manure, sub-soil where required, plough and power harrow twice before stone lift. • Roll before and after seed sowing.
Method 3	• Plough, stone lift, power-harrow, land-level, pause • Stale seed bed period, spray weed seedlings, sow seed, then roll.
Method 4	• Close grazing with sheep, seed stitched in directly to soil surface
Method 5	• Minimal tillage establishment: mole drained, power harrowed, seed sown by Einboch air seeder, then rolled.

The consequence of any degree of soil disturbance is the resultant and sometimes rapid germination of broad leaf weeds and natural grass weeds from the soil seedbank. The stale seed bed technique can be used to exhaust the weed bank of seeds near the prepared soil surface by waiting for weed germination, to then spray off just before sowing the new seed mixture. Where this was deployed on the participant farms it gave good results. The observation from those that undertook the method however was that whilst it was a plausible method to minimise weed burden, from a practical perspective it requires more time to carry out. This is especially difficult if it coincides with an early summer dry period. It needs two good ‘weather windows’ for cultivation and again for seed sowing, and so is better suited to spring and early summer rather than late summer reseeding.

In situations where a substantial area is to be established over a short period of 1-2 years then it is inevitable that a combination of methods will be required; from minimalist methods such as close graze - no sward kill - direct seeding through to full cultivation with sward kill – plough – cultivations - seeding. These contrasting methods will differ in cost, time required, seasonality and suitability for the terrain and soil type. Based on the findings of this study there is a clear need for a comprehensive establishment trial for MSS seed mixtures, especially given the range of soil type and rainfall scenarios experienced across NI.

Objective 2: Assess the impact of multi-species incorporation on animal performance

<u>Live-weight Gain</u>

Where it was feasible on farm animal performance was assessed on a comparison basis. Three farms were able to keep batches of stock on MSS and PRG/WC swards exclusively and monitor their performance over the 2022 grazing season. *Table 3* shows performance data for two flocks of 74 ewes rearing double lambs that were taken through to slaughter. No supplementary meal was offered to the lambs. Daily live weight gain (DLWG), slaughter weight/age and carcase weight were recorded. Lamb DLWG was consistently higher with MSS over the first 8 weeks of the grazing period. Slaughter weights were similar but lambs grazed on MSS were finished much earlier (-29 days) which would have significant cost saving and a lower HGH footprint relative to those grazing PRG/WC.

Table 3 - Lamb performance on a sheep-only system in 2022

	MSS	**PRG/WC**
Lamb DLWG (weeks 1-4) (kg/d)	0.376	0.304
Lamb DLWG (weeks 1-8) (kg/d)	0.310	0.280
Mean Slaughter Weight (kg)	42.86	42.96
Mean Carcase Weight (kg)	19.95	19.50
Mean Slaughter Age (days)	167	196


Ewes and lambs grazing the MSS ward at the farm of operational group member Dale Orr in Apil 2022. Lambs grazed MSS only from birth.

Broadly similar cattle performance was recorded (see *Table 4*) with two cattle groups rotationally grazed exclusively on either MSS or grass-only (GO) both throughout the season and for the grazing season as a whole. This was achieved on MSS with zero N fertiliser added compared with grass-only swards plus 90kgN/ha. Another farm recorded 0.87 and 0.70 for GO and MSS groups respectively. Farm to farm variation underlines the need to evaluate growth rates under more controlled conditions and to investigate the underlying reasons for animal performance.

Table 4 - Animal performance on a cattle-only system in 2022

DLWG (kg/d) from 31st March	MSS	PRG
31st May	0.6	0.82
12th July	0.85	0.8
30th Aug	0.63	0.65
21st Sep	0.67	0.185
Whole season	0.68	0.70

Cattle grazing MSS sward at the farm of operational group member Paul Turley in August 2022

For those farms utilising MSS within a mixed grazing rotation animal performance was more variable. The majority were not concerned with animal performance finding little difference to when grazed on PRG or PRG/WC swards. On one farm however lamb performance dropped when grazing the MSS swards after grazing PRG only swards, as part of a rotation, as illustrated in *Table 5*.

Table 5 - Lamb performance on an alternating sheep-only system in 2022

Sward type	**Grazing Period (2022)**	**DLWG** (kg/day)
PRG	21/07 - 28/07	0.340
MSS	28/07 - 03/08	0.160
PRG	03/08 - 12/08	0.350
PRG	12/08 - 19/08	0.240
MSS	19/08 – 26/08	0.090
PRG	26/08 – 02/09	0.420

The farmer believed the lambs to be unsettled and thought the PRG seed type within the MSS mix may not have been the correct choice for sheep grazing preferences. These observations further underline the need for research into the effect of alternating sward diet/composition on sheep productivity, which will be especially important if farms were to gradually convert grazing areas over to MSS.

By way of comparison with the on-farms results, a grazing trial was set up at AFBI Hillsborough which had two groups of dairy-origin calves which grazed either a Grass-White Clover (GCS) sward (A) or a MSS sward (B). Both swards received 75 kg N/ha in spring and 85kg/ha of Sulphate of Potash during the growing season. The swards produced approximately 12 tDM/ha/yr which was similar to yields estimated on the farm sites. The performance of the calves throughout the grazing season are presented in Figure 1. Dairy origin beef calves grazing MSS had a higher (P<0.001) DLWG during both 2020 and 2021 than those grazing GCS swards (Newell *et* al. 2023).

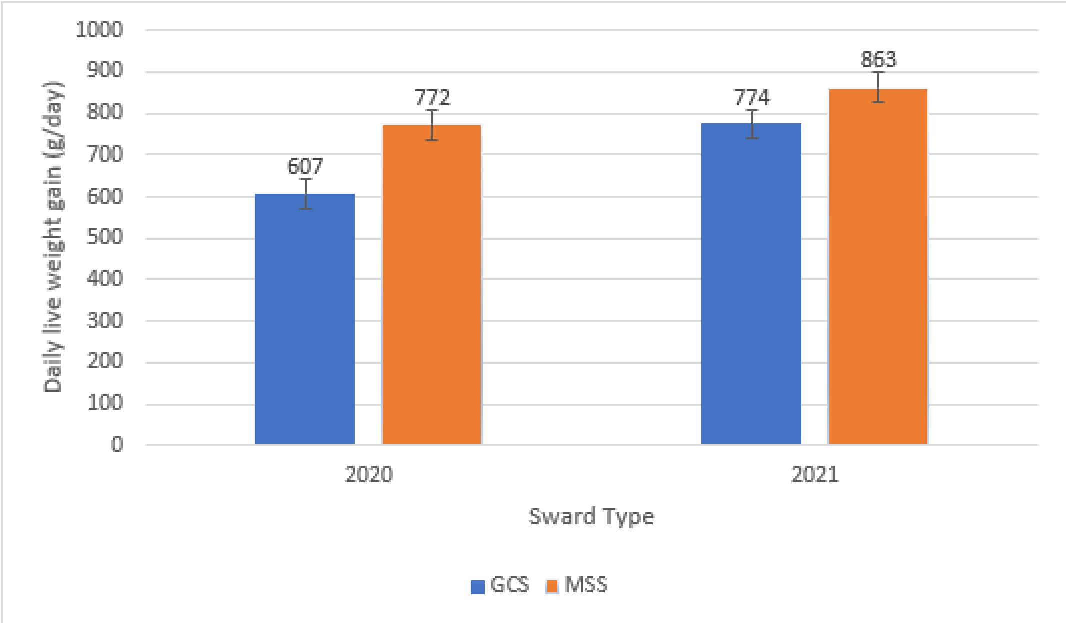

Figure 1 - Live weight gain of dairy origin calves grazing either grass clover (GWC) or multi species swards (MSS) during 2020 and 2021.

Animal Health

The sheep farm who closely monitored the performance of the lambs (presented in *Table 3*) also monitored faecal egg counts (FEC) during the season. Lambs only received an anthelmintic dose when the FEC indicated that it was required. All lambs were dosed for worms at 8 weeks. The MSS batch had a Strongyle count of 140 and PRG/WC batch a count of 245 at 12 weeks so only the PRG/WC lambs got another dose. All lambs got another dose at around 16 weeks when they were all weaned. The PRG white clover lambs received another dose around 20 weeks. The MSS lambs received no more dosing. From that point onwards only individual lambs with an average DLWG for the previous week of less than 225 g per day received and anthelmintic dose. Overall, this monitoring indicated the lambs on MSS had lower FEC and required less dosing than their counterparts grazing PRC/WC swards. The farmer also noted that both the ewe and lambs on the MSS were visually cleaner than those grazing PRG/WC.

Table 6 - Blood profiles for lambs grazing MSS or PRG

	MSS Lambs	**PRG&WC Lambs**
Plasma Copper (uM)	23.6	25.8
GPX (u/g) [Selenium]	768.8	1159.2

Six lambs from each group were also blood sampled for copper, selenium and Iodine. No differences were observed in blood levels, with lambs having sufficient copper and selenium for optimal performance (see *Table 6*). Iodine levels were comparable across treatment groups but low and an Iodine bolus was used to supplement the lambs. These results were not surprising as a forage analysis undertaken in autumn 2022 shows relatively similar trace elements between the MSS and PRC/WC swards (see *Table 7*).

Animal health on a beef farm (animal performance presented in *Table 4*) was also monitored. In this case, no difference in FEC were observed. Similarly, blood samples for copper, selenium and Iodine were comparable (see *Table 8*).

Two additional beef farms reported that their animals grazing MSS received less anthelmintic treatments relative to those grazing PRG swards. This may potentially be linked to the year and the weather patterns within it but reductions in treatments saved money, handling and time.

Table 7 - The sward mineral analysis of MSS and PRG_WC.

	MSS	PRG&WC
Calcium (%)	0.64	0.48
Magnesium (%)	0.2	0.16
Manganese (ppm)	42.7	56.2
Boron (ppm)	6.3	3.1
Copper (ppm)	9.3	8
Molybdenum (ppm)	3.67	5.55
Iron (ppm)	90	108
Sodium (%)	0.12	0.18
Iodine (ppm)	1.4	1.9
Cobalt (ppm)	< 0.2	< 0.2
Zinc (ppm)	18	19.1
Sulphur (%)	0.24	0.32
Phosphorus (%)	0.33	0.5
Potassium (%)	3.45	3.03
Nitrogen (%)	3.07	2.85
Selenium (ppm)	0.03	0.05

Table 8 - Blood profiles for cattle grazing MSS or PRG

	MSS Cattle	PRG Cattle
Plasma Copper (uM)	18.22	14.88
GPX (u/g) [Selenium]	91.7	65
Iodine	26.0	32.0

Objective 3: Assess the management requirements of multi-species incorporation

N-Fertiliser Use

All farmers within the project were able to significantly reduce manufactured Nitrogen fertiliser use in comparison to traditional PRG swards on farm and in some cases removed Nitrogen fertiliser application completely (see *Table 9*). Sward performance was not hindered with the majority producing comparable tonnes of DM per hectare to PRG swards on farm.

Reduction in nitrogen fertiliser had a direct cost saving for the farms particularly given the inflated price of fertiliser in 2022. A number of the farms that did still apply some fertiliser indicated they might use even less in 2023 or try more specialised fertiliser options such as those designed for clover swards.

A number of the participant farms in County Down experienced a prolonger dry period in 2022 during which many noted their MSS fields were the only green fields on the farm. On one farm in particular PRG swards at this time were only achieving 10/12/15kg DM/ha whereas MSS fields were achieving 45kg DM/ha. Three weeks into the drought period stock grazing PRG swards were receiving supplementary feed but stock grazing the MSS fields were not.

Table 9 – Summary of fertiliser application and sward performance

Dale Orr	• No N-fertiliser applied. • In 2022 swards received one dressing of 85kg per ha of Sulphate of Potash during the year • Swards produced nearly 12 tonnes of DM per hectare
Paul Turley	• No N-fertiliser applied • Swards performed similarly to PRG (whole farm average and average across MSS both 12.5t DM/ha)
Roger & Hilary Bell	• 40 kg/N/ha applied in 2022 • 11 tonnes of DM per hectare
Sam Chesney	• Applied 50% of less of usual applied to PRG (180kg/N/ha) • Sward performance comparable to PRG and exceeded it in drought conditions
Crosby Cleland	• 32kg/N/ha applied in 2022 • Achieving between 7 – 10 tonnes of DM per hectare – comparable to PRG swards on farm

Sward Composition

Although there were differences in time of reseeding, location, soil type, seed mixtures and establishment methods used on the participating farms, the majority of fields had quite similar grass content after 2 years, see *Table 10*. The herb and clover content were more variable across the farm sites. Despite this, these non-grass species did form a significant proportion of the resultant MSS over the project lifetime, typically 30-50% when combined. The participant farmers did also report that of all herb species sown, the most persistent was plantain followed by chicory. Where other lesser-known legume and herb species were sown, such as birds foot trefoil and yarrow respectively, they often did not establish well and were not present in the final botanical field survey. Of the participant farmers that did sow more extensive species mixes such as a 13 species or 18 species mix feedback was consistent that the additional components did not establish well and could be regarded as unnecessary and in some cases detrimental leaving the sward too open and susceptible to tramping and weeds.

All participant farms within the project experienced some degree of weed burden within their established swards, a common consequence of soil disturbance during establishment. The stale seed bed method was utilised by one farm to good effect with weed burden minimal. Others did not fare so well and weed burden in year one was significant but not insurmountable and the weeds became lesser more manageable as the sward matured as illustrated in *Table 10*.

Table 10 - Proportion of clover, herbs and grass in MSS fields from 5 farms

Farm	Field	Proportion of Sward			
		Clover	**Herbs**	**Grass**	**Weeds**
P Turley	1	11%	34%	52%	4%
	3	8%	34%	53%	6%
	5	25%	21%	54%	0%
	7	11%	30%	58%	0%
D Orr	2	7%	33%	60%	0%
	3	8%	15%	77%	0%
C Cleland	2	0%	7%	93%	0%
R Bell	1	7%	25%	67%	1%
S Chesney	1	17%	18%	65%	0%

The average dry matter % of the sward components across all sites was 15.1 for clover, 16.6 for grass but only 10.3% for herbs. This presents a challenge more so for silage making from MSS in order to achieve a satisfactory wilt with a MSS crop. Despite this when one participating farmer made MSS silage, with wilting to 25% and 46% dry matter on two occasions, the ME, crude protein and intake potential were very similar to grass-only silage made around the same time.

Objective 4: Assess the impact of multi-species incorporation on Biodiversity and Soil

<u>Soil</u>

Soil carbon was assessed across all MSS farm fields at the end of the 2022 grazing period as well as a nearby Grass only field for comparison (*Table 11*). Soil cores were taken at both 10 and 30cm depth. A range of parameters were reported, such as organic matter %, soil organic carbon % and organic carbon stock (t/ha). There were no clear differences in carbon parameters between sward types on the six farms. This result is not surprising due to the long-term nature of the dynamics of soil carbon content. Further studies are required to evaluate carbon soil dynamics under MSS over a much longer period.

Soils were also sampled in January 2021 (pre-establishment of MSS) and again in January 2023 an analysed for a comprehensive suite of trace elements including the standard soil (pH, P, K and Mg). No significant changes were observed in the two-year duration of the project but would be recommended again to observe longer-term impact of MSS swards.

Table 11 - Average Soil carbon results after 2 years

		Total Carbon %	Total Nitrogen %	C:N Ratio	Organic Matter %	Soil Organic Carbon (SOC) %	Organic Carbon Stock t/ha
MSS	**10cm**	4.77	0.49	9.62	8.14	4.71	44.8
Grass-only	**10cm**	5.33	0.54	9.83	9.13	5.32	48.9
MSS	**30cm**	4.18	0.43	9.47	7.15	4.15	118.0
Grass-only	**30cm**	4.35	0.44	9.50	7.43	4.30	123.8

Biodiversity

Although biodiversity was not able to be directly assessed on the farm sites during the project, throughout the project participant farmers reported anecdotal evidence of greater worm abundance in the soil beneath. Earthworms provide an indicator of soil health, with higher levels equating to greater soil health. Improved soil structure and drainage as a result of both earthworm activity and the improved variety of root structures within an MSS sward was also observed.

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Grass Clover Plantain Chicory

Diverse rooting systems of legume and herb components of MSS observed during the project

A parallel PhD study investigating both adult and juvenile earthworms on AFBI field sites found adult and juvenile populations to be higher in multispecies sward soils compared to PRG and permanent pasture soils (*Figure 2*). MSS yielded significantly higher populations of epigeic and anecic worm species compared to perennial ryegrass or permanent pasture. The higher levels of earthworm biomass present in MSS soils suggest improved soil health relative to the other sward types (Boughton et al., 2023).

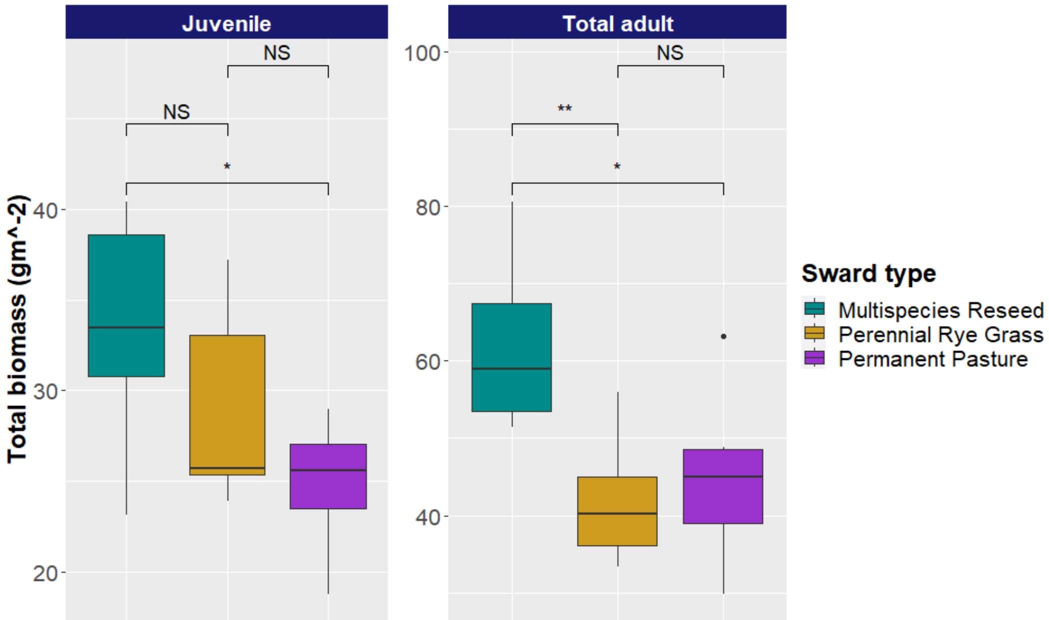


Figure 2 - Total biomass of juvenile and adult earthworms in MSS, PRG and Permanent Pasture

Above ground, increased insect (butterflies etc.) and bird presence and activity were also observed by the participant farmers in comparison to their PRG predominant fields. This was also evident and commented upon during on farm discussion meetings and at the knowledge exchange events. Although not physically measured this observation indicates MSS provides improved habitat for biodiversity which would be expected given the increased number of pollinator plants within the sward.

Objective 5: Determine prospects for success of multi-species incorporation on commercial NI farms

<u>Review</u>

The conclusions and summary from the on-farm experiences of this project would very much concur with the findings of the literature review of the scientific data regarding MSS. There are varying levels of success across both scientific papers and indeed across these participating farms as to the ability of MSS to compare with grass only or grass clover swards. However, it is clear from the number of people attending workshops, webinars, meetings and farm walks that there is a definite industry interest and desire for MSS going forward.

There is a great variation in seed content of the available commercial seed mixtures ranging from just a few grasses, clover plus plantain and/or chicory to mixtures with 18 plus different seed components. The conversations and discussions with the participating farmers, seed supplies and other researchers in this field have clearly not led to any concluding recommendations as an ideal sward mixture. However, experience from this project would indicate that Plantain appears to be the most likely herb for persistence within NI soils. Additional research is required in this area, but it is likely that in the future this might not change, and the ideal mixture may be more related to the field soil type, fertility and species of animal likely to be grazing it. Farmers considering MSS should discuss the seed choice with their seed merchant.

The greatest challenge appears to be with getting a good establishment of the sward in the first instance. The duration of this project has seen very variation patterns of weather which have created difficulties for grassland management. Indications from this project would direct farmers towards a spring or early summer reseed. Many beef and sheep farms would traditionally reseed at this time so this would not be a limiting factor for widespread uptake. Soil fertility is criteria for good establishment and performance of MSS swards, with high soil pH being desirable. Soil pH across Northern Ireland farms are often lower than optimal for grass production so it is essential that measures are taken to address this prior to establishment of MSS. At present the NI Soil Health Scheme will be providing farmers with free soil analysis which will be valuable information for getting the recommendation for the lime application required for optimal soil health. Therefore, an idea time to consider reseeding if farmers are going to address their soil health. This should aid uptake of reseeding across NI farms and potentially incorporation of MSS.

The next greatest challenge for MSS swards is weed control. There is currently no suitable herbicide available in Northern Ireland that can be safely applied to MSS. Therefore, weed control must be undertaken in advance to sward establishment. A stale seedbed (whereby the land is prepared for reseeding and then rested for 2 weeks and re-sprayed to kill the weeds prior to final cultivation and seed sowing) offers an opportunity to reduce weed in the new swards. However, from a practical perspective this is challenging as it delays reseeding and removes the sward from grass production for a longer period. Plus with challenging weather patterns increases the risk of a very delayed reseeding programme. Within this project farmers have become more resilient to weeds and are less worried about them with some suggesting that the livestock grazing MSS are more likely to eat some of the weeds which helps control than what they would do in a grass sward. However, more research is required in this area over a longer duration to ensure the weeds do not dominate the sward after a few years. This will certainly be a major challenge for the long-term uptake of MSS and if sward longevity is reduced due to weed control this would be a major concern.

Within the scientific literature there is conflicting reports of effects of MSS on animal health and performance. A similar observation was made in this study, with some farms seeing benefits of MSS and others having comparable levels of performance. However, the evidence from this project would generally be favourable for MSS that it would either sustain or enhance the performance of livestock relative to a grass only or grass clover sward. From an animal health perspective, although again some conflicting outcomes, there would appear to be evidence to support that animals grazing MSS may have lower faecal egg counts relative to animals grazing grass only or grass clover swards. This reduces some anthelmintic usage which brings health, environmental and cost benefits which would be a positive message for the beef and sheep industry.

Biodiversity measurements were not taken during this project, however, observations above and below the ground level provided some indication that MSS are better for biodiversity than grass only swards. Early evidence would indicate that MSS may improve soil structure and increase carbon sequestration, which is positive. At present, farmers are not financially rewarded for biodiversity or carbon storage, so this is unlikely this benefit is unlikely to lead to widespread usage at this point in time. However, the evidence gained from this project clearly illustrates a simple approach that could be adopted on farm if such requirement was introduced into future payment structures.

This project was conducted during a period (2021-2023) when we experienced unprecedented rises in fertiliser prices. The ability of the participating farmers to either reduce or replace fertiliser nitrogen with clover inclusion as part of the MSS sward and maintain similar levels of performance has probably been one of the most significant factors that will influence uptake of MSS swards across NI farms. Nitrogen has historically been so cheap that many farms chose grass only swards rather than trying to manage clover as a tool for supping nitrogen. The management of an MSS sward is very similar to that of a grass clover sward; and if the herbs do not persist after a few years a good grass clover sward should remain. Beef and sheep farms generally operate under low financial returns relative to other agricultural enterprises. The inclusion of clover either in a grass clover or MSS sward has excellent potential to reduce input costs and maintain performance levels provided that management is correct. However, there is a huge education piece required to ensure farmers get the correct advice and guidance to correct establish the sward and thereafter manage it to reap the rewards of the clover. Initial uptake is predicted to be high and evidence from seed merchants would support this, however, correct grassland management, particularly around weed control are critical to ensure that the clover persists within the sward otherwise the initial response will be short lived.

Overall, this project has demonstrated that MSS could have a significant role at reducing production costs, improving environmental credentials, and maintaining output levels on beef and sheep farms. Collectively, these should lead to widespread adoption of MSS swards throughout NI. However, knowledge gaps on choice of mixture, establishment, and optimal management in a range of soil conditions over a prolonged timeline (>5 years) remain and will be the ultimate determinate to widespread adoption.

Participant Farmer Survey

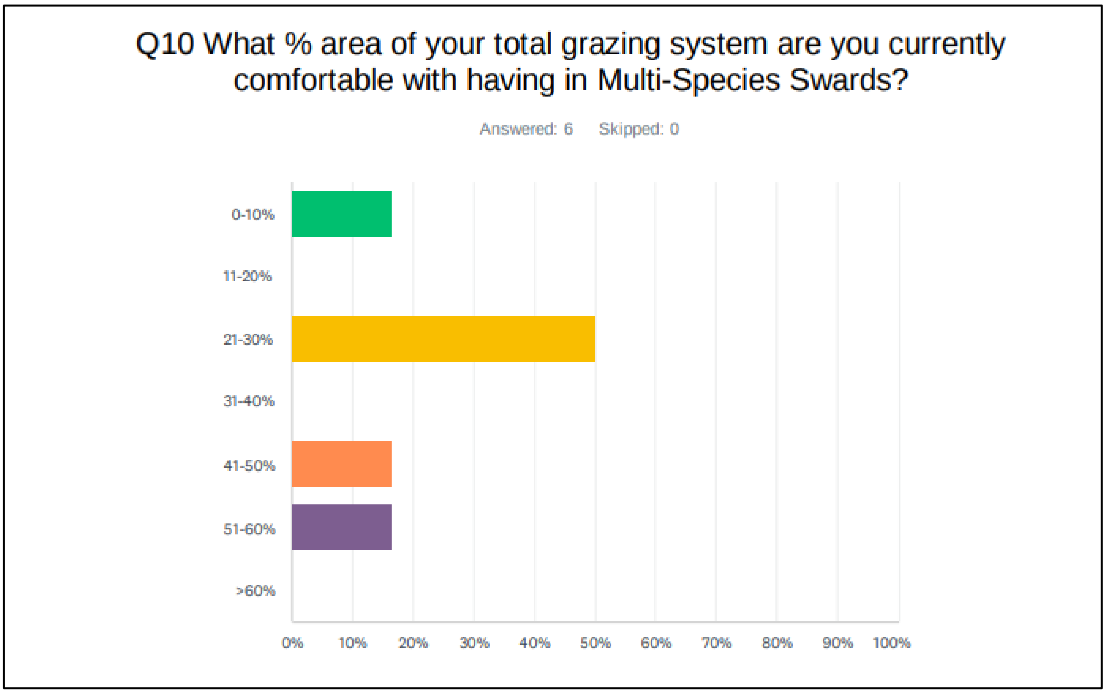
A short survey was issued to each of the six participant farmers in May 2023 to gather their opinions on their own experience as part of the project and also the wider applicability of MSS in the NI agricultural context.

All the farmers indicated that they were either satisfied or very satisfied with the outcomes of their own MSS trial as part of the EIP project and all would consider establishing more MSS on farm in the future (with some already having done so). Despite their satisfaction with the trial they all stated that they would likely make changes to establishment technique, seed mix, grazing management and fertiliser application to improve outcomes further. Comments included that there are always improvements that can be made and that the project was a learning experience that will be built upon going forward.

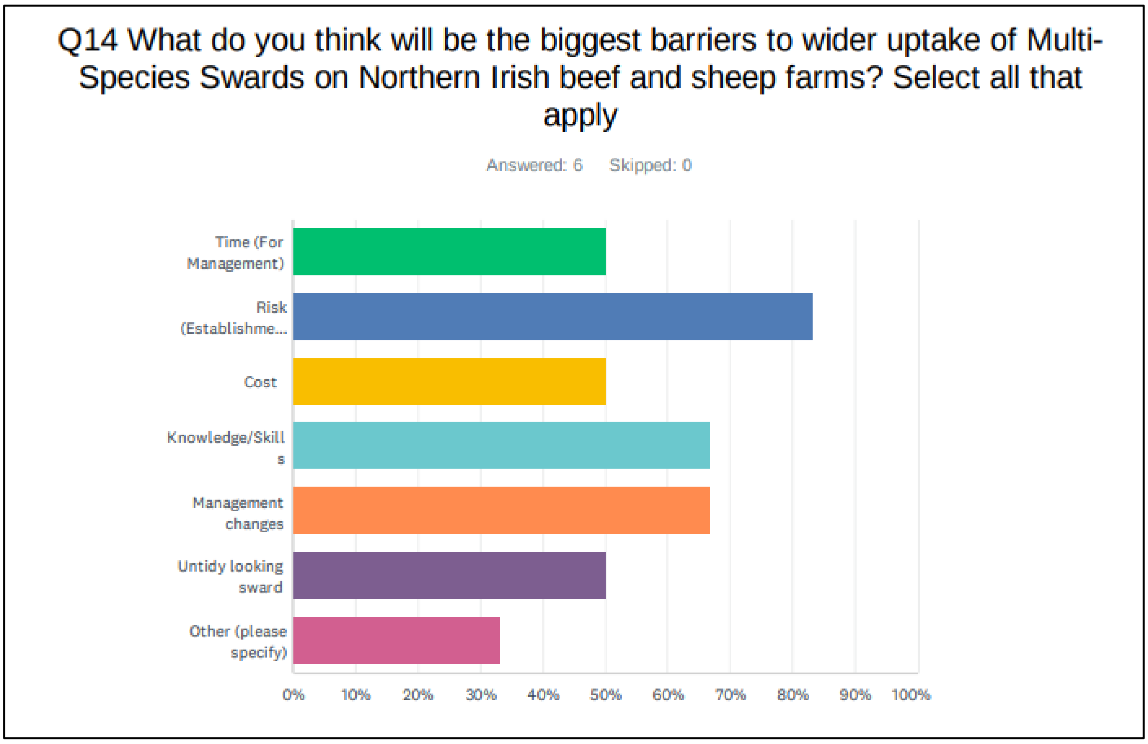
The biggest benefits to having MSS were believed to be drought resistance (location dependent) and reduction (and in some cases removal) of nitrogen fertiliser requirement as well as improvements to soil health and structure. When asked what the biggest challenges were, weed control was the most popular answer. Utilising MSS within a rotational grazing system and changing mindset with regards management were also selected.

All of the participant farmers stated that they would encourage others to establish MSS following their own experience during the EIP project with responses indicating they believe it to be best suited to a sheep grazing systems. Support was still evident for suckler beef and intensive beef rearing/finishing and other, which was classified as any system by the respondent.

None of the farmer participants thought it feasible that any farm should move to MSS only across their whole grazing platform. They themselves indicated only being comfortable with a maximum of 60% of total area in MSS with the majority of responses lower than that in the 20-30% range.



When asked what they considered the biggest barriers to wider uptake of MSS on NI beef and sheep farms the most popular answer was risk e.g. the risk of establishment failure etc. followed closely by lack of knowledge and skills and the required changes to management.



When asked to provide any additional comments their opinions included the following:

- There is a clear difference between cattle and sheep systems. Species mix choices and management decisions will change depending on the intended grazing stock
- There is no 'no size fits all' approach for MSS - trial and error is required and should be expected
- A change in mindset is required – re-education of sward management needed to broadened perspectives from those used to PRG only swards
- It was noted that many will just not like the untidy look of the sward. It won't be for everyone.

AgreCalc Scenario Analysis

The role MSS can play in reducing climate impact on farming operations was indicated as a potential driver for increased uptake in Northern Ireland. To investigate the role MSS can play with regards reducing greenhouse gas emissions and/or increasing carbon storage on farm a whole farm carbon audit was undertaken for participant farmer Paul Turley using the AgreCalc calculator.

Mult-species swards comprise a grass, herb and legume components. Increasing clover content in a sward allows for a reduction in nitrogen application due to the clover fixing nitrogen in the soil. It is the reduction in fertiliser which affects the total net carbon emissions within a calculator such as AgreCalc.

Using scenario analysis, increasing clover content on farm to an average of 20% across all silage and graze fields and decreasing/removing fertiliser use accordingly (as per management during the EIP project) was modelled in comparison to the current trajectory.

Increasing clover content resulted in decreased emissions from fertiliser (embedded CO2 and N20) and also a decrease in the soil carbon losses in the system. Smaller emissions reductions were made from a reduction in diesel usage as a result of a reduction in fertiliser application. In comparison to the current system a 20% increase in clover across the farm could achieve a 66% reduction in soil carbon emissions, along with an overall 23% decrease in total emissions.

Whilst emissions savings can be made it is important to note that a number of relevant practices have the potential to reduce/increase greenhouse gas emissions and/or carbon storage on farm. A second scenario was modelled to show the difference in total net emissions if cattle breed were switched to allow for quicker and more efficient finishing and could result in a 33% reduction in total emissions without incorporating MSS and associated fertiliser reductions. Increasing clover on farm is therefore one option for reducing carbon emission on farm but there are a number of others they may have greater or equal impact when deployed instead or in combination with MSS.

It is also important to note that it is the clover component of the MSS sward which drives the change in total emissions on farm and therefore the establishment of good perennial grass clover and white clover swards would also have the same effect and may be easier to manage in farm situations were perhaps drought is not such a concern.

Building bridges between farmers, the research and development community and others supporting the agriculture sector

Operational Group

The Operational Group was formed of those with a shared interest in on-farm innovation and improved grassland management. This was evident throughout the project by the enthusiasm shown and the willingness to share with both each other and the wider agricultural industry.

The nature of the EIP funding framework ensured a project that was farmer-led with each participant farm being able to choose their own MSS path suitable to their existing farm enterprise. Having made the decisions on species mix, establishment method and management regime each had a vested interest in the outcomes and results that is often absent from other on-farm research trails which tend towards a fixed pre-determined methodology.

Having easy access to advice and support from academic experts within the operational group was vital and the formation of a WhatsApp group to share photos, videos and ask questions worked extremely well for the group. Over 2000 messages and 500 media files were sent via the platform. Regular group meetings supplemented this and allowed for topics to be discussed in more depth.

Group cohesion was further enhanced when the operational group members embarked on a two-day study tour in October 2021 visiting MSS trials at Dowth, UCD Lyons and Teagasc Johnstown Castle as well as a farm in Waterford that has been working alongside DLF Seeds Ltd. The tour reinforced the importance of what the group were trialling on their own farms and set the scene for what else is being researched and achieved elsewhere on the topic of MSS. There was plenty of discussion at each visit and the group members were left with plenty of food for thought regarding sward management options going forward within the project.

Operational group members at the UCD long term grazing platform at the Lyons Estate, Dublin

Project Dissemination

Project dissemination was central to project activity throughout the duration of the project. Dissemination included general media communication via the press and social media, a webinar, a series of farm walks and a closing conference.

The farm walks in particular were scheduled specifically to tie in with important stages in the project and at times where there would be plenty for attendees to see. It was widely acknowledged and agreed within the group that for farmers to be able to consider the option of MSS they would need to see it in person and hear directly from those that have already tried it. The first farm walk was scheduled for September 2021 and focused on establishment whereas the second was held in June 2022 and focused on sward management and animal performance. At each farm walk there were always plenty of questions and the farmer participants of the operational group freely spoke on both the benefits and the challenges of MSS. Over 200 people attended the second farm walk, many of whom who had attended the first and were interested in hearing more about the farmers experience.

Operational Group Member Paul Turley speaking to attendees of the farm walk held on his farm in June 2022

Feedback was sought after each farm walk event. Approximately 60% of respondents indicated they were a farmer with content judged to be 'about right' and the majority believing the delivery of presentations to be very good or excellent. Over 90% on both occasions indicated they would be keen to attend a similar event in future. Specific feedback stated that having farmers and advisors speaking at the same event left them feeling well informed and that the farmers open and honest viewpoints were appreciated. It was suggested, however, that an event should be held in the west of the province where soil types and climatic conditions differ. The prepared booklets for each farm walk are available to download from the AgriSearch website.

Interest in MSS noticeably increased over the duration of the project no doubt as result of the sharp rises in fertiliser prices. To capture this interest a webinar was held in March 2022 prior to the spring reseeding period. Each farmer participant provided a short explanation of how they went about their own establishment and their experience thus far, providing a clear overview of the range of options suitable for MSS should attendees chose to establish MSS themselves. The webinar was recorded and published to the AgriSearch YouTube channels to provide a lasting informational resource.

Feedback following the webinar indicated that ~80% of attendees were farmers with the majority agreeing the webinar format worked well for them. A number of respondents commented that the webinar provided with a lot of information in a short time, that they were perhaps going to try and establish some MSS themselves. The commitment shown by the farmers taking part in the project was also noted as being evident.

Project progress and details of upcoming events were regularly released to the NI farming press and posted to AgriSearch social media channels. Social Media was also often utilised to showcase photos and updates of what was happening on each of the participant farms. For example a short series of 'Meet the Farmer' videos were released in summer 2021 to introduce who was participating in the project and what each hoped to achieve.

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SEA OF POTENTIAL

Jenny and David O'Halloran, of Bláth na Mara, tell us about the opportunities that seaweed harvesting can bring

Talks on NI climate target under way

Free 68-page Plough On magazine inside

PETER MCCANN
NORTHERN CORRESPONDENT

Talks are under way at Stormont to find a compromise between two climate change bills which are currently making their way through the NI Assembly.

A private member's bill brought forward by Green Party leader Clare Bailey aims to reach net zero greenhouse gas emissions by 2045, while a separate bill from DAERA Minister Edwin Poots aims to cut emissions by at least 82% by 2050.

The Green Party bill previously had the support of all the main political parties except the DUP.

However, there appears to be a growing appetite at Stormont for more realistic targets after MLAs who supported the private member's bill received an angry reaction from farmers.

Ulster Unionist leader Doug Beattie has now said his party will support legislation which includes an % cut in carbon emissions by 2050. he best result is if agreement can reached on one amalgamated . This is too important an issue politicians to attempt to score tical points," he said.

spokesperson for Sinn Féin re- ed non-committal on the matter, hey did not rule out supporting nalgamated bill going forward. ieve there may be discussions en the drafters of both bills, and I will await their outcome," the Sinn Féin spokesperson told the *Irish Farmers Journal*.

Farmer frustrations intensified last month when independent analysis by consultancy firm KPMG found that reaching net zero by 2045 could require an 86% reduction in cattle and sheep numbers on NI farms.

The headline target in the DAERA bill is based on recommendations from the Climate Change Committee (CCC), an expert group which advises the UK government on climate policy.

It would still mean significant change for NI farmers, with CCC analysis suggesting that dairy and meat consumption would need to fall by up to 35% by 2050, so a similar drop in output from local farms would likely be expected.

AgriSearch, along with AFBI, CAFRE and Queen's University Belfast organised a farm walk to show the opportunity of multispecies swards on Dale Orr's farm at Strangford, Co Down. Dr David Patterson, AFBI, gives a talk on seed mixture examples and cultivation options. See report on p6

PLOUGH ON
Ploughing on into the future

Harvest 2021 – one of the best ever
FARMER WRITES >> 6

Focus on grazing pays dividends
DAIRYLINK >> 32

Irish Farmers Journal

The farm walk event held at the farm of operational group member in September 2022 made the cover of the Irish Farmers Journal

To conclude the project a conference and farm visit was held in June 2023 to provide an overview of the whole project, what it has achieved and thoughts on practicality and feasibility of MSS for the NI beef and sheep sectors. A panel discussion involving each farmer participant and their opinions formed the core session on the day. The conference included a visit to nearby MSS fields established as part of the EIP project where attendees heard more on the specific benefits and challenges experienced at that site.

In contrast to the farm walk and webinar events feedback following the conference indicated a lower number of farmers in attendance (~56%) with a greater number of attendees from industry and other sectors. Attendees were primarily from Northern Ireland, but a number of individuals were in attendance from the Republic of Ireland. In the feedback all respondents indicated that the event was well organised, had 'about right' content and that they would be interested in attending a similar event in future. Specific comments included that there was a good blend between conference content at the venue and content in the field. Some did however comment that whilst the overall opinion presented of MSS was positive a number of difficulties were highlighted throughout the day during the different sessions. The conference was recorded, and the videos of each session are available to view on the AgriSearch You Tube channel.

In addition to farm walk booklets and video recordings a number of other resources are available on the AgriSearch website and combined provide a useful repository of information for any farmer in Northern Ireland considering the incorporation of MSS on their own farm.

Additional benefits or unintended negative consequences that have arisen from the delivery of the project

A number of additional benefits have arisen from the delivery of the project:

- The formation of the group created a supportive network of farmers with an interest in alternative swards and on-farm innovation. The group WhatsApp in particular has allowed for the sharing of advice (with over 2,000 posts and over 500 photographs videos shared since it was set up) which in turn has encouraged further on-farm activity. A number of the group members have now established a field of lucerne as a result.
- By undertaking a study tour in the Republic of Ireland connections were made with researchers in UCD and Teagasc working in the field of MSS and legume rich swards. Meetings have since been held to improve communication between research bodies across the island of Ireland and discuss on-going and proposed research.
- The project was extremely timely and was able to fill the knowledge gap at time when farmers in Northern Ireland where in need of information on MSS. Interest in the topic increased quickly as a result of the sharp increase in fertiliser and feed prices.
- It was able to build on research already undertaken in NI

Few negative Consequences arose with the majority felt most strongly by the farmer participants in the project. Each took a risk in establishing MSS on farm which in the majority of cases paid off but wasn't without challenge or compromise and often derision from others. By taking part in the study they pioneered the way for other farmers in Northern Ireland to follow suit learning from their mistakes and experience.

Conclusions

This study has provided initial insight into sward and animal performance from mixed species swards utilised on a small number of beef and sheep farms in Northern Ireland. Although this was not a scientific study per se, the results do suggest that MSS swards can maintain or enhance animal performance compared to grass-only or grass-clover swards in terms of daily weight gain and age at slaughter, albeit switching swards in a rotation was found to be counter-productive. Sward establishment methods did vary across the farms and weather patterns were erratic during the 2 years of the study. Despite this, farmers successfully established swards with herbs and clover present along with grass. Although the seed mixtures used varied considerably on each farm, there was continuity in the main species present at the end of the project. Soil carbon assessments have provided a useful baseline from which to monitor soils over the coming years. Overall this project has highlighted the need for additional research in a number of key areas such as establishment, species persistency and grazing animal performance.

The on-farm experiences of this project would very much concur with the findings of the literature review of the scientific data regarding MSS. There is varying levels of success across both scientific papers and indeed across these participating farms as to the ability of MSS to compare with grass only or grass clover swards. However, it is clear from the number of people attending workshops, webinars, meetings and farm walks that there is a definite industry interest and desire for MSS going forward.

Overall, this project has demonstrated that MSS could have a significant role at reducing production costs, improving environmental credentials, and maintaining output levels on beef and sheep farms in Northern Ireland. Collectively, these should lead to widespread adoption of MSS swards throughout NI. However, knowledge gaps on choice of mixture, establishment, and optimal management in a range of soil conditions over a prolonged timeline (>5 years) remain and will be the ultimate determinate to widespread adoption.

Recommendations

There is potential for MSS to build resilience into beef and sheep systems but further research and support for uptake is required. A number of recommendations are listed below:

1. There remains a lack of evidence for establishment techniques and management options of MSS under the full range of varying soil and climate conditions within NI.
2. This study was short and so long-term management considerations such as persistency of herbs within the sward and soil carbon could not be studied. Further research is required or funding to support continued study of the sites established in the project.
3. Farm to farm variation observed underlines the need to evaluate growth rates under more controlled conditions and to investigate the underlying reasons for animal performance. Should include the effect of alternating sward diet/composition on sheep productivity, which will be especially important if farms were to gradually convert grazing areas over to MSS.
4. A full cost benefit analysis from establishment to end of the sward life to take into account sward persistency and the effects of MSS on animal production, use of antimicrobial resistance and carbon footprint would be beneficial.
5. Further research is needed on grass species to include within MSS other than PRG (e.g. Timothy, festulolium, tall fescue and cocksfoot)
6. Further research is needed on the nutrient requirements (P, K and trace elements) needed by MSS to ensure optimal production.
7. Education / training is required for farmers, advisors and wider industry in the management of legume rich swards and MSS.
8. Guidance resources required for on-farm strategies to manage bloat risk
9. Support options for MSS should be considered under the forthcoming DAERA Farming with Nature and Farming for Carbon schemes

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Appendix 1 - Operational Group members

Operational Group Member	Operational Group Member's Business	Role within the Operational Group
AgriSearch	Facilitation of on-farm research	Project Lead – Project management, group facilitator and delivery of dissemination activities
Crosby Cleland	Ruminant Livestock Farmer - Sheep	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Roger Bell	Ruminant Livestock Farmer - Sheep	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Paul Turley	Ruminant Livestock Farmer - Beef	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Sam Chesney	Ruminant Livestock Farmer – Beef & Sheep	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Dale Orr	Ruminant Livestock Farmer - Sheep	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Andrew Clarke (Wayne Acheson)	Ruminant Livestock Farmer - Beef	Participatory Role - Collecting data on farm, sharing and evaluating outcomes and participating in dissemination activity
Prof Nigel Scollan - QUB	Academic Scientist – Agri-food systems	Advisory Role - Assisting in on-farm activity design and evaluation of outcomes
Dr Denise Lowe and Dr David Patterson - AFBI	Research Scientist – Grassland focused ruminant research	Advisory and Participatory Role - Assisting in on-farm activity design, analysing data collected and evaluation and presentation of outcomes

Appendix 2 - Organisations who delivered services to the project

Organisation	Service Provided
AgriSearch	Innovation Broker Project Promotion
AFBI	Scientific Studies
Fane Valley	Soil and Sward Analysis
Techion	FECPAK^{G2}
AgreCalc Ltd	Carbon Audit & Scenario Analysis

Appendix 3 – Dissemination Events

1. Farm Walk – 1 September 2021

'Opportunities of Multi-Species Swards' was the theme of the Farm Walk organised by the Multi-Species Swards for Beef and Sheep European Innovation Partnership (EIP) group. Held on the farm of group member Dale Orr, Strangford Co. Down, the walk featured additional talks from AFBI and CAFRE and was coordinated by AgriSearch. The farm walk was the first to be hosted by the group , having only commenced the project in November of 2020, and provided an excellent opportunity for the group to share its progress and findings to date.

Attendees made their way around various informational stops on farm starting with an introduction to multi-species swards from Dr Denise Lowe, AFBI. Denise shared with attendees the findings of a literature review conducted for the EIP group prior to establishing swards on farm. An introduction to the farm, the multi-species swards established and experience to date was then given by Dale Orr, supported by his fellow EIP group members. The majority of swards on Dales farm are comprised of the more traditional white clover/perennial ryegrass (PRG) swards or red clover/ PRG silage swards but he has added a number of multi-species swards within his grazing platform.

Dr Francis Lively followed Dale with a summary of the multi-species sward research trials that have been taking place in Northern Ireland including an early look at some of the results arising from them. Dr David Patterson, AFBI, then provided attendees with the final talk of the day and some food for thought if planning to establish MSS themselves. To wrap up the event Brian Finch, CAFRE, provided attendees with some take home messages from the event.

The full farm walk booklet is available to download at:
https://agrisearch.org/publications/farm-walk-handouts/publications/farm-walk-handouts/opportunities-of-multi-species-swards

2. Webinar – 1 March 2022

AgriSearch hosted a webinar on Tuesday 1st March 2022 at 8pm to give an insight into the experience of establishing multispecies swards (MSS) on Northern Ireland farms. Each farm participating in the MSS for Beef and Sheep EIP project took a slightly different approach to sward establishment and it was their personal experiences that the webinar focused upon. Each of the six farmers involved in the EIP project presented on the night covering topics such as what species they selected and why, what establishment method they used, what were the challenges they faced and what are their thoughts so far regarding performance and management of the sward.

Results from SUPER-G MSS research studies taking place on both commercial farms and at AFBI Hillsborough were also be presented within the webinar by Sarah Brown (AgriSearch) and Dr David Patterson (AFBI) respectively.

The webinar recording is available to watch at:
https://www.youtube.com/watch?v=2ZGFJLsjnoU

3. Farm Walk – 13 June 2022

Operational Group member Paul Turley hosted a farm walk on Monday 13th June at his farm in Downpatrick, County Down. Over 100 individuals were in attendance at both the afternoon and evening sessions to see the wide range of multi-species swards that have been established on the farm.

At the first stop Paul and his sons Frank & Thomas welcomed everyone to the farm giving an introduction to their farming system and outlining the reasons why they decided to try out multi-species swards on farm. Paul decided to sow a range of species mixes over 10 different fields (40 acres) to see how each fared and the farm walk visited a number of them.

The experience of establishment of multi-species swards was also discussed, with Dr David Patterson (AFBI) providing information on the range of options available. Paul candidly detailed the challenges he'd personally faced with regards weed burden in the first few months after establishment and the steps he'd taken to graze them out following advice from other members of the EIP group. Sward and animal performance were also discussed with Paul giving indications of the latest Yield and DLWG figures. Overall the sward has been performing extremely well over the past year but has required a shift in mindset with regards management of the sward.

Questions were not in short supply at any of the stops on the walk and participants were encouraged to stay and chat with Paul, his sons and the other EIP members alongside the researchers from AFBI at the end of each session.

The farm walk booklet is available to download at:
https://agrisearch.org/publications/farm-walk-handouts/publications/farm-walk-handouts/learning-by-doing-multi-species-farm-walk-at-frank-paul-turley-s-13-06-2022

4. Conference – 28 June 2023

To conclude the project AgriSearch held a conference and farm walk in Cookstown on the use of multi-species swards on beef and sheep farms. The event reported the results of the EIP project, focusing on the feasibility and practicality of incorporating MSS on NI beef and sheep farms. The special guest speaker at the conference was Professor Helen Sheridan from University College Dublin who spoke on the results of MSS trials at University College Dublin's Lyon's Estate.

The conference also included a comprehensive panel discussion with the six farmers involved in the project. The farmers discussed their experiences of establishing, managing and utilising multi-species swards and lessons they have learned.

Following lunch, the delegates visited the nearby farm of Wayne Acheson, an EIP group operational member, to view the multi-species swards. There were stops on establishment of multi-species swards, animal and soil health and management of MSS.

A video recording of the conference sessions is available to watch at:
https://www.youtube.com/@agrisearchni/videos

Copies of the farm walk poster boards are available to view at:
https://agrisearch.org/add-file-to-publications/multi-species-swards-science-practice-farm-walk-boards/viewdocument/632

Appendix 4

EIP Multispecies swards for beef and sheep

March 2021

A review of multispecies swards for beef and sheep

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1. Introduction

Beef and sheep production systems in Northern Ireland (NI) are largely grass based, consisting predominantly of perennial ryegrass (PRG) (*Lolium perenne*). Monoculture PRG swards are easily managed, with potential to be high yielding (Williams et al, 2003; O'Donovan et al., 2011) and of high nutritional value (Fulkerson et al., 2007). However they are nitrogen dependant and therefore have a high reliance on artificial fertiliser inputs (Vibart et al, 2016). There are environmental concerns associated with dependence on fertiliser, such as leaching and gaseous emissions (Lüscher et al., 2014; Bryant et al, 2019; Grace et al., 2019). In addition, high input monoculture swards do not enhance biodiversity. Furthermore, alternative measures will need to be taken within livestock grazing systems if net zero carbon targets are to be achieved and if concerns over antimicrobial resistance in livestock are to be addressed. It is pertinent to explore how the use of multispecies swards (MSS) can contribute to alleviating some of these concerns in the NI beef and sheep industries. This review provides an overview of the challenges and opportunities presented by the establishment and use of MSS in beef and sheep systems, with a particular focus on their effect on animal production, health, and environmental consequences.

2. **Sward mixes**

Re-seeding is an expensive procedure and therefore choosing an appropriate seed combination, suited to an individual farm's soil and environment, is essential. Multispecies swards consist of grasses, legumes and herbs (sometimes called forbs). Multispecies swards mixes can be simple consisting of just one of from each of these functional groups or it may contain many more. The more variable the environment and the more functions the swards will be used for (e.g. grazing by different livestock /ensiling) may increase the requirement for a range of species. Individual species are suited to different environments, with species also complementing one another with regards to rooting depth, yield and persistency and these have been summarised in Table 1.

Table 1: MSS positive, negatives, persistency and rooting depth

Group	Sward species	Positives	Negatives	Persistency	Rooting
Grasses	PRG	High yielding Suits most soils Quick germination Highly palatable Long growing season	Resistant to normal breeding methods Performance reduced on very wet or dry soil Needs N input Dislikes acidic soils	Very persistent 5+ years	Shallow rooting
	Timothy	Works well in wet soils High output on heavy soils High quality value Palatable	Low output on light soils Doesn't like hard grazing	Very persistent (especially in cold and wintery conditions)	Deep rooting
	Cocksfoot	Works well in dry soil Drought tolerant Early growing Low N input	Low palatability Low quality value Slow to establish	Persistent	Deep rooting
Legumes	White clover	High in protein (~27%) Nitrogen fixing Highly digestible Highly palatable	Prefers high pH soils Yields less than RC Can cause bloat	5 + years More persistent than RC	
	Red clover	High in protein Nitrogen fixing Highly digestible	Can cause bloat May cause ewe fertility Prefers high pH soils	3-5 years Less persistent than WC	
	Lucerne	Works well with dry soil Very versatile			Deep rooting
	Plantain	Highly palatable High in minerals (e.g. copper and selenium)	Prefers warmer conditions (7-10ºC)	Up to 5 years	Deep rooting

		Suits most soils Drought tolerant Anthelmintic properties Good with spring sowing			
Herbs	Sainfoin	High levels of condensed tannins Anthelmintic properties	Can be tricky to establish Requires high seeding rates which can be costly	3-5 years	
	Chicory	Drought tolerant High yielding Highly palatable Anthelmintic properties High mineral content (e.g. copper)	Prefers highly fertile soil Prefers warmer conditions (7-10ºC)	3-5 years	Deep rooting
	Yarrow	Works well with dry soil	Poor palatability Can be invasive if not managed correctly		
	Burnet	Works well with wet soil and dry soil Tolerates cold			

Sheaffer et al, 2003; Peyraud et al, 2014; Dhamala, 2017; AHDB, 2020; Germinal, 2020; Teagasc, 2020; The Diverse Forages project, 2021

PRG is the most common sward and the foundation of grassland systems in the UK and Ireland. A well-managed PRG sward can persist for over 10 years or more (Sanderson and Webster, 2009), and therefore, the existing sward may not require cultivating. It is generally a good all-rounder and is advantageous due to its high yielding nature, in addition to being very persistent and also palatable to grazing animals. However, performance is reduced on both very wet and very dry soil, it does not yield well in acidic soils and requires significant fertiliser input.

White clover is another common sward and the most popular forage legume. It is usually mixed with PRG and is a popular choice for grazing due to it persistency, compatibility under harsh temperature climates and nitrogen fixing properties (Guy et al, 2018). White clover is a highly digestible and palatable sward for grazing animals. White clover has a high protein content (~27%), compared to PRG (~17%), therefore mixing PRG with white clover increases the grazing crude protein potential. Legumes are advantageous as they nitrogen fixing meaning they convert atmospheric nitrogen and subsequently store it within the soil in a form useable by plant species (Connolly et al, 2009; Kakraliya et al, 2018). This means there is a reduced need for nitrogen fertiliser usage. A mix which contains 30% legumes (e.g. red or white clover or a combination) will ensure the swards are self-sustaining in nitrogen (Lüscher et al, 2014). Nitrogen accumulates in small spherical nodules which are affixed to the roots of the legumes.

MSS commonly work with PRG and white clover providing a sward foundation and is built up with the inclusion of herbs and potentially other grasses and legumes. Legumes and herbs used in MSS all possess very different root structures and draw nutrients (including minerals) from different levels in the soil (Table 1). This means the species within the MSS are not directly competing with one another. Species such as cocksfoot and Timothy are deep rooting and in turn have a very high mineral content, especially compared to PRG and white clover.

Red clover is a nitrogen fixing legume and a popular choice for finishing lambs given its high protein content and persistency (Table 1). However, inclusion levels must be considered with caution. When feeding ewes on red clover, ovulation rates may be suppressed due to the legume containing heightened levels of phytoestrogens, such as isoflavones, compared to other swards such as PRG and white clover (Mustonen et al, 2018). This can result in reduced fertility. However, research surrounding this is conflicting with some studies finding no effect of increased ingestion of sward phytoestrogens and fertility (Mustonen et al, 2014).

Other popular choices for MSS include herbs such as chicory and plantain. They are deep rooting, drought resistant and can persist for 5 years (Table 1). Uniquely, herbs such as these possess anthelmintic properties and research has proven the benefits in reducing parasite burden in sheep (Grace et al., 2019). Despite this, research evaluating the anthelmintic properties of swards such as chicory and plantain is often successful *in vitro* or at high inclusion levels (70%+ of total sward; Peña-Espinoza et al, 2018).

Thus there is a pivotal need to select an appropriate sward combination and recent research has attempted to lay the foundations of optimal sward mixtures. This presents many challenges as it is highly dependent on soil type, environment and weather conditions, which vary not only country by country but also within counties and even neighbouring farms. It is likely that swards mixes are unique to each farm or even each field and should be made accordingly. Researchers in the TOMS project (Toolbox of MSS) in a consortium which included Rothamsted Research, North Wyke and Duchy College have recently collated evidence of the attributes of different species into a Decision Support Tool (DST), which can be downloaded as a mobile phone app called Sward App (Stagg et al 2021). Table 2 illustrates a snapshot of some of the information available from this app, by highlighting some of the attributes studied (the app also has information on digestibility, relative yield cut as well as for grazed; intensive cut/ graze tolerance, and frost tolerance and for legumes bloat tolerance. It also contains information on further species of meadow fescue, meadow foxtail, PRG, tall fescue, sheep's burnet, sheep's parsley and lucerne). It should be noted that this DST only compares like with like, so grasses are only compared with other grasses; legumes compared with other legumes and herbs with other herbs. Further information is contained within the app on the number of published studies available for each parameter e.g. with Cocksfoot there were two studies reported that it is not tolerant of low fertility; with Timothy there were fewer studies carried out which looked at Timothy, but there was evidence it is better suited to wet soils and is tolerant of low soil fertility; and in the legumes e.g. sainfoin where there is evidence of anthelmintic properties from four studies and that sainfoin needs alkaline soil pH between 7.0 and 8.0 (3 studies).

Table 2: Evidence of characteristics of commonly used grasses, legumes and herb species using the TOMS app

(where green is means there is evidence this is a relatively positive atttribute, red is negative, amber is no differnce and "?" is not enough evidence available)

	Cocksfoot	Timothy	Chicory	Plantain	Alsike clover	Birds foot trefoil	Red clover	Sainfoin	White clover
Protein									
Minerals		?			?			?	
Persistence (grazing)					?				
Relative yield (grazed)					?			?	
Anthelmintic properties					?		?		
Waterlogging tolerance			?		?				
Marginal soils tolerance			?						
Drought tolerance									

Another important consideration is the number of species to be included in the mix. This question is one that should be considered again in light of other evidence in this review (e.g. in section 5) but for now we will consider the effect of species number on yield. In the TOMS project 6, 12 and 18 species mixes were compared with a PRG/ white clover sward and no differences were reported in yield but the MSS had a reduced weed burden. Barker et al (2021a) compared 6, 12 and 17 species mix with PRG control in the Diverse Forages Project at University of Reading. The 6 species mix (named Smartgrass) consisted of PRG, timothy, red and white clover, plantain and clover; the 12 species (named Biomix) also had further grasses (cocksfoot, festulolium and meadow fescue) and legumes (alsike clover, black medick and lucerne); while the 17 species mix (named Herbal) also included tall fescue in addition to those grasses in Biomix, the legumes included sweet clover, sainfoin and birdsfoot trefoil replaced lucerne and black medick in the Biomix and additional herbs of yarrow, burnet and sheep parsley were also included. The PRG control received 250kg N/ha, while the 3 MSS received no artificial fertiliser. In terms of the annual biomass in the first year PRG produced more, but by the 3rd year of the study the MSS all outperformed the PRG. A lower biomass yield was found in Years 2 and 3 compared with Year 1, which is understood to have resulted from drought conditions in those seasons. In the wetter conditions of Year 1 PRG yielded significantly more than all other treatments, but this was reversed by Year 3 following two consecutive dry seasons, thus providing evidence of the deeper rooting species in the multispecies treatments performing well in the dry conditions.

Boland et al (2021) compared PRG only, receiving 163 kg N/ha/yr (PRG); PRG and white clover sward at 70:30 mix and receiving 90 kg N ha/yr (PRGWC); a six species (6S) sward containing two grasses (PRG and timothy), two legumes (white and red clover) and two herbs (ribwort plantain and chicory) receiving 90 kg N ha-1 yr-1 (6S); and a nine species sward (9S) containing each of the species included in the 6S sward plus cocksfoot, birdsfoot trefoil and yarrow and receiving 90 kg N/ ha/yr. This work, carried out at UCD, reported that MSS produced the same amount of herbage dry matter (DM) as the PRG, but with 45% less nitrogen fertiliser. Values from AHDB suggest that on average, a good grass and clover sward (30–40% of dry matter of clover) will give an annual dry matter yield equivalent to that produced from about 180 kg N/ha applied to a pure grass sward in the first year. Furthermore, as part of the TOMS project the literature on MSS was reviewed and reported that almost 70% of the 47 studies which looked at the effect of MSS on yield reported higher DM production in MSS than in the control (Beaumont 2020). However there is no evidence to indicate that the number of species included in a MSS effects yield.

3. Establishment

Ensuring good establishment is critical and can be challenging. MSS are expensive to sow, especially compared to PRG and a PRG and white clover mix. It is important to ensure weeds have been treated and eliminated as once the MSS have been sown, herbicides cannot be used as it will target the herbal species within the mix. Farmers have highlighted establishment methods and weed control to be the biggest concerns and barriers when establishing MSS, followed by variety selection, (AHDB 2020).

The first question to be addressed in establishment is on the method of establishment. Establishment should consist of a full reseed or in some cases where it would not be possible or desirable to plough, other minimum tillage (min til) options need to be explored. There is a lot of interest in min til options due to the perception that less soil disturbance retains soil nutrients and causes less soil erosion. The WEB project (wide scale enhancement of biodiversity) at Rothamsted, North Wyke compared ploughing with a min til option using a slot seeder which disturbed about 40-50% of the sward (Beaumont, 2020). The ploughed plot was sprayed with glyphosate and then ploughed to a depth of 25- 30 cm, with the soil inverted and power harrowed. A grass/ legume/ forbs mix was broadcast into both. The sward did not establish very well on the min til option on the clay soils of this study and it was concluded that more of the existing sward needed to be destroyed to reduce the competition from that sward. In TOMS project they tried other min- til options, comparing spraying and ploughing with using a power harrow, where it was sprayed first and then power harrowed down to a depth of 5cm, (thus leaving a bit of the existing sward behind) and the third option was using a disc harrow which further disturbed the soil down to a depth of 10-15cm. Tillage depth had no effect on DM yield with herbal leys and found equal success with power harrowed 5 cm depth and disc harrows at 10-15 cm depth. The conventional method of ploughing resulted in greater abundance of sown species and fewer weeds compared to using the disc and power harrow. This suggests that the longevity of the diverse species should be increased due to improved establishment and there is also indications that forage quality is improved due to better persistence (Tozer et al, 2017; Beaumont, 2020).

There is concern in the industry about the impact of ploughing on carbon footprint but work at AFBI has suggested that while there are short- term carbon losses in the days and weeks after ploughing, in the longer- term it seems that the overall effect is minimal, so studies of this type are on-going to confirm these preliminary findings (Dario Fornara, personal communication).

Another question to be addressed is the seed rate and Beaumont (2020) reported a study on the TOMS project where a standard seed rate of 14 kg/ acre was compared with a 50% higher rate (21kg/ acre) and no differences were reported either in terms of yield or suppression of weeds. They concluded that increasing seed sowing rate (and in turn increasing cost) is not a beneficial method to keep weeds at bay. With this in mind, it is recommended that sowing of herbal leys should be done at the opposite time to which dominant pasture weeds tend to germinate to optimise establishment potential. It is therefore recommended to seek advice from an agronomist to understand when the most problematic weed in your sward will germinate.

In addition, Glassey et al. (2013) evaluated four methods for sowing chicory and plantain into existing PRG pastures in Australia. The authors reported that herbicide application followed by direct drilling resulted in the greatest herb density and pasture yield, which compensated for the increased cost of this sowing method. Herbicide application before sowing was deemed to beneficial as it reduced competition between seedlings, pasture plants and weeds (Thom and Barker, 1993). A similar study was conducted in Northern Tasmania, assessing two sowing methods (direct-drilling and broadcasting) and three sowing rates (2.5, 5.0, and 7.5 kg of seed/ha) for establishing plantain into existing irrigated PRG pastures (Raedts and Langworthy, 2020). The authors reported that direct drilling initially resulted in a greater seedling density of plantain, while broadcast sowing resulted in delayed germination. However, the differences were short-lived, and thus the findings suggest that both sowing methods can result in the successful establishment of plantain into existing PRG swards. Plantain sowing rates of 2.5kg/ha and 5.0kg/ha resulted in plantain occupying 32.4% and 44.4%, respectively of available DM. However, increasing the sowing rate to 7.5kg/ha did not increase the proportion of plantain, due to increased competition between plants (Raedts and Langworthy, 2020). Seed rates will depend on the method of sowing, current sward density and desired proportion of each plant species within the sward, and thus a tailored approach is needed.

Sowing depth will also impact on establishment rates of individual species. Sanderson and Elwinger (2000) reported the greatest seedling emergence rate when chicory and plantain were sowed at a depth of 1cm, compared with depths of 3 and 6cm. Similarly, under controlled conditions Peri et al. (2000) reported that the emergence of PRG and plantain were unaffected by sowing depth. However, the emergence of white clover, lotus and cocksfoot was reduced as sowing depth increased from 5 to 25mm, while chicory emergence decreased as sowing depth increased from 5 to 15mm. Therefore, the authors concluded that sowing methods needed to be aimed at achieving good legume establishment, with shallow sowing depths being used (but without risking seed desiccation; Peri et al, 2000). Broadcasting works well or a shallow drill to about 1cm.

Sowing time is important to the success of MSS establishment and late spring and early autumn (end August/ beginning September) both work well depending on the conditions in any particular year. Similarly, another important consideration is soil temperature. Certain legume and herb species such as chicory and plantain require warmer soils for germination than a PRG monoculture, so soil temperatures should be around 10°C for successful germination and establishment of MSS. Good levels of soil moisture are also essential for successful germination of MSS.

Regardless of establishment method, rolling seems to be essential to ensure good soil-seed contact and also to lock in moisture (Beaumont, 2020). The more compact the soil and seeds the more successful germination is. Anecdotally, rolling twice to ensure optimal establishment is advised. This, again, will be dependent on soil type and sward mixes used.

Additionally, legumes and herbs can also be over-sown into existing grass swards as an alternative method for establishing a MSS. It is critical to address any weed issue first and to reduce competition from established plants. This could be after a silage cut or after tight grazing and grazing can continue for 7-10 days after sowing to further reduce competition from the existing sward. The MSS would be ready for first grazing 6-8 weeks after sowing. Legumes and herbs could also be under-sown, this has been demonstrated in cereals such as spring barley but under-sowing in a grazing cover crop such as redstart could be considered also.

4. Management

After MSS establishment, early management post establishment is important and will impact the persistence and the overall success of implementing them. Pastures are ready around 6-8 weeks post establishment for light grazing (Beaumont, 2020). Research suggests that rotational grazing is a superior management system opposed to set stocking. This has been reinforced by results from EIP Wales MSS project, whereby rotational grazing compared to continuous grazing prevented herbs from being grazed out. Rotational grazing results in superior sward quality, equal grazing and sward persistence (AHDB, 2020). However, in a 3-4 week rotational grazing study, Cranston et al, (2015) found that PRG and white clover had comparable DM production, but growth patterns were variable. This is because set stocking can result in selective over grazing. Consequently, plant diversity could be depleted and the benefits of using MSS reduced. Other methods such as mob grazing have been examined which is successful in averting selective grazing (Laliberté et al, 2012). The Wales EIP MSS project also noted diversity decline, this is likely to be as a result of late autumn grazing and the consequence of under-grazing in the spring period. Leader-follower grazing systems have also been undertaken with sheep post-weaning, where lambs were removed from the paddock at a post-grazing sward height of 5cm, and then ewes were introduced to reduce the post-grazing sward height to 4cm. This resulted in ewes gaining body condition between weaning and breeding, while lamb performance did not differ significantly according to sward type, but ranged from 183 to 193g/d (Grace et al., 2019). Therefore, a leader-follower approach may still be considered when implementing an intensive sheep grazing strategy with MSS. A rest period in winter is advised to ensure and improve the persistence of herbs and legumes (Kemp et al, 2010). Similarly, a single mid-season silage cut had no detrimental effect on the ley. Subsequent grazing management is also important as selective and over grazing specific leys can reduce the longevity of MSS. Grazing animals for short periods of up to three days maintains sward diversity. This must be followed by a sufficient resting period. Multi-species sward persistence is improved when pastures are rested for a three-four weeks period.

Once a sward is established, there are a number of factors which will impact on the persistence of each species. Sheep grazing can affect the plant community composition and consequently plant productivity in several ways, by preferential grazing and recycling of nitrogen in animal excreta and treading (Evans et al., 1998, Frame and Hunt, 1971, Pain et al., 2015). Furthermore, avoiding damage to the tap root when ground conditions are wet in autumn and winter is also a key component of maintaining persistency of MSS (Li and Kemp, 2005). Yet, species persistency within MSS has been reported to decline over time and is recognised as one of the main challenges of intensively grazing these swards (Grace et al., 2018). For example, in a two year sheep grazing trial, Grace et al. (2019) observed that the proportions of grass increased by 9%, legumes increased by 1%, while herbs decreased by 10% after just one grazing season.

Similarly, Jing et al. (2017) reported a reduction in the herb portion of a grazed MSS, which reduced the DM yield compared to cut swards. Research has shown that MSS (6, 12 and 18 species) had a reduced weed burden compared with a PRG/ white clover sward (Beaumont, 2020). While, Grace et al. (2018) reported that although sward chemical composition was similar, the herb content of MSS decreased substantially after one grazing season. The authors outlined that the post-grazing height used was 4cm, yet the recommended post-grazing height is 5cm to avoid damage to the tap root of herbs (Li and Kemp, 2005). Thus, the correct grazing management (no over grazing) of herbs and the resultant survival of the tap root, would improve the persistency of these species (Kemp et al., 2010). In relation to legumes, Grace et al. (2018) reported that the persistence of white clover remained constant after one grazing season. Yet earlier research by Brock and Hay (2001) reported that it was difficult to maintain white clover above a 10% inclusion rate over the lifetime of a PRG pasture. Therefore, for the effect of grazing on species persistency to be fully understood, it needs to be monitored over the full lifetime of the sward. In which case the optimum time and method for re-establishment could also be examined.

The use of MSS is appealing due to the reduced need for nitrogen fertiliser (Aboagye et al, 2018). This is significant as on average farmers will spend large amounts of money on nitrogen fertiliser for pasture. Legumes, such as white clover, have good levels of persistence without the use of nitrogen fertilizer (Andrews et al, 2007). Similarly, the yield of MSS receiving no nitrogen fertilizer was comparable with nitrogen fertilized PRG on wet and dry soils and in drought conditions (Barker et al, 2021b). Consequently, commercial businesses suggest that around 30% of the MSS should be legumes, with the other 70% being made up of herbs and other grass species. Although less fertiliser is needed when MSS are used, some nitrogen may be needed particularly to encourage early spring or late autumn growth. There is limited viable weed control measure as species such as plantain and chicory will be negatively affected by herbicide usage.

5. Beef cattle and sheep performance

MSS offer a diverse wealth of nutritional components, especially compared to traditional grass species such as PRG and white clover (Grace et al, 2019). The nutritional matrixes and makeup vary considerable between species and sward combinations offer a unique opportunity for grazing animals such as sheep and cattle. Benefits of cattle and sheep grazing on diverse swards may include reduced toxin consumption, increased rumination and maintenance of ruminal microflora (Provenza, 1996; Tracy and Faulkner, 2006). There is considerable literature surrounding the impact of MSS on ewe, lamb and dairy cow performance, but the literature surrounding beef is considerably more limited.

A recent study by Grace et al. (2019), evaluated four pasture types for sheep grazing (i) PRG sward, (ii) PRG and white clover sward (iii) six species MSS (PRG, timothy, white clover, red clover, plantain and chicory), (iv) nine species MSS (the previous six species with the addition of cocksfoot, greater birdsfoot trefoil and yarrow). Grace et al. (2019) found that ewes grazing the two MSS had an increased live weight and body condition score during early lactation compared to ewes grazing the PRG and PRG/white clover swards. Furthermore, the six species MSS resulted in the greatest 6 week weight and weaning weight of lambs, while that of the nine species MSS was similar to lambs grazed on PRG /white clover. Improved lamb performance to 6 weeks of age, is thought to be due to the improved ewe condition, which would impact ewe milk yield and composition (Grace et al., 2019, Danso et al., 2016). For example, Hutton et al. (2011) reported that ewes grazing herb-legume swards produced 17-25% more milk than the ewes grazing predominately PRG swards, although in this particular study, milk composition (measured on days 7, 14 and 21 of lactation) did not differ between grazing treatments. In addition, lamb survival to 75 days of age has been reported to be greater for those grazing a herb sward than those on a PRG / white clover pasture (Kenyon et al., 2010). Grace et al. (2019) also reported that of the four pasture types, lambs grazing PRG had the greatest days to slaughter. The literature on pastures containing three functional groups is limited, however, numerous studies have reported improved post-weaning growth rates of lambs grazing herb-legume (two functional group) swards (Golding et al., 2011, Fraser et al., 2004, Moorhead et al., 2002, Speijers et al., 2004, Kenyon et al., 2017). These improvements in lamb performance are thought to be due to the higher nutrient value and/or herbage intakes of herb-legume swards than PRG swards (Fraser et al., 2004, Golding et al., 2011). Over a three year period, Kenyon et al. (2017) reported that a chicory-plantain-clover pasture and plantain-clover pasture produced 12.4 and 14.5% more kg live weight per hectare, respectively than a grass-clover pasture; indicating that increased levels of production could be obtained over more than just one grazing season.

The effect of multi-species sward pastures on daily live weight gains (DLWG) have been inconsistent within cattle studies. An individual study documented an increased DLWG of 0.33 kgd^{-1} for individual grazing seasons and no effect other years for cows and calves (Tracy and Faulkner, 2006). Inconsistent effects of MSS on DLWG has also been reported by Giebelhausen et al., (2007). More recently increases in DLWG and animal performance were reported in calves grazed on diverse swards composed of grasses, forbs and legumes, however, results were, again, inconsistent and varied depending on year and season (Jerrentrup et al, 2020). Similarly, no differences were found when Angus-Holstein steers were grazed on either herbal (17 species), ‘Biomix’ (12 species) or ‘Smartgrass’ (6 species) multi-species sward combination compared to PRG (Humphries et al, 2021a). A study evaluating the effect of a chicory and PRG sward mix compared to PRG reported that the chicory and PRG mixture effect on live weight gain was consistent with that of the PRG control treatment (Marley et al, 2014). This is in accordance with a similar study evaluating the effect of chicory and PRG on beef steers (Parish et al, 2012). These studies are also consistent with research investigating MSS pastures and dairy cow milk yield performance (Totty et al, 2013). Despite this, finishing steers on alfalfa and chicory during the summer months has also been documented to increase DLWG compared to steers fed burmudagrass, cowpea and pearl millet swards (Schmidt et al, 2013).

This inconsistency would suggest that seasonality (and in turn nutritive value) is a stronger influence than sward diversity in increasing DLWG of cattle. Despite this, a potential for DLWG and live weights to be increased as a result of diverse sward mixtures has been highlighted, particularly in very dry summer months, if the supply or nutritive value of PRG or white clover becomes limited (Elgersma et al, 2000). The potential is directly reflected by improvements in feeding values of leys over the last 15 years (Kemp et al, 2010; Grace et al, 2018). Similarly, large ruminants such as beef cattle graze less selectively, but equally have a reduced bite depth when swards are shorter, compared to small ruminants (Martin et al, 2020), highlighting the importance of sward length when considering a multi-species sward mixture. Research suggests, the link between beef cattle and lamb nutrition and MSS could be bridged by carefully combining swards species such as cocksfoot, lucerne and chicory, which are rich in minerals (due to being deep rooting) while also being appropriate for soil type and rainfall levels in NI (Connolly et al, 2009; Pirhofer-Walzl et al, 2011). For example; chicory and plantain are high yielding herb species which are particularly productive in the summer months (Cranston et al, 2015). However, grazing on chicory and plantain in the winter is less successful where the nutritive value and persistence is reduced (Sanderson et al, 2003).

The use of herbage in multi-species sward combinations contain higher levels of crude protein and acid detergent fibre (Jerrentrup et al, 2020). This has the potential to improve animal production, while maintaining or acting favourably to rumen health by ensuring optimal digestion by rumen bacteria (O'Callaghan et al, 2018; Smith et al, 2020). Other studies, however, have disputed this. For example; when PRG was studied alongside a mix of *Leptostigma setulosum* and *Centella* spp., crude protein levels were higher in the PRG group

(White et al, 2004). This could have detrimental effects on forage digestibility and may also result in urea being recycled to cover the shortfall (Mutsvangwa et al, 2016). Low crude protein is also associated with reduced nutrient digestibility and reduced DM intake, ultimately resulting in a reduced DLWG and impacting in overall animal production.

6. Other potential benefits of multispecies swards

6.1 Meat quality

Meat and carcass sensory and nutritional quality is directly impacted by animal diet (Scollan et al, 2017). Therefore, any alteration in diet of meat animals must not have a consequent negative impact on the meat or carcass. Research has shown that some forage-types may alter carcass and meat quality (De Brito et al., 2016), for example finishing lambs on brassicas can lower meat sensory quality (Hopkins et al., 1995). MSS containing plantain and chicory have been reported to have a higher proportion of polyunsaturated fatty acids (PUFA) than a ryegrass clover sward, while also containing secondary compounds such as phenols (Elgersma et al., 2013). Kliem et al (2018) reported improved PUFA concentration in lamb muscle offered a MSS (consisting of PRG, Birdsfoot Trefoil, Knapweed, ribwort plantain, red clover, selfheal and yarrow) compared with PRG sward. In beef cattle, a mix of chicory and ryegrass diet had no effect on fat grade, kill out and carcass weight of steers, compared with a grazing diet PRG (Marley et al, 2014). Steers finished on alfalfa and cowpea resulted in an increased dressing percentage at slaughter, in addition to a reduced shear force value (Schmidt et al, 2013). Other positive effects such as improved meat fatty acid profile was also observed when Bermuda grass and pearl millet was consumed (Schmidt et al, 2013). This could lead to a greater concentration of PUFA in the meat and milk of ruminants (Rodriguez et al., 2020a), while having no detrimental effect on the sensory meat quality of meat and milk (De Brito et al., 2016).

6.2 Mineral content

The mineral content of MSS is greater and more diverse than PRG. For example plantain contains higher concentrations of selenium, magnesium, iron and calcium (amongst other minerals) than PRG (Raeside et al., 2017) and Darch et al (2020) showed herbs were highest in iodine and selenium (two trace elements that we know there are deficiencies in NI both in soils and in livestock themselves), grasses in manganese and legumes in copper, cobalt, zinc and iron. In particular, chicory and plantain possess a deep taproot with the potential to reach soil nutrient resources inaccessible to other forages. Work by Marley et al (2021) compared the first harvest year yield and micronutrient composition of pure swards of chicory or plantain with those of clovers or PRG. Plantain was demonstrated to contain high calcium levels of 18.01 g/kg DM compared to chicory (12.78 g/kg DM), PRG (6.42 g/kg DM), white clover, (10.25 g/kg DM) and red clover (14.28 g/kg DM; Marley et al, 2021). However, in the same experiment plantain was documented to have the lowest levels of magnesium (1.06 g/kg DM) compared to the other four sward species. It is less clear however on how different mineral content in the herbage affects mineral content in meat. Initial research has shown that the mineral content of meat is similar for lambs finished on PRG and MSS, however lambs were only offered MSS for a finishing period of 49 days (Rodriguez et al., 2020b). The nutritional content of meat products is important from a one-health perspective and the growing public concern around the consumption of healthy foods (Rodriguez et al., 2020a), yet these findings on MSS are based on a small number of studies conducted internationally.

6.3 Animal health

Grazing MSS has been reported to have health benefits for sheep and beef cattle. Endo- and ecto- parasites dominate grass based systems and parasite control is a significant financial burden to farmers and are the leading causes of production losses in the cattle industry (Jäger et al, 2005). Parasites, such as round worm and liver fluke, will result in reduced feed intake and in turn reduced nutrient intake (Heyward et al, 2020). Parasitic infections have also been documented to affect fertility of cows (Johnson et al, 2020). In recent years, emergence of resistance to chemical anthelmintics has forced farmers to seek alternative and more sustainable parasitic control methods. Research has demonstrated the ability of diverse pastures including herbs and legumes, to overcome some of the challenges as an alternative, preventative control measure for parasite burdens from grass based systems. Studies evaluating the role of MSS as a parasite control measure in beef are extremely limited, but studies for lambs have been conducted.

An initial study evaluated replacing PRG with a multi-species sward composed of bromes, tall fescue, phalaris, timothy and red and white clover for grazing lambs (Knight et al, 1996). No effect was identified on nematode larvae, adult nematodes or faecal egg count. Lambs grazing pure chicory, however, did have reduced endo-parasite infections. Currently, feeding pure chicory is not practical and raises other nutritional and managerial concerns. In the study of Grace et al (2019) lamb faecal egg count was monitored every 2 weeks from 6 weeks of age and all lambs were dosed at 12 weeks and then lambs were only treated with anthelmintics when the mean lamb faecal egg count per sward type was above a certain threshold level (400 eggs per gram). There was a reduced requirement for anthelmintic usage in lambs grazing the herb containing swards (both six species and nine species swards). In other studies, chicory, birdsfoot trefoil (Marley et al., 2003), ribwort plantain (Judson et al., 2009) and yarrow (Tariq et al., 2008) have all been reported to reduce parasite burden in sheep. There is also evidence of anthelmintic properties of some legumes, particularly sainfoin (Mueller- Harvey et al, 2019).

These effects are thought to be due to a combination of factors. Depending on cultivar management, plantain and chicory contain beneficial levels of condensed tannins (Loza et al, 2021), which have been suggested to possess anthelmintic properties (Peña-Espinoza et al, 2018), through reduced survival, growth and/or fecundity of nematodes in the gut (Waghorn et al., 1995). The mechanisms surrounding this are unclear, however it is hypothesised that condensed tannins enhance protein utilisation when being digested (Judson et al, 2009). Other mechanisms include, improved protein utilisation by the host (Aerts et al., 1999), improved mineral (Coop and Field, 1983) or trace element (Suttle et al., 1992) status of the host which may contribute to improved immunity. Finally, MSS may provide an unsuitable pasture environment for the development or survival of parasite larvae (Niezen et al., 2002), thus reducing pasture infection rates. A sub-clinical parasite infection can reduce lamb growth rates by as much as 40% (Marley et al., 2003).

A deeper understanding of the mechanisms behind the efficacy of chicory and other sward species in endo-parasite control could help establish a multi-species sward combination with a level of anthelmintic properties (McRae et al., 2015, Pena-Espinoza et al., 2018). Nevertheless, further research is needed to explore this further and to establish if using MSS can act as a sufficient, efficient and sustainable parasite control measure on farm taking into consideration animal production, farm management and financial implications.

6.4 Environment

There is significant pressure to optimise farming systems to reduce environmental impacts. Grazing ruminants, in particular cattle are often criticised for the production of potent greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) (Thompson and Rowntree, 2020). Levels of CH_4 released from ruminants fluctuates depending on the nutritional makeup of the food that is consumed (Møller et al, 2014). Literature surrounding the impact of MSS on CH_4 emissions for sheep and beef cattle is scarce and the majority is conducted *in vitro*. However, condensed tannin-rich MSS have been evaluated to assess any mitigation potential of environmental harm in sheep and dairy cows (Aboagye et al, 2018; Niderkorn et al, 2019; Carmona-Flores et al, 2020). MSS have been reported to reduce CH_4 (g/kg DMI) in grazing dairy cows (Carmona-Flores et al., 2020). Although Niderkorn et al. (2019) observed similar CH_4 emissions from lambs grazing PRG or MSS, they also reported a 22% reduction in CH_4 (g/kg DMI) in lambs grazing pure chicory compared to PRG. Angus X Holstein and Holstein steers grazed on PRG produced significantly higher CH_4 emissions of 190 g/day, yielding 25.9 g/kg DMI, compared to cows grazed on three different MSS mixtures (~120 g/day, yielding

~18 g/kg DMI; Humphries et al, 2021b). Conversely, another study reported that grazing Jersey cows on six species MSS, compared to a PRG and white clover mix increased CH_4 emissions by 18% (Loza et al, 2021). Similar, conflicting research is reported in sheep, with some studies reporting positive effects of chicory in mitigating CH_4 emissions, but no effect when diverse multi-species sward are grazed (Niderkorn et al, 2019). This suggests that it is individual swards species, grazing in high proportions that can influence the CH_4 emissions released from rumination. Therefore, further research is needed to establish what sward mixtures and at what proportion are required for an impact to be made. This can be done through on-farm trials, *in vitro* or through modelling work.

Greenhouse gas measurements are commonly assessed in grazing trials using the SF_6 technique. However, new methods of emissions monitoring at pasture are now available and AFBI have recently purchased a 'GreenFeed' system, which monitors daily individual GHG emissions of sheep at pasture. This novel technology has a number of benefits in comparison to traditional greenhouse gas measurement methods, including the ability to monitor a larger number of animals over a longer period of time without the constraints of individual confinement (Hammond et al., 2015). The accurate monitoring of greenhouse gas emissions could then be used to quantify the carbon footprint of each system.

It is apparent that a key influencer of the success of MSS in mitigating green-house emission risk is directly correlated with the combinations of swards used. The conflicting research surrounding any potential benefits of MSS on CH_4 emissions from grazing ruminants is limited and studies that are published use an array of methodologies which makes comparison and understanding of contradictory results challenging. A further point to note however is that an additional carbon footprint benefit would be seen from the decrease in N_2O from reduced artificial fertiliser application, as reported by Cummins et al (2021) where six MSS species were compared with PRG.

As we strive towards net zero carbon, MSS have aroused much interest since it is thought that the deep rooting species can break up compacted soils, putting carbon deeper into the soil and improving soil organic carbon leading to improved soil carbon sequestration. Previous work in the USA compared 1, 4, 8 and 16 grassland savanna plots over a 12 year period and demonstrated that monoculture plots lost carbon, while carbon content increased in diverse plots (Fornara and Tilman, 2008). In the UK, work on the effect of MSS on soil carbon stocks are currently being assessed as part of the Soil Carbon Project, a collaboration between Duchy College, Rothamsted and Plymouth University, however it will take around 4-5 years for changes in soil carbon to be observed.

Recently, the effect of reducing environmental impact from intensively reared beef and sheep fed on MSS using a simulation model was evaluated (Vogeler et al, 2017). The model was programmed to simulate profitability, nitrate leaching, growth patterns, and seasonal yields of diverse pasture swards. The model suggests that feeding MSS in intensive systems would be beneficial by decreasing nitrate leaching and with farm profit increased by 16% when 50% of the farm area was replaced with diverse swards. However, this is a hypothetical model and therefore recommendations cannot be made until comprehensive on-farm research studies using beef and sheep have been conducted and thoroughly evaluated. Geographical location and variations in livestock production management would also need to be considered.

Another area of interest is using MSS in silvopastoral systems, combining the attributes of MSS and trees in terms of carbon footprint and the other potential attributes of MSS previously discussed. This would appear to have potential in a NI beef and sheep setting and would merit further research.

7. **Gaps**

The following gaps have been highlighted in the review of the literature:

- There is potential for MSS to build resilience into beef and sheep systems. There is, however, a lack of evidence for establishment and management of MSS under NI conditions of soils and climate.
- A change in mind-set is required on how to manage MSS compared to a traditional PRG sward. In particular, ideal pre- and post- grazing covers need to be set for different physiological stages of beef and sheep production. Furthermore accurate equations need to be developed for using rising platemeters in MSS to estimate sward covers in kg DM/ha.
- Further research is required on optimising species persistency, especially under a cutting regime or when multi species are under-sown in other cover crops.
- Large, long-term studies are required to assess the impact of eating beef and lamb which has been grazed on MSS on human health, particularly mineral status.
- A full cost benefit analysis is required from establishment to end of the sward life to take into account sward persistency and the effects of MSS on animal production, use of antimicrobial resistance and carbon footprint.

8. Conclusions

There is evidence of many positives aspects of incorporating MSS in beef and sheep systems. MSS provide an opportunity to increase sward diversity whilst producing similar herbage yields to PRG swards, but with 45% less nitrogen fertiliser/ha/year (Grace et al., 2018), thus increasing nitrogen use efficiency. Herb species such as plantain and cocksfoot are characterised by their deep root system, which assists in drought resistance and resource utilisation from deeper soil layers (Jing et al., 2017). In addition, herb and legume swards to have a higher feeding value for ruminants than PRG swards (Kemp et al., 2010). These swards can contribute to rumen health, provide a higher feeding value for ruminant species, while improving biodiversity and mitigating environmental concerns by reducing the need for fertiliser and nitrogen leaching risks (Vogeler et al, 2015; Vibart et al, 2016).

However research on the effect of grazing MSS on animal performance is often conflicting and a focus on beef cattle in particular is limited. Much of the research that has been carried out is conflicting especially in regards to animal performance, endo-parasite control and environmental impacts. This is likely as a consequence of different methodologies and different combinations of swards (which have different nutritional properties). Additionally MSS are harder to manage than PRG swards and there are often problems with persistency in the sward. Balancing swards with seasonality, financial implications and grazing animal species will be complex and needs a consensus from many research partners. Therefore, a comprehensive analysis of the impact of multi-species sward grazing on animal performance, health, disease control, in addition to environmental impacts, soil quality, financial viability and overall suitability to farm management is essential.

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Appendix 5

Dale Orr, Strangford

Introduction

Dale and his father John run a suckler to beef and lowland sheep enterprise on their 204-hectare farm under a rotational grazing system.

In recent years, Dale has planted herbal ley mix and is currently assessing its performance using soil analysis and grass platemeter measurement. In addition to this, he grows red and white clover swards organically without the use of nitrogen fertiliser.

Establishment - 2021

Establishment: Mid-April 2021

Area sown: 14.6ac total (3 fields)

Field	Field Reference	Area (ac)	Total Area (ac)
1	3/108/005/**7**	4.08	
2	3/108/005/**8**	4.54	
3	3/108/085/**19**	5.98	14.6

Establishment Method:

- Plough, lift stones and harrow
- Rolling, sowing, and then rolling the field again.

The following mix was sown (per acre):

- 6 kg Baraula Cocksfoot
- 1.5 kg Barvital Meadow Fescue
- 0.5 kg Comer Timothy
- 1 kg Aberclaret Red Clover
- 1.5 kg Aberpasture White Clover Blend
- 1 kg Tonic Plantain
- 0.5kg Puna 11 Chicory
- Nurse Crop - 1.5kg Redstart (Hybrid Brassica) per acre, added to the MSS mix

Field details were as follows determined by soil sampling in January 2021:

Field 1	• Soil textural class – Clay: 14% sand, 42% silt, 44% clay • Major soil classification – heavy • Organic matter – 7.2%, above average • Soil pH – 6.7 • Microbial Activity – good • Soil health index – 5.4 (very high) • Soil microbial index – 4.9 (high) • Phosphorous levels are very low

	• Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 2	• Soil textural class – Clay: 16% sand, 43% silt, 41% clay • Major soil classification – Heavy • Organic matter - 8.4%, above average • Soil pH – 6.4, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.4 (very high) • Soil microbial index – 4.9 (high) • Phosphorus levels – low • Potassium levels - low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 3	• Soil textural class – Clay: 13% sand, 41% silt, 46% clay • Major soil classification heavy • Organic matter- 8.8%, above average • Soil pH – 7.1, slightly above optimum range • Microbial activity – moderate • Soil health index – 5.3 (very high) • Soil microbial index – 4.7 (high) • Potassium -level is very low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon

Sward Management - 2022

- Nearly 12 tonnes of DM per hectare
- Started grazing around 25 February and they were finally closed off at the end of November.
- Winter growth over November/December estimated to be about 6kg DM per hectare daily.
- Each MSS sward received one dressing of 85kg per ha of Sulphate of Potash during the year. The swards produced nearly 12 tonnes of DM per hectare.

Animal Performance - 2022

Two flocks of 74 ewes rearing double lambs that were taken through to slaughter were monitored – one grazing MSS and one grazing PRG/WC. Started off with over 100 ewes in each flock but the female lambs from the best ewes in each flock were kept as replacements so have been taken out of the calculations. Did not feed meal to any lamb so all growth performance is from forage and milk.

	MSS Lambs	**PRG&WC Lambs**
First 4 Weeks – DLWG	0.376 kg per day	0.304 kg per day
First 8 Weeks – DLWG	0.310 kg per day	0.280 kg per day
Average Slaughter Weight	42.86 kg	42.96 kg
Average Carcase Weight	19.95 kg	19.50 kg
Average Slaughter Age	167 days	196 days

Paul Turley, Downpatrick

Introduction

Paul alongside his two sons runs an extensive Aberdeen Angus and Wagyu beef enterprise on their 160-hectare farm in County Down. Their enterprise consists of suckler to beef and contract rearing of dairy-origin calf systems on a rotational grazing system.

Establishment - 2021

Establishment: April 2021

Area sown: 23.8ac (7 fields)

Field	Field Reference	Field Name	Area (ac)	Total Area (ac)
1	3/107/112/**8A**	Stable 1	4.0	
2	3/107/112/**10**	Stable2	2.8	
3	3/107/112/**12B**	LHS horse 1	1.5	
4	3/107/112/**11B**	LHS horse 2	1.5	
5	3/107/112/**6**	McMullan	5.9	
6	3/107/112/**7**	Long	2.7	
7	3/107/112/**12A**	Winter	5.4	23.80

Establishment Method:

- MSS followed kale.
- Applied farm-yard manure, sub-soiled where necessary, then ploughed and power harrowed twice before lifting stones.
- The field was rolled before and after the mix was sown.

Field details and species mixes sown were as follows:

Field 1	• Soil textural class – clay: 15% sand, 41% silt, 44% clay • Major soil classification – heavy • Organic matter – 9.2%, above average • Soil pH – 6.6 • Microbial activity – good • Soil health index – 5.9 (very high) • Soil microbial index – 5.0 (high) • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	Cocksfoot, meadow fescue, timothy, red clover, white clover, plantain chicory, burnet, birdsfoot trefoil ,yarrow, sheeps parsley
Field 2	• Soil textural class – clay: 16% sand, 41% silt, 43% clay • Major soil classification – heavy	Cocksfoot, tetraploid PRG, PRG, timothy, meadow fescue ,tall fescue, alsike

	• Organic matter – 7.4%, above average • Soil pH – 6.6 • Microbial activity – good • Soil health index – 6.0 (very high) • Soil microbial index – 5.1 (very high) • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	clover, red clover, sweet clover, sainfoin, birdsfoot, trefoil, chicory, burnet, yarrow, sheeps parsley, plantain, knapweed
	• Soil textural class - clay loam: 29% sand, 37% silt, 34% clay • Major soil classification - medium • Organic matter – 9.1% • Soil pH – 6.9 • Microbial activity – 9.1% • Soil health index – 5.6 (very high) • Soil microbial index – 4.9 (high) • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	worming paddock: Sainfoin, chicory, birdsfoot trefoil, ribgrass, meadow fescue, timothy
Field 4	• Soil textural class – clay: 16% sand, 42% silt, 42% clay • Major soil classification – Organic • Organic matter – 12.4% • Microbial activity – good • Soil health index – 5.6 (very high) • Soil microbial index – 4.9 (high) • Phosphorus -availability low • Magnesium – availability low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	worming paddock: Sainfoin, chicory, birdsfoot trefoil, ribgrass, meadow fescue, timothy
Field 5	• Soil textural class – clay:13% sand, 42% silt, 45% clay • Major soil classification – heavy • Organic matter – 7.3%, above average • Soil pH – 7.2, slightly above the optimum range • Microbial activity – good • Soil health index – 6.0 (very high) • Soil microbial index – 5.1 (very high) • Magnesium – availability low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	Cocksfoot, meadow fescue, timothy, red clover, white clover, plantain chicory, burnet, birdsfoot trefoil ,yarrow, sheeps parsley
Field 6	• Soil textural class – clay: 14% sand, 42% silt, 44% clay • Major soil classification – organic • Organic matter – 11.9%, above average	Cocksfoot, tetraploid PRG, PRG, timothy, meadow fescue ,tall fescue, alsike clover, red clover, sweet clover, sainfoin, birdsfoot,

	• Soil pH – 7.1, slightly above the optimum range • Microbial activity – good • Soil health index – 5.7 (very high) • Soil microbial index – 5.0 (high) • Phosphorus – availability low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	trefoil, chicory, burnet, yarrow, sheeps parsley, plantain, knapweed
Field 7	• Soil textural class – clay: 16%, 40% silt, 44% clay • Major soil classification – heavy • Organic matter – 7.3% • Soil pH – 7.3, slightly above the optimum range • Microbial activity – good • Soil health index – 5.8 (very high) • Soil microbial index – 4.9 (high) • Magnesium – availability low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon	Cocksfoot, meadow fescue, timothy, red clover, white clover, plantain chicory, burnet, birdsfoot trefoil ,yarrow, sheeps parsley

Sward Management – 2022

- No N-fertiliser applied

Animal performance - 2022

Two batches of cattle put out on 31st March 2022. One on MSS grazing platform one on Grass only grazing platform. 48 Cattle in Grass only batch and 52 in MSS batch.

	DLWG/kg at Grass Only	DLWG/kg at MSS
At 31st May	0.82	0.6
At 12th July	0.8	0.85
At 30th Aug	0.65	0.63
At 21st Sep	0.185	0.67
Full Season Average	0.70	0.68

Roger & Hilary Bell - Kells

Introduction

Husband and wife Roger and Hilary Bell from Kells both farm full-time on their 78-hectare farm, where they finish a number of beef cattle on a rotational and strip grazing system. Their main enterprise, however, is a combination of lowland and upland sheep, which are reared on a rotational grazing system. In recent years, innovative practices have involved the trial of an automotive outdoor weighing system for their flock of 550 breeding ewes.

Establishment - 2021

Establishment: June 2021

Area sown: 7ac (1 field)

Field	Field Reference	Area (ac)	Total Area (ac)
1	1/071/085/**5B**	7.0	7.0

Establishment Method:

- Field Ploughed and stones lifted
- Power-harrowed, land-level
- Stale Seed Bed Technique – weed sprayed off
- Seeds are sown and rolled.

Species Mix Sown: DFL Six Species Mix

- PRG
- Timothy
- Chicory
- Plantain
- Red Clover
- White Clover

Field 1	• Soil textural class – silty clay: 17% sand, 46% silt, 37% clay • Major soil classification – organic • Organic matter – 13.9%, above average • Soil pH – 6.2, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.8 (very high) • Soil microbial result – 5.0 (high) • Magnesium – availability is high, may restrict plant uptake of potassium • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon

Sward Management – 2022

- Field production of approximately 11tDM/ha
- Received 39.54kg/N/ha

Animal performance - 2022

Two mobs of mixed ewe and tip lambs monitored - 418 total. Lambs were not exclusively grazed on MSS but as part of a mixed grazing rotation. Lambs weighed when entering/exiting fields.

Field	Dates	DLWG kg/day
Out PRG Field	28/07/2022	0.340
MSS	28/07 - 03/08	0.160
PRG	03/08 - 12/08	0.350
PRG	12/08 - 19/08	0.240
MSS	19/08 – 26/08	0.090
PRG	26/08 – 02/09	0.420

Lambs didn't go back onto MSS after the 26/08/22 due to low DLWG each time they went into it. Lambs visibly were looking out of the field. May be related to the grass mix within the MSS sward and the mixed grazing rotation unsettling the lambs.

Andrew Clarke & Wayne Acheson, Cookstown

Introduction

Andrew works on a 400-hectare beef enterprise owned by Wayne Acheson, with a combination of beef finishing, suckler and store cattle to beef systems on a rotational grazing system, supplying beef cattle to Foyle Food Group. Each year, around 3000 cattle are finished on this system.

Establishment - 2021

Establishment: June 2021

Area sown: 20.2ac

Field	Field Reference	Field Name	Area (ac)	Total Area (ac)
1	6/106/**111/5**	Tullylagan river field	11.68	
2	6/106/**014/13**	Swales	5.56	
3	6/106/xxx/xx	Tullylagan EXTRA	4.5	21.74

Establishment Method:

- Minimal tillage establishment – field mole drained and power harrowed
- Mix is sown by Einbock and then rolled

Field details and species mixes sown were as follows:

<table>
<tr><td>Field 1</td><td>Soil textural class – clay loam: 39% sand, 35% silt, 26% clay
Major soil classification – Organic
Organic matter – 13.8%, above average
Soil pH – 6.1, lower than desired level for optimum
Microbial activity – good
Soil health index – 5.6 (very high)
Soil microbial index – 5.1 (high)
Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon</td><td rowspan="2">14 species:
Ryegrass Inter D
Ryegrass Late T
Timothy
Meadow Fescue
White Clover
Red Clover
Sainfoin
Sheeps Burnet
Yarrow
Sheeps Parsley
Birdsfoot Trefoil
Alsike Clover
Plantain
Chicory</td></tr>
<tr><td>Field 2</td><td>Unknown (*originally a different field was to be sown but this was changed in the summer of 2021</td></tr>
</table>

Field 3	Unknown (*originally a different field was to be sown but this was changed in the summer of 2021	• Intermediate Perennial Ryegrass (Nifty) • Late Perennial Ryegrass (Kerry) • Late Perrenial ryegrass (Aspect) • Timothy • Chicory • Plantain • Red clover • White Clover

Animal performance - 2022

Two mobs, MSS (16) vs PRG (21), monitored at grazing from Mid-April/Early May and weighed again mid-August/Ealy Sept. Missed being weighed at end of grazing season due to staff resource limitations.

	MSS	**PRG**
Average DLWG (kg/day)	0.691	0.871

Sam Chesney, Kircubbin

Introduction

Along with his family, Sam runs a predominantly beef enterprise on an 80-hectare farm, along with a lowland sheep enterprise on a rotational grazing system. The Chesney's beef enterprise consists of rearing suckler cattle and store cattle to beef, as well as being involved with ABP Blade Calf finishing programme.

Establishment - 2021

Establishment: May 2021

Area sown: 5ac (1 field)

Field	Field Reference	Area (ac)	Total Area (ac)
1	3/003/046/9	5	5

Establishment Method:

- Ploughed with farm-yard manure
- Sprayed and power-harrowed twice before rolling and broadcast sowing of the mix.
- Two tonnes of lime will also applied.

The following mix was sown:

- Red clover
- White clover
- Plantain
- Chicory
- Tetraploid ryegrass
- Timothy

Field details were as follows determined by soil sampling in January 2021:

Field 1	• Soil textural class – clay; 17% sand, 42% silt, 41% clay • Major soil classification – heavy • Organic matter – 7.4%, above average • Soil pH – 6.4, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.7 (very high) • Soil microbial index – 4.9 (high) • Phosphorus – availability is low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon

Sward Management - 2022

- During drought period PRG swards were only doing 10-15 kg/DM/ha but MSS was achieving 45kgDM/ha. At 3 weeks into the drought, at it's height, were supplement feeding cattle on PRG – not on the MSS.
- Applying 50% or below of usual PRG fertiliser amount of 180kg to the MSS. Significant cost saving at 2022 prices.
- In 2023 planning to reduce N application further lower and use a Clover specific fertiliser

Animal Performance - 2022

- Similar DLWG achieved on the MSS grazed vs PRG grazed stock – taking into account different breeds.
- Tried to keep batches on MSS full time but not enough fields and had to rest MSS at times.
- 60 calves on a 1ha paddock (going in at 4000 cover) for 3 days achieved a 0.300kg/day growth. Would have been hungry on it so may have done more kg/day if had had more fields.

Crosby Cleland, Saintfield

Introduction

Crosby runs a lowland flock on a rotational grazing system across 73-hectares.

Establishment - 2021

Established across two time periods:

- Fields 4 & 5: Early June 2021 – after first cut silage
- Fields 1, 2 & 3: August 2021 – post grazing when stocking pressure reduced early June 2021Herb mix sowing late July / Silage Grazing mix early June 2021

Field	Field Reference	Field name	Area (ac)	Total Area (ac)
1	3/119/00115A	claras hill lane side	2.2	
2	3/119/001/14 (B side only - other half already in herbs)	back hill grsas lane side	1.9	
3	3/119/001/6	orchard field	3.7	7.8
4	3/119/001/10	flynns hill	4.9	
5	3/119/053/2	JR bungalow hill	6.6	11.5

Establishment Method:

- Field grazed very tight by sheep (not sprayed or limed – not possible in 2021 conditions)
- Sown in using Einbock method (double crossing runs) and rolled

Fields 1, 2 & 3	• PRG • Timothy • Tall fescue • Cooksfoot • White Clover • Red Clover • Chicory • Plantain
Fields 4 & 5	• PRG • Timothy • Red Clover

Field details were as follows determined by soil sampling in January 2021:

Field 1	• Soil textural class – clay: 11% sand, 44% silt, 45% clay • Major soil classification – organic • Organic matter – 12.1%, above average • Soil pH – 6.6 • Microbial activity – high • Soil health index – 6.0 (very high) • Soil microbial index – 5.3 (very high)

	• Phosphorus – availability low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 2	• Soil textural class – clay: 11% sand, 44% silt, 45% clay • Major soil classification – organic • Organic matter- 12.1%, above average • Soil pH – 6.9 • Microbial activity – good • Soil heath index- 5.8 (very high) • Soil microbial index - 5.1 (very high) • Phosphorus – availability is low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 3	• Soil textural class – clay: 12% sand, 44% silt, 44% clay • Major soil classification – organic • Organic matter – 11.9% • Soil pH – 6.3, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.9 (very high) • Soil microbial index – 5.1 (high) • Phosphorus – availability is low • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 4	• Soil textural class – Silty clay: 11% sand, 46% silt, 43% clay • Major soil classification – organic • Organic matter – 10.8%, above average • Soil pH- 6.4, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.8 (very high) • Soil microbial index – 5.0 (high) • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon
Field 5	• Soil textural class – clay: 13% sand, 42% silt, 45% clay • Major soil classification – Clay • Organic matter – 13.3%, above average • Soil pH – 6.2, lower than desired level for optimum plant growth • Microbial activity – good • Soil health index – 5.8 (very high) • Soil microbial index – 4.9 (high) • Soil texture – fine micro-aggregate structure, maintains low exchange rates of air and water, very slow conversion/ loss of soil carbon

Sward Management – 2022

- Fields 1, 2, & 3 established well but little chicory evident in September 2021. More plantain and clover emerged in 2022. Managed as grazing paddocks.
- Fields 4 & 5 - no rain for 7 weeks after established. Some red clover emerged in 2021 but none since. Failed.
- MSS grazing paddocks grazed stock for the same length of time as PRG paddocks. 7-10 tDM/ha.
- 32.96kg/N/ha applied
- Species choice has been appropriate for sheep, climatic condition and soil type

Animal Performance - 2022

- Was able to allocate a flock of 100 ewes with 2 lambs each to MSS paddocks and in comparison a similar sized flock to standard grass clover sward paddocks
- Could only hold trial on these two flocks from late march to late June when the lambs were weaned, as after this date lambs are split into groups according to weight and readiness for market
- The group on grass clover showed a DLWG of 214; The group on MSS showed a DLWG of 226