European Innovation Partnership (EIP) Wales

Sustainable Intensification in Upland Grazing Production Systems

Final Report

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Project description

There are increasingly challenging European and world trade conditions affecting upland production systems; thus, it is essential that upland beef and sheep and dairy producers look at ways to ensure they produce red meat and milk as efficiently and sustainably as possible. Improving the financial return and viability of upland units via improved carrying capacity and output is vital to ensure the industry's long term survival and the survival of the wider rural community. This trial work will improve knowledge and encourage innovation in rural areas, whilst also strengthening the links between the farming and academic institutions.

The inspiration for this project comes from Finland, which the farmers in the operational group visited through a Farming Connect exchange to look at work carried out utilising Timothy as a mainstay of grass leys, which has proved very successful in grazing regimes. In Finland, the use of Timothy has in some cases led to a doubling of grassland production in 7 years. If this was to be realised in Wales, the wider application of this small project could lead to significant improvement to financial performance and perhaps help to secure the long-term viability of Welsh upland farming.

The long-term strategy of this project is to examine and highlight the benefit of alternative species within grassland leys, and the potential for those to improve upland farm viability. The project utilised leys with various percentages (by weight) of Timothy, with a view to improve the carrying capacity and finishing ability of intensive upland grazing systems. The leys were established using two different methods – Scratching and Slot Seeding. Over the trial phases, the quality and yield of these leys was compared to an existing upland ley.

Project Aims

- Identify the best technique for the establishment and production of a Timothy dominant sward.
- Examine if Timothy-based leys offer any benefits above standard Ryegrass leys.
- Promote the benefits of diverse leys in improving farm viability, creating an economic and environmentally resilient system.
- Improve available nutrition and management practices to improve health and welfare of livestock, whilst reducing investment in alternative finishing methods.
- Increase farmer confidence in selecting site-specific reseed mixes which provide benefits over and above the standard 'off the shelf' mixes, e.g., biodiversity / environmental benefits.
- Encourage and foster the development of knowledge throughout the agricultural community and strengthen the links between research /innovation and the rural community.

Experimental Design

At the start of the project a trial area of 30 acres (12.1ha) was identified on a parcel of hill ground at Mynydd Clogau, owned by the Yeomans family.

Initial plot establishment was carried out as follows:

- Eight trial plots were selected at random, two plots had a control 'off the shelf' ley while six plots had a base of Ryegrass and White Clover, with increasing levels of Timothy.
- Soil status – pH, P, K, Mg– was established and corrected in the first phase.

Across all three years, the following advice and support was provided by external experts:

- Growth rate, yield, persistence and quality of the ley were monitored regularly by Chris Duller.
- Dr Iwan Owen examined the results, highlighting areas for development and improvements as the project progressed.
- Expert advice was provided by Finnish Agricultural experts from ProAgria.
- Anecdotal evidence of animal performance was recorded.

Important Additional Information

Tragically, in spring 2020, Richard Tudor died suddenly in an accident. Tom and Morgan Tudor have maintained contact with the members of the project operational group and continue to be involved with the project.

The project was also affected by COVID-19 lockdowns which limited the number of meetings, site visits and knowledge transfer activities that could take place. The project was paused for three months in spring 2020 and the project deadline was extended to June 2022 as a result.

Conclusions

The analyses and subsequent advice provided throughout the course of this project enabled the participating farmers to make informed choices with regards to seed mixes, seeding ratios, and drilling methods to ensure a high Timothy content ley was established. The main findings of the project are summarised below.

- The project was able to successfully establish swards with a strong Timothy component – but was not able to generate Timothy dominant swards.
- There was no major penalty to yield from high inclusion rates of Timothy.
- There was a slight penalty to forage quality from including Timothy and other grasses in mixtures.

- Increasing the productivity of the hill land through reseeding and higher stocking rates increased the carbon storage levels in the soil.
- The project has challenged some traditional ideas about suitable seed mixtures for upland situations.

Methodology and results

Phase 1 methodology

In the spring of 2019, a detailed soil status (pH, P, K, Mg) - was carried out and soil nutrient status was corrected accordingly.

Eight trial plots were selected at random and split equally over 30 acres (12.1 ha). Two of the eight plots contained a control ley of Germinal HSG3 plus Plantain (*table 1*). The remaining six plots contained the same base ley but included increasing levels of Timothy (Rubina) by 10%, 25% and 40% seed weight *(table 2).* Total seed weight reductions were spread evenly across the Perennial Ryegrasses to compensate for the additional weights of Timothy.

Table 1. Breakdown of Germinal HSG3 plus Plantain ley which was used as a control plot in 2 out of the 8 experimental plots.

Kg/acre	Variety	Type
3.5	Toddington Late PRG	Perennial Ryegrass
2.8	AberChoice Late PRG	Perennial Ryegrass
2.8	Romark Late PRG	Perennial Ryegrass
2.9	Abergain Tet Late PRG	Perennial Ryegrass
0.5	Rivendel White Clover	Perennial Ryegrass
0.5	Merwi White Clover	White Clover Blend
1.0	Tonic	Plantain
Total: 14kg		

Table 2. Increasing levels of Timothy, by weight. Percentage of total sowing rate, and corresponding seed weight for each increase.

Percentage increase (%)	Total amount of Timothy (Kg)
10%	1.4
25%	3.5
40%	5.6

The existing ley was sprayed off using *Kyleo* chemical (active ingredients 2.4D and glyphosate) in preparation for establishing the new leys. Two different establishment methods, scratching and slot seeding, were randomised for each seed mixture type. This allowed the project to establish whether there was a variation in Timothy establishment and/or yield as a result of establishment method.

Scratch seeding involves scratching the surface in different directions with a set of tined grass harrows before applying the seed, scratching again, and then rolling. Meanwhile, the slot seeder places the seed into the ground by cutting a groove with two offset discs per slot. The seed is then blown or placed into the slot, which is then closed by a large ballasted flat roll. The slots were spaced approximately 70mm apart, which allowed the seed sufficient growth space, but also enabled existing grass to survive.

Phase 1 results

Following the establishment of plots with different levels of Timothy inclusion in May 2019 (0, 10, 25 and 40% of seed mixture by weight), it was planned to assess the resultant swards for yield and quality and to monitor animal performance through 2020.

There were already concerns in 2019 that the Timothy component of the swards had failed to establish. Sward assessments in the autumn of 2019 revealed no significant differences between many of the plots in terms of Timothy plants – even in the 40% inclusion plots there was less than 12% Timothy in the actual sward.

It was hoped that 2020 would see a development of the Timothy plants through spring and early summer, with several people suggesting that Timothy was a slow starter and may well show improvement in the year following establishment.

However, sward assessments in late May 2020 still found the swards to be Ryegrass dominant, with Timothy plants averaging less than 10% across all the different Timothy plots.

Table 3. Visual assessment of sward composition of plots at the end of Phase 1 (May 2020).

% timothy inclusion	establishment method	%Ryegrass	%Timothy	%Plantain	%Wclover	% Meadow grass	Average % Timothy
0	drill	76	0	1	2	20	0
	broadcast	47	0	0	4	37	
10	drill	36	9	2	4	47	7.5
	broadcast	60	6	2	1	28	
25	drill	57	12	3	2	17	8
	broadcast	63	4	3	0	28	
40	drill	68	2	2	3	23	9.5
	broadcast	70	17	3	1	8	

There were isolated areas within each of the plots with a greater Timothy presence, but on a plot scale there was little to differentiate the plots. Throughout 2020 the nine plots (eight treatments and a control) were assessed for grass dry matter production with monthly cuts taken from under the grazing cages (*table 4*).

Table 4. Dry matter production from the plots (March-October 2020)

Plot	Treatment	Method	kgDM/ha/yr
1	Nil Timothy	Rake	11980
2	10% Timothy	Drill	10430
3	10% Timothy	Rake	10730
4	Nil Timothy	Drill	8960
5	40% Timothy	Drill	11412
6	25% Timothy	Rake	7480*
7	25% Timothy	Drill	8755*
8	40% Timothy	Rake	10110
Control	Old Pasture	-	3192

* Incomplete data sets due to animals disturbing grazing cages.

The new leys, although short of Timothy, performed incredibly well, providing a hugely valuable supply of forage - particularly through the dry period of May/June when the plots (10ha in total) carried over 600 ewes plus lambs. This extra forage supply gained from reseeding is particularly valuable to an upland farm, allowing more stock to be sent to the hill and lowland silage fields closed out earlier, offering opportunity to increase silage quality and reduce purchased feeds.

The average first year yield from the reseeds of 10.6tDM/ha compares closely to the results from another EIP Wales project (Alternative Forage Systems for Marginal Land) where the reseeded upland pastures grew 10.2tDM/ha in their first full year of production. The yields are a massive contrast to the 3.2tDM/ha grown on the older permanent pasture that neighbours the plot area.

Plate 1. With delayed spring grazing due to wet conditions, high covers developed on the plots – requiring high stocking rates.

By May 2020 it was felt there was little value to be gained from detailed monitoring of sward quality and animal productivity with such small differences in Timothy contents on the different plots. It was decided that the project would have another attempt at establishing a Timothy sward in 2020.

Possible oversowing of Timothy into the existing plots was considered but this was rejected due to concerns that the very small seed size of Timothy would limit its establishment and competitive ability in a young, Ryegrass dominant ley.

The possible reasons behind the failure of the Timothy to establish successfully were debated. It was deemed likely a combination of the following:

1) Very wet soil conditions post-establishment which may have led to the small seeds rotting at the base.
2) Ryegrass competition shading out the young Timothy plants.
3) High organic matter content soils slowing the liming effect of the ground lime applied at establishment.

There were concerns that direct drilling may have placed the Timothy seed too deep in the soil and limited germination – but there was no distinction between the raking and drilling options in terms of establishment success. Plant populations and sward production showed neither being clearly the better option.

Summary of main findings from phase 1

It proved difficult to establish a Timothy dominant sward and none of the plots sown in 2019 had more than 10% Timothy, despite including over 5kg (40% of total) in some of the seed mixtures.

The lack of success with Timothy was considered mainly due to poor establishment conditions (wet soils, small seeds) along with strong competition from the companion Ryegrass and a possible negative impact of low soil pH.

There appeared to be no difference in establishment success with either raking and broadcasting or direct drilling.

The reseeding was successful in creating highly productive swards that produced over 10tDM/ha in their first full year; over three times the production of neighbouring old permanent pasture. Average forage yield from the reseeds was 10.6tDM/ha, an enormous contrast to the 3.2tDM/ha grown on the older permanent pasture that neighbours the plot area.

The project successfully established a Ryegrass dominant sward in a difficult upland situation, using two different establishment methods.

Although not the intended dominant species, a Ryegrass sward is a vast improvement in terms of both production and sward quality in comparison to the sward it replaces, and those from the neighbouring control.

Without major differences in sward composition on the plots the plans to assess sward quality and animal performance were abandoned for 2020.

Phase 2 methodology

After the difficult start to the project in phase 1, it was decided that a second set of two trial plots on 12 acres (4.86 ha) of adjacent land would be established (*labelled plot A and plot B, for reference*). These two new plots were established with the view to reduce Ryegrass levels and introduce a wider variety of grasses into the ley to establish a sward with different characteristics to the traditional Ryegrass/Clover sward. Having observed no differences between the establishment techniques in phase 1, the trial plots were sown by raking and broadcasting – which can take place in a wider range of soil moisture conditions than drilling and is a cheaper method.

For phase 2 the project concentrated on assessing and comparing the performance of four trial plots. Two plots from the original sowings in phase 1 – plot 1 0% Timothy and plot 8 40% Timothy - and the two plots that were established in phase 2 – plot A high% Timothy and plot B multi-species ley.

Plate 2. Map of the new plots – plot A high% Timothy, and plot B multi-species ley.

New plot establishment

The plots were sprayed off with glyphosate, then scratched and seeded with a grass harrow. Soils were analysed at 5.5 and 5.7 pH, so prilled lime was applied at 300kg/acre (741kg/ha) to raise pH levels and encourage a more rapid breakdown of the desiccated sward.

To allow more opportunity for the Timothy to dominate the sward, the Ryegrass component of plot A was scaled back to just 3kg of AberGain tetraploid, with Timothy raised to 8kg with 1kg of White Clover (*table 4*). For comparison, the 40% Timothy sown mix in phase 1 contained 6.4kg of Ryegrass and 5.6kg of Timothy. Plot B included a broader mix of grasses (table 5), to assess whether a variety of grasses in the sward would provide better opportunity for the Timothy to establish in a less competitive environment

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Plate 3. Seed bed post glyphosate, scratching and seeding with grass harrow.

Table 4. Plot A seed mix – Timothy dominant to provide more opportunity for Timothy to establish successfully and reduce Ryegrass competition.

Sowing rate (kg/acre)	Variety	Type
3	AberGrain	Late Tet
8	Dolina	Timothy
1	Rivendel	Medium White Clover

Table 5. Plot B seed mix – included a wider range of grass species, to repeat the 40% Timothy inclusion of the first trial but with different, less aggressive companion grasses.

Sowing rate (kg/acre)	Variety	Type
2	AberGrain	Late Tet
3	Laura	Meadow Fescue
1	Donata	Cocksfoot
2	Lofa	Festulolium
4	Dolina	Timothy
1	Rivendel	Medium White Clover

These two plots were sown in August 2020 in a narrow window of dry weather. The ground was very wet thereafter, and there was no opportunity for autumn grazing to encourage tillering or exert some pressure on establishing weeds. Fifty days post-sowing, multiple 0.1m^2 quadrat assessments were made in each of the two plots to record plant numbers of sown grasses and clover, as well as weed grasses and/or broadleaf weeds.

Plate 4. A fair degree of chickweed in the new plots, due to the conditions it was not easy to give the plots any grazing pressure to reduce the presence of weeds.

Site management

Nitrogen fertiliser was applied through the latter part of phase 2 (*table 6*), and farmyard manure was applied during the summer at 4t/acre (10t/ha).

Table 6. Phase 2 fertiliser applications through spring and summer 2021.

Month	kgN/ha
April	34
June	32
July	20
September	20

Ninety ewe hoggs grazed through late winter and early spring of phase 2 to reduce the high level of grass cover. Poor growing conditions in the following spring slowed grass growth, though by June the whole plot area was carrying approximately 400 ewes and lambs (two gangs, rotational grazing). The sheep were happy to graze the Ryegrass heads but less keen on grazing the mature Timothy.

Plate 5. Timothy plants in full head. Sheep grazed the Ryegrass heads but were less keen on grazing the mature Timothy

A total of 24 heifers/dry cows joined the grazing regime to cope with peak grass growth in early summer. Two of the plots (3 and 6) were cut for silage. Stock numbers remained high through August, including a small herd of cattle on plots A and B. The ewes were removed, and lamb numbers reduced, through the autumn. Last grazing was mid-November.

Plate 6. Plots A and B carried high numbers of stock through August, including a small herd of cattle.

Monitoring and assessments

The site was visited for monitoring and analysis once per month between March and September 2021, when plots were plate metered, cut for yield assessments and forage quality assessments, herbage separation to identify sward composition and mineral composition was assessed.

Soil carbon assessments

During phase 2 it was decided that the soil carbon status of the different grassland systems on the hill should be assessed as part of the project. The following types of plots were sampled:

- Unimproved hill - Heather/Nardis Fescue dominated
- Improved hill - Previously improved but since reverted to Agrostis dominant sward with rushes, with minimal inputs
- Improved hill (trial site) – Ryegrass dominant. Has been ploughed in recent years and had fertiliser inputs.

Soil carbon assessments were carried out by taking soil samples and measuring bulk density and soil organic matter levels. Samples were assessed for organic matter by loss on ignition and carbon content estimated by conversion factor of 0.58.

Phase 2 results

New plot establishment

Initial germination of plot A and plot B was good, and although there were early signs of Chickweed, the number of grass seedlings remained stable.

During the 50 days post sowing quadrat assessments, very high numbers of Chickweed plants were present. These were very brittle in nature; thus, individual plant counts were not possible. Instead, a % ground cover assessment was made, estimating overall Chickweed coverage at 45% in plot A and 30% in plot B. Plant counts of the sown leys were taken to establish the species composition of plots A and B, showing successful Timothy dominance (*figure 1*).

Plot A Plot B

Plate 7. Example of quadrat assessments from plot A (left) and plot B (right).

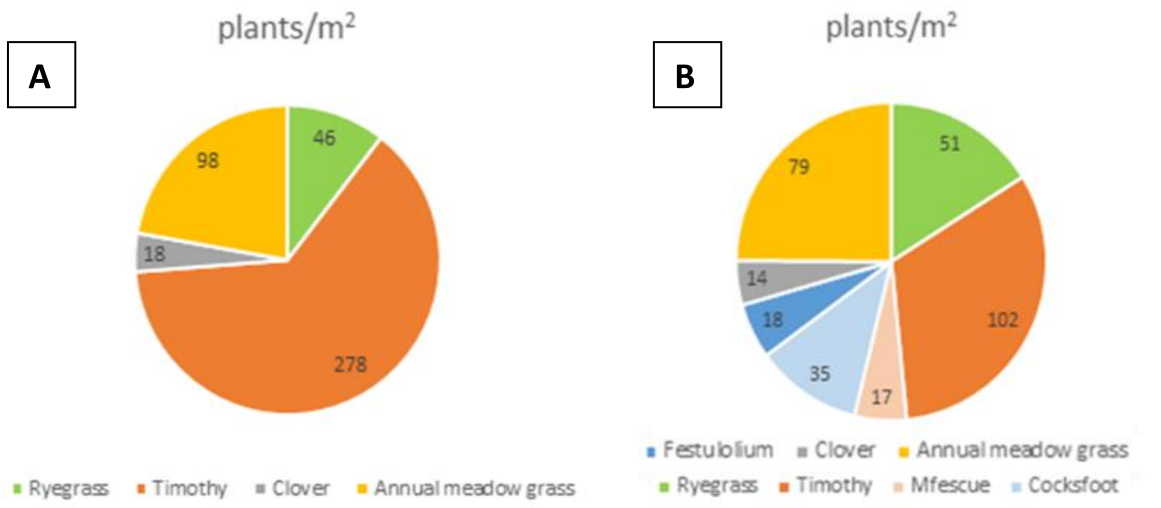

Figure 1. Number of plants in the two newly established plots of phase 2, as counted in October 2020.

A demonstrates the success of a Timothy dominant seed mix, yielding 278 Timothy plants, 46 Ryegrass plants, 98 annual meadow grass plants and 18 White Clover plants. **B** shows the success of establishing a diverse ley to reduce competition for Timothy, with 102 Timothy plants, 52 Ryegrass plants, 79 annual meadow grass plants, 35 Cocksfoot plants, 18 Festulolium plants, 17 Meadow Fescue plants and 14 White Clover plants.

Productivity

The original plots established in phase 1 continued to perform well. Plot 1 averaged just above 12tDM/ha, and plot 8 averaged approximately 13tDM/ha (*figure 2*). Plots A and B matched the control, though plot A yielded significantly more dry matter (12tDM/ha) than plot B, which averaged just 8.8t/DM/ha (*figure 2*). There was no evidence of any benefit to early season growth with the inclusion of Timothy or other alternative grasses – but the high Timothy content sward (plot A) did show increased growth in autumn.

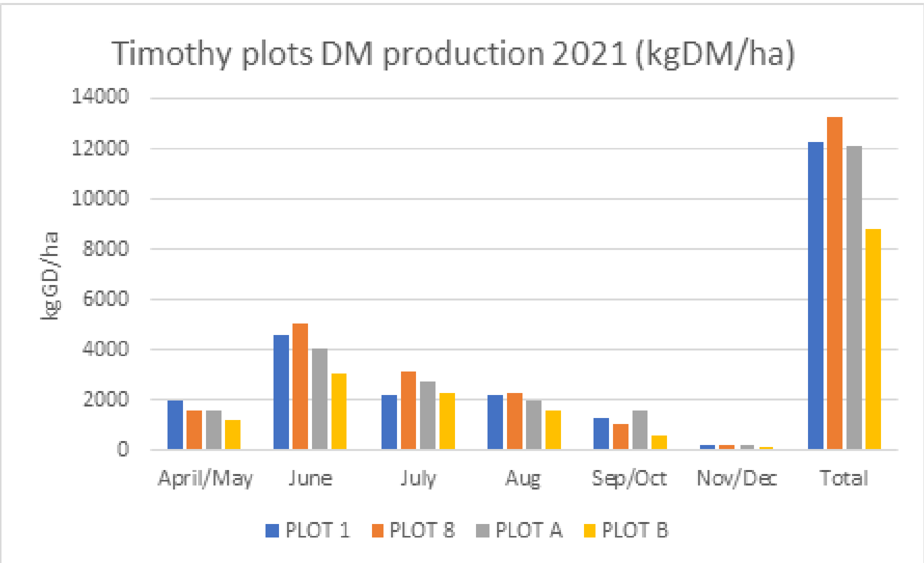

Figure 2. Average dry matter yield throughout phase 2 of all four assessed plots. Plot 8 was the highest producing plot, with approximately 13tDM/ha, followed by plots 1 and A with approximately 12t/DM/ha. Plot B was the least productive plot, producing just 8800kgDM/ha.

Sward composition

The percentage of Timothy in plot 8 increased by 7% during phase 2, though Ryegrass remained the dominant species. It had some competition from meadow grasses and creeping bent in wetter areas. The two plots established in phase 2 (Plots A and B) had markedly different sward compositions in comparison to the original phase 1 plots (*figure 3*). Plot A maintained a Timothy presence of 25%, though Ryegrass did seem to be increasing in dominance. Plot B maintained a good mixture of different grasses, and levels of Chickweed and meadow grasses reduced. However, distinguishing Meadow Fescue and Festulolium from the Ryegrass was difficult. Final sward compositions were assessed in phase 3 with more accurate identification.

In the final stages of phase 2, there were areas of plots A and B in which Chickweed and Spear Thistle were very pronounced. It was difficult to tell whether the weed levels were a genuine treatment effect, or if it was simply localised soil conditions.

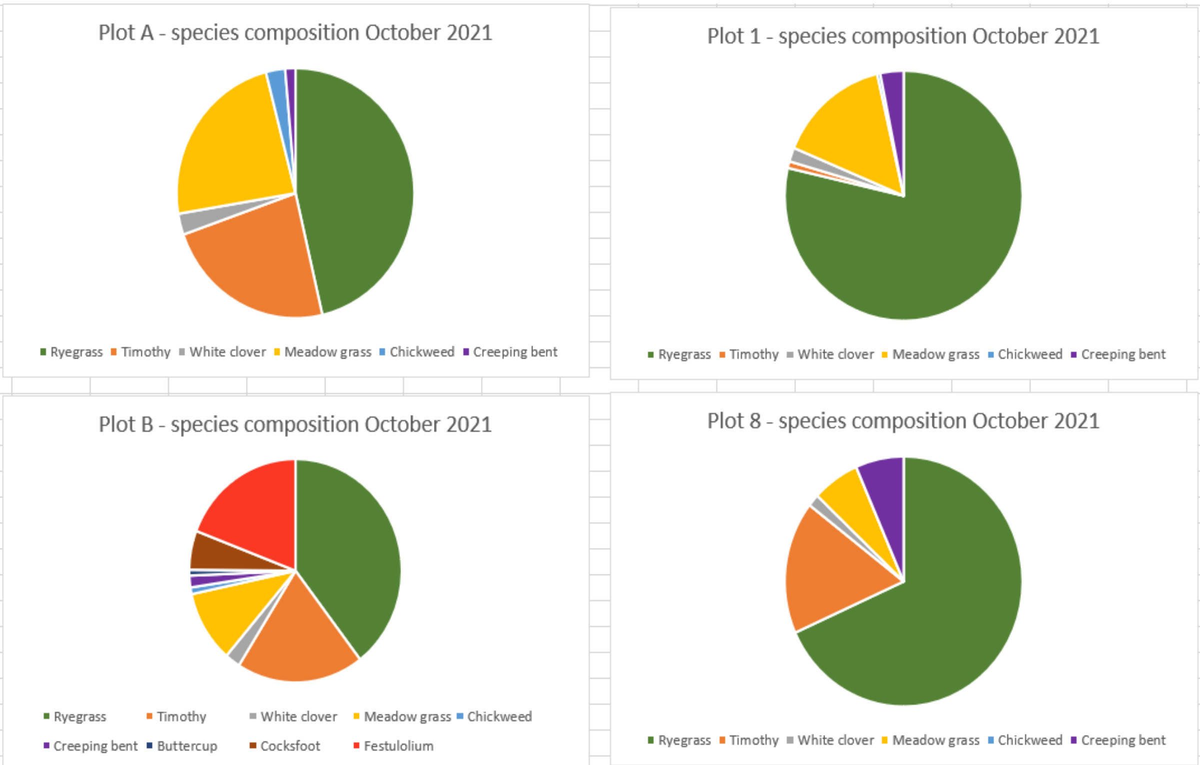

Figure 3. Species composition towards the end of phase 2.

The grazing wedge in October was maintained *(figure 4*) – although entry covers were too large for efficient sheep grazing - especially at this late stage in the season. Plots were very wet and carrying no stock in mid-December 2021, although it was hoped that the plots would be grazed if conditions improved in the New Year.

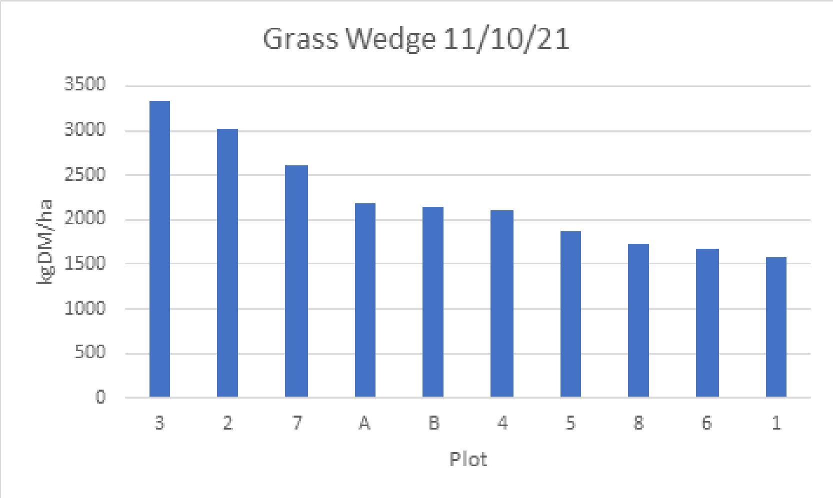

Figure 4. Grass wedge yield in each plot as assessed in October 2021.

Plate 8. Whilst grazing conditions were good in early October the ground conditions deteriorated quickly through the latter half of the month – leaving high covers on some plots

Sward quality

There was no evidence at this point of any improvement in nutritional quality through the inclusion of Timothy, either in energy or protein (*figure 5*). Both plots A and B were lower in ME and CP than the Ryegrass dominant plots. The mineral status of the Timothy plots was very similar to control plot 1 and there was no recorded difference in trace element status (*figure 6*). Plot A was low in Calcium, Selenium, Iron and Sodium, resulting in a lower Cation/Anion balance. Both plots A and B were lower in Magnesium, Sodium, Sulphur, and Iron in comparison to the Ryegrass dominant plots, though they did measure higher in Phosphorus, Potassium and Chloride.

	DM (%)	CP (%)	ME (MJ/kg DM)	WSC (%)
PLOT 1	17.4	11.3	9.3	9.8
PLOT 8	17.5	15.7	9.5	8.7
PLOT A	20.1	11.7	8.9	7.2
PLOT B	19.9	9	9.4	11.3

A

	DM (%)	CP (%)	ME (MJ/kg DM)	WSC (%)
PLOT 1	17.4	11.3	9.3	9.8
PLOT 8	17.5	15.7	9.5	8.7
PLOT A	20.1	11.7	8.9	7.2
PLOT B	19.9	9	9.4	11.3

B

Figure 5. Sward quality. **A** level of nutrition as analysed in June 2021, **B** level of nutrition as analysed in August 2021. Although the nutrition of all plots increased over the course of the summer, there was little variation between plots, indicating that the inclusion of Timothy had little benefit in terms of sward quality during phase 2 of the project.

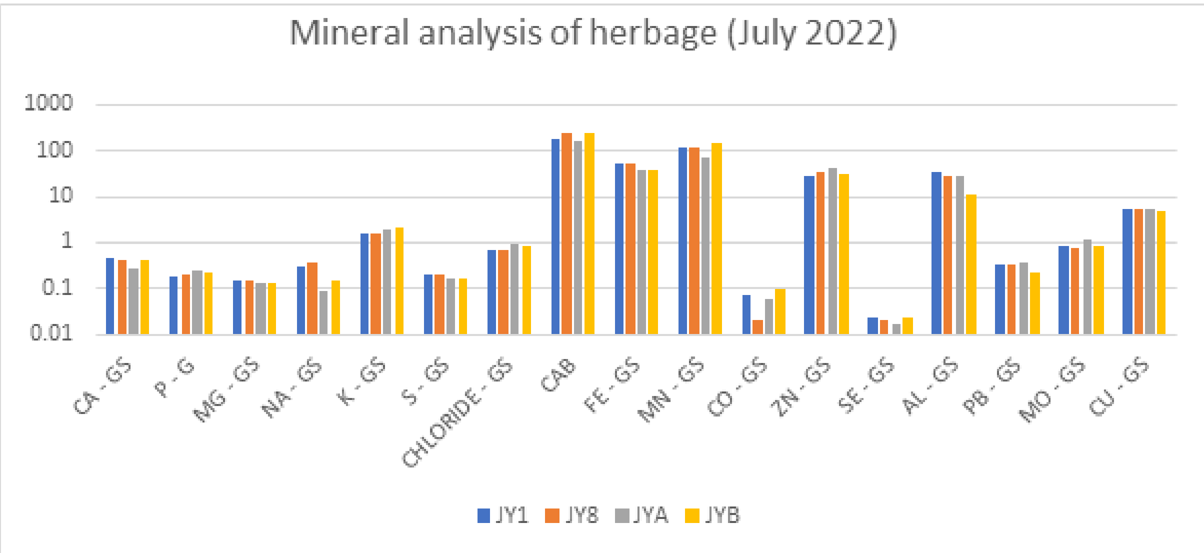

Figure 6. Mineral analysis of the forage in July 2021 demonstrates little difference in mineral analysis between the two Timothy plots (A and B), the Ryegrass dominant plot (8) and the control (plot 1). This was measured in mg/kg DM.

Soil carbon assessment

Soil samples were collected in August 2021 to assess bulk density and soil organic matter status of the plots – and included adjoining areas with different management history and vegetation structure.

Plot 1 - Improved in the 1980s. Last surface cultivation in 2019. Soil profile suggests ploughing at some stage – no dark organic matter layer – good mixing down to about 20cm.

Plot A - Improved in the 1980s – but little activity until surface cultivation in 2020. Organic matter layer evident at around 10cm.

Plot 9 – Improved in the 1980s but with minimal inputs since. Ingression of rushes into a *Agrostis* dominant sward. Large root mat (0-5cm), dark OM layer (5-15cm).

Unimproved hill. Heather and bilberry plus mat grass (*Nardus Stricta*) and *fescues* plus mosses. Upper vegetation layer of 10cm, organic matter layer down to 20cm – straight to subsoil.

Samples were assessed for organic matter by loss on ignition and carbon content estimated by conversion factor of 0.58. Results were presented for three different assessment methods – soil carbon (g/100g of soil), soil carbon mass per ha (0-30cm) and soil carbon with equivalent soil mass.

Looking at the distribution of soil carbon through the profile there are major differences between the four management regimes. The recently improved plots have a more even distribution of carbon through the profile – whilst the unimproved and old improved areas have far more carbon in the surface layers (*figure 7*). It may be that the higher pH and nitrogen regime of the improved plots encourages deeper rooting and more biological activity – so helping to store more carbon at depth.

	0-10cm	10-20cm	20-30cm
Plot 1	29%	35%	36%
Plot 8	37%	42%	21%
Unimproved hill	48%	29%	23%
Old improved pasture	59%	17%	24%

Figure 7. Distribution of total soil carbon in the soil profile

This suggests that improvement of upland pasture (on this soil type) with surface cultivations is not hugely detrimental to soil carbon stocks. There is an indication that a low input system that allows sward reversion to weed grasses and rush intrusion may penalise carbon sequestration due to a low pH and poor biological activity. Results were presented for three different assessment methods – soil carbon (g/100g of soil), soil carbon mass per ha (0-30cm) and soil carbon with equivalent soil mass (*figure 8*).

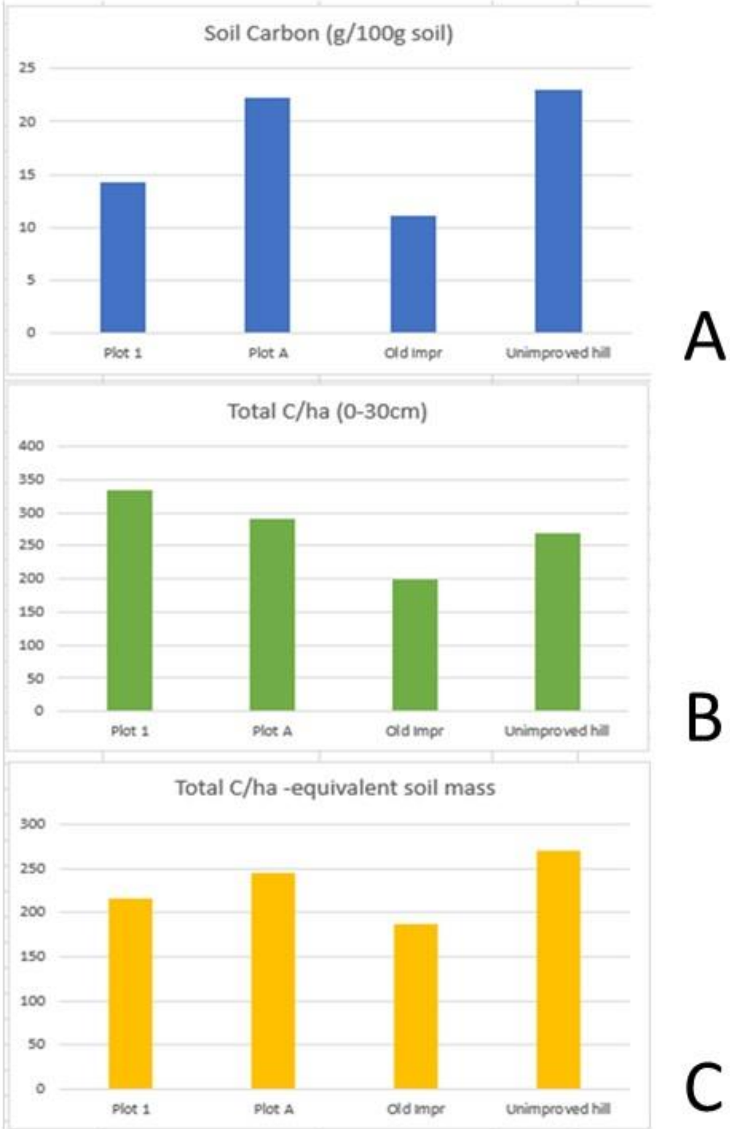

Figure 8. Soil carbon results – **A** soil carbon in g/100g of soil, **B** soil carbon mass per hectare (0-30cm), **C** soil carbon with equivalent soil mass. Looking at the distribution of soil carbon through the profile there are major differences between the four management regimes. The recently improved plots had a more even distribution of carbon through the profile – whilst the unimproved and old improved areas had far more carbon in the surface layers. It may be that the higher pH and nitrogen regime of the improved plots encourages deeper rooting and more biological activity – so helping to store more carbon to depth.

Summary of main findings for phase 2

Productivity

The plots established in 2019 continued to perform well – with both plots averaging above 12tDM/ha. The control - plot 1 - matched its 2020 performance and plot 8 increased slightly. Plots A and B matched the control, though plot B yielded far less dry matter. It should be noted that plots A and B were still extremely variable on a whole plot scale, and the measured cage areas represent the 'better' parts of the plots.

Ground conditions and the exposure of the site do limit the grazing window and can often compromise 'ideal' grazing practice – so utilisation can be affected, particularly in early and late season.

There was no evidence of any benefit to early season growth with the inclusion of Timothy or other alternative grasses – but the high Timothy content sward (A) did show increased growth in autumn.

Sward composition

The percentage of Timothy in plot 8 increased from around 10% in 2020 to 17%. Similar small increases in Timothy were observed in some of the other original plots (2, 3 and 7) – although there was still not sufficient Timothy present to have any significant impact on sward performance.

Ryegrass was still very dominant in the original plots – but meadow grass and creeping bent were starting to come in, especially in the wetter areas.

The plots established in 2020 had a markedly different sward composition from the original plots. Plot A has 25% Timothy, but the Ryegrass did appear to be increasing in dominance. In plot B there was still a good mixture of different grasses – and levels of chickweed and meadow grass had reduced.

The plots A and B were extremely variable and there were some wetter parts of the plots where chickweed and spear thistle were very pronounced. It is impossible to determine if these weed levels were being accentuated by the sward composition; as a genuine treatment effect – or if it was simply localised soil conditions.

Sward quality

There was no evidence of any improvement in nutritional quality through the inclusion of Timothy – either in energy or protein. The mineral status of the Timothy plots was very similar to the control (Plot 1) and there was no recorded difference in trace element status.

Soil carbon assessment

The soil carbon assessments do suggest that improvement of upland pasture (on this soil type) with surface cultivations is not hugely detrimental to soil carbon stocks. There is an indication that a low input system that allows sward reversion to weed grasses and rush intrusion may penalise carbon sequestration due to a low pH and poor biological activity.

Phase 3 methodology

Phase 3 of the project was the final phase. As the bulk of the establishment and adjustments were done in phases 1 and 2, phase 3 was mostly focussed on site management, monitoring and evaluating, with final measurements and analysis done at this point. A project open day was held in June 2022 to facilitate a knowledge exchange to the wider community.

Site management

The grass was cut back to baseline in December 2021. A small group of ewe hoggs grazed the site on and off over the winter.

Plate 9. Plot conditions 25/3/2022

The main flock returned to graze the plots in May 2022 and were joined by a small herd of young cattle. Grass covers had risen well above the average target, so fertiliser was not applied until late May after some grazing. The plots received 40kgN/ha in the form of Ammonium Nitrate. Only plot 8 was cut for silage, as grass supply was far more than animal demand.

Plate 10. Plot conditions 26/5/2022 following return of main flock (A) and small herd of young cattle (B)

Monitoring and assessments

Grass recording was done earlier in phase 3, taking place in March, April and May, with the final forage assessments taking place in May as the project was coming to an end in June 2022. Herbage nutritional quality was assessed with a clean cut (no stem formation and no dead material), and swards were assessed for species composition by hand separation in May 2022.

The soil carbon assessments which were carried out in phase 2, were repeated in May 2022 of phase 3. Cores were taken to assess bulk density and soil carbon (loss on ignition).

Phase 3 results

Productivity

The final yield assessments were carried out on all plots in June 2022. Plot 8 and plot A were the highest producing plots, both measuring over 5tDM/ha, with plot 1 being the least productive (*figure 9*). The differences in productivity were minor, and all plots outperformed the recordings of phase 2. Plots A and B recorded the most significant differences in productivity, with plot B having the largest increase in yield by 2tDM/ha (*figure 10*).

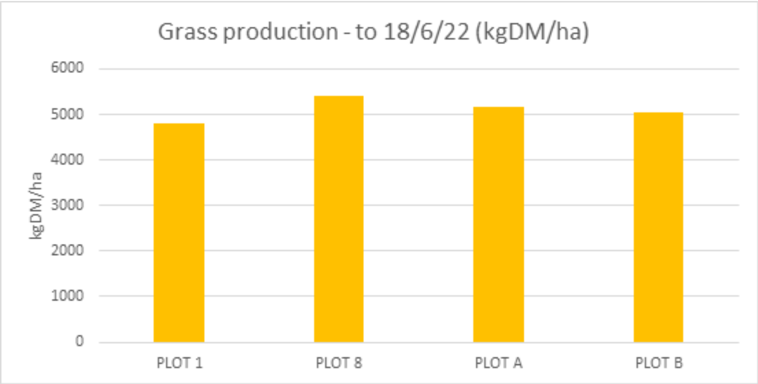

Figure 9. Plots 8 and A were the highest yielding plots, both measuring in excess of 5tDM/ha, followed by plot B at almost exactly 5tDM/ha. Plot 1 was the least productive, producing just under 5tDM/ha.

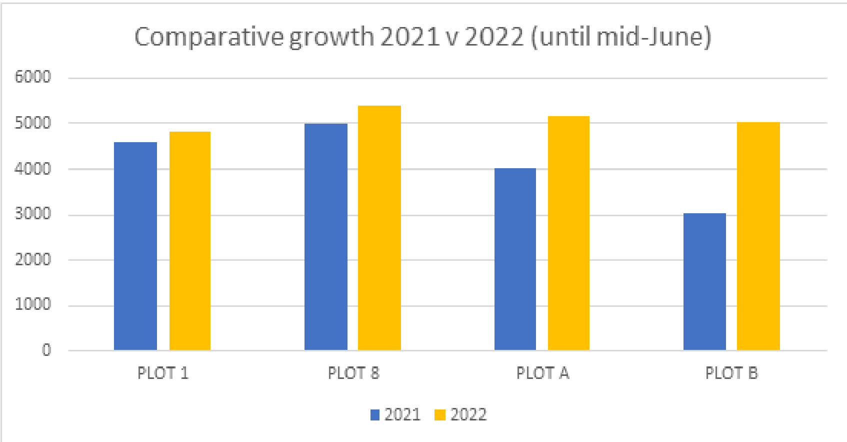

Figure 10. Difference in forage productivity between phase 2 (2021) and phase 3 (2022). All plots exceeded the productivity levels of phase 2, with the biggest increase in productivity being in plot B.

Sward composition

Sward composition was measured by hand separation in May 2022 (*figure 11*). Both plots A and B saw a rise in meadow grasses with plot A suffering a slight decline in Timothy levels. The Timothy levels of plot B remained stable, and the Ryegrass levels declined, though the presence of Chickweed increased marginally.

The timing of this analysis allowed for better differentiation between Ryegrass / Festulolium and Meadow Fescue plants in the mixed sward, which had proved difficult in phase 2. These three species continued to make up approximately 50% of the sward, though the Timothy component was stable at around 25%. Ryegrass continued to be the dominant species in plots 1 and 8. Timothy remained present in plot 8, though had decreased slightly to around 10%. The small amount of White Clover present in plot 8 during phase 2 had completely disappeared from the sward, a small amount remained present in plot 1. The weed burden of both plots 1 and 8 had decreased significantly, though it is important to highlight that seasonality affects sward species balance, and this is an autumn-spring comparison. Timothy levels of all plots may increase again later in the season, and meadow grass prominence may reduce.

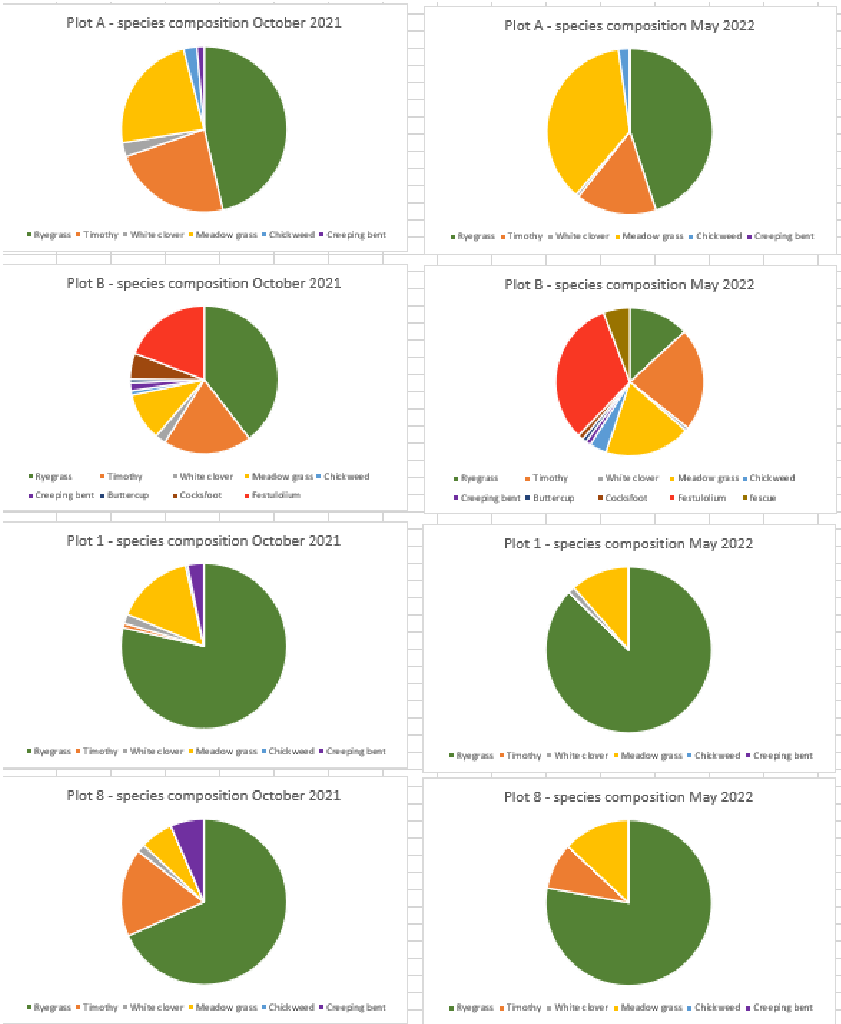

Figure 11. Difference in sward composition between phase 2 (2021) and phase 3(2022). It is important to note that this is an autumn-spring comparison, and levels may change as the phase 3 season progresses.

Sward quality

The levels of productivity provided the opportunity for herbage samples to be taken for chemical analysis in April 2022. There were few differences in the major nutrients (*figure 12*), though the Ryegrass dominant plots 1 and 8 had slightly higher levels of Ca and Mg. Further research would be required to determine if this is a result of forage species, rooting depth, or variation in soil chemistry.

	Ca	P	Mg	Na	K	S	Cl	CAB
JY1	0.61	0.3	0.17	0.13	2.76	0.25	0.75	401
JY8	0.58	0.26	0.21	0.14	2.55	0.23	0.71	370
JYA	0.61	0.33	0.01	0.22	2.42	0.27	0.62	372
JYB	0.43	0.28	0.07	0.14	2.54	0.26	0.62	374

Figure 12. Results of major chemical forage analysis. Plots 1 and 8 showed slightly increased levels of calcium and magnesium.

Trace elements were also analysed and showed more variation between plots (*figure 13*). However, it is again difficult to ascertain if this is the result of soil variability, as it is well recognised that rising pH levels lower the availability of both manganese and cobalt.

	Fe	Mn	Co	Zn	Se	Al	Pb	Mo	Cu
JY1	105.5	62.9	0.06	18.2	0.019	66.4	0.43	1.78	4.1
JY8	91.5	66.6	0.03	19.3	0.027	54.8	0.31	1.33	4
JYA	111.2	103.5	0.08	24.7	0.022	99.9	0.39	1.75	5.8
JYB	83.3	118.7	0.12	23	0.017	43.1	0.5	1.1	6.3

Figure 13. Results of trace element forage analysis.

During this phase, it was possible to extract a clean sample for herbage nutritional quality, with no stem formation and no dead material. This is the truest assessment of the sward quality to the grazing animal. In April 2022, all plots were of a high quality, with over 12ME and in excess of 18% CP - levels which are comparable with concentrates that many sheep producers would be feeding through March/April. These levels reduced through May 2022 as would be expected (*figure 14*). The phase 2 herbage nutritional quality assessments were carried out in June 2021 and August 2021, thus a direct comparison of the data is not possible, though it can be hypothesised that there was no change in recorded ME levels between phases 2 and 3.

ME and sugar levels were lower in plots A and B, whilst plot A showed significantly higher NDF levels in comparison to the other plots.

	28 April 2022				
	DM%	ME	CP	WSC	NDF
Plot 1	21.8	12.1	19.7	11.2	42.1
Plot 8	22.9	12.1	18.8	10.4	43.7
Plot A	19.4	12	21.6	9.9	45.5
Plot B	21.7	12.1	18.8	11.5	39.5

	25 May 2022				
	DM%	ME	CP	WSC	NDF
Plot 1	17.9	11.6	12.5	11.6	46.8
Plot 8	17.5	11.7	16.9	10.2	47.7
Plot A	16.1	11	16.3	8.2	53.2
Plot B	16.7	11.3	14.2	9.6	48.2

Figure 14. Herbage nutritional quality as assessed in the spring of phase 3. Two measurements were taken 1 month apart (April 2022 and May 2022) to assess seasonal variance.

Soil carbon assessment

The soil carbon assessments that were carried out in phase 2 were repeated in phase 3. As expected, the data flagged up the large variability that occurs when dealing with grassland soils. Whilst there were a few differences in the trends observed in phase 2, there was still a strong message that productive Ryegrass and Timothy swards are a better carbon sink than low input poor quality swards (*figure 15*).

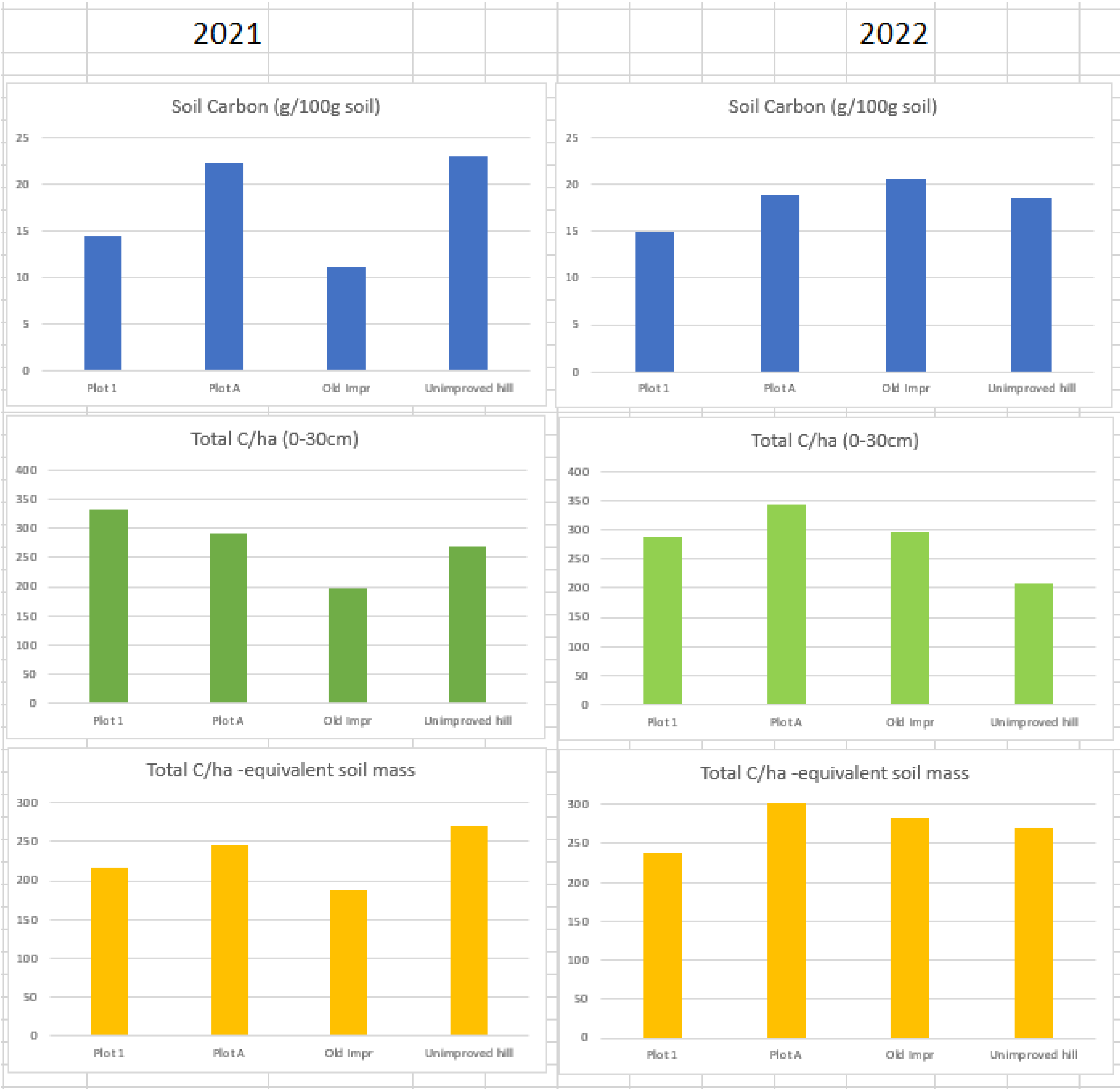

Figure 15. Phase 3 soil carbon analysis compared with phase 2 soil carbon analysis.

These figures show the variances that occur so frequently when dealing with grassland soils, though there remains a strong indication that productive Ryegrass and Timothy based swards are a better carbon sink than low input poor quality swards.

Summary of main findings for phase 3

Productivity

The differences in productivity between plots was minor. All plots outperformed the recordings of phase 2, with plots A and B recording the most significant differences in productivity. Plot B had the largest increase in yield by 2tDM/ha

Sward composition

Ryegrass, Festulolium and Meadow Fescue dominated the sward at approximately 50%, though the Timothy component was stable at around 25%. The weed burden of both plots 1 and 8 had decreased significantly, though it is important to highlight seasonality affects sward species balance. Timothy levels in all plots may vary according to season, with meadow grass prominence reducing, and Timothy levels increasing later in the season.

Sward quality

A clean sample for herbage nutritional quality, with no stem formation and no dead material, was taken. All plots were of a high quality, with over 12ME and in excess of 18% CP - levels which are comparable with concentrates that many sheep producers would be feeding through March/April.

There were few differences in major nutrients between plots, though there was slightly more variation in trace element levels. However, further research would be required to determine if these differences are due to forage species, rooting depth, or variation in soil chemistry. It is possible that soil variability can impact nutrients availability – for example, rising pH levels lower the availability of both manganese and cobalt.

Soil carbon assessment

The data flagged up the large variability that occurs when dealing with grassland soils. Whilst there were a few differences in the trends when comparing the results from phase 2 and phase 3, there was still a strong message that productive Ryegrass and Timothy swards are a better carbon sink than low input poor quality swards.

Project outcomes and key messages for the wider industry

Following lengthy discussions with the Finnish grassland experts from Proagria and other members of the operational group and specialists we have drawn together the key project outcomes and messages – along with a range of possible questions that may warrant future project work.

The project was able to successfully establish swards with a strong Timothy component – but was not able to generate Timothy dominant swards.

In the original plots the % inclusion of Timothy in the mixture was not matched by plant numbers in the sward. There was a strong feeling that very wet conditions post sowing may have impacted on establishment of the Timothy. There was no obvious treatment effect (drilled vs rake and broadcast). There was no evidence of a delayed development of the Timothy plants in the year after establishment.

In the later sown plots (A and B) limiting the Ryegrass component to just 2kg/acre did allow for other grasses to occupy a greater proportion of the sward in the early stages of sward development – although even in this situation Timothy didn't develop above 25% of the sward composition.

*See*d mixture composition didn't seem to play a huge role in this outcome – even with huge numbers of Timothy seed going into mixtures, swards were still likely to be dominated by more aggressive grasses (Ryegrass, Festulolium).

Sowing depth may be an issue with the small Timothy seed. Anu and Jarkko from Proagria were wary about the use of direct drills to sow the very small Timothy seed. There were discussions that the long day length in Finland at sowing time may help in the rapid and aggressive establishment of Timothy in their leys.

Lower soil chemistry status (P, K and pH) may enable the Timothy to form a greater component of the sward.

Regular nitrogen inputs and rotational grazing may be helping to promote the Ryegrass component to the detriment of Timothy. Anu and Jarkko suggested that grazing height and frequency may also play a role in restricting Timothy.

With a lack of any real cold spell in 2019/2020 or 2021 there was no genuine test of the winter hardiness of Timothy compared to Ryegrass.

The project site and weather conditions in 2019 and 2020 didn't allow for early season reseeding – which Anu and Jarkko suggested may be important in establishing large healthy Timothy plants going into their first winter.

The project found no major penalty to yield from high inclusion rates of Timothy.

Over the three years of the project the Timothy and mixed grass plots produced very similar dry matter yields to the Ryegrass control. The only exception was with plot B in 2021 where poor early season growth reduced total yields to 8tDM/ha – this was in part due to high levels of chickweed and poor ground/drainage conditions. Despite claims that Timothy has strong early/late season growth, the project didn't record any significant difference in seasonal growth profile.

With only small amounts of Timothy in the sward, no major impacts on yield would be expected. The bigger driver has probably been localised soil conditions on each of the plots.

More broadly, the project has highlighted the benefits of reseeding to increase productivity and extend the grazing season. The project demonstrated increased productivity above the older swards by over 300%.

With any reseeding trial there is a strong argument that the real economic impacts can't be resolved until the different leys have been in place for 8-10 years. Short-term gains in yield and quality can easily be negated by the need for more regular reseeding.

The project found a slight penalty to forage quality from including Timothy and other grasses in mixtures.

NIAB data has indicated Timothy has lower energy levels compared to perennial Ryegrass. This outcome was observed in the project in both 2021 and 2022 – with the only exception being in very early season grass quality where all plots produced forage of around 12ME.

The project found no consistent effects of Timothy inclusion on protein levels or on any mineral component.

Again, there is a strong argument that a higher component of Timothy will be needed to produce consistent effects on forage quality – and on animal performance.

At a field scale there may be an issue with the propensity for the Timothy/mixed grass swards to be slightly more open and allow more weed ingression. The sampling strategy was stratified – in that the better areas of the plots were monitored rather than the very poor areas – this may have masked some of the negative aspects of lower Ryegrass inclusion and less aggressive tillering.

The project found that increasing the productivity of the hill land through reseeding and higher stocking rates increased the carbon storage levels in the soil.

With some very limited data and sampling points there are indications from the project that sward improvement may benefit carbon storage. Certainly, there are no signs that liming operations and increased nitrogen inputs have led to a decline in soil carbon.

There are a few reservations with the soil carbon findings in the project due to the massive variability of the soils (texture/depth/bulk density/OM%). But the results do raise some interesting discussion points about how the high organic matter content soils of large parts of upland Wales can be managed to conserve or improve carbon stocks.

The project has challenged some traditional ideas about suitable seed mixtures for upland situations but there are several issues that warrant further investigation:-

1) *Do more diverse grass mixtures provide any greater persistency than Ryegrass in marginal areas?* This project was relatively short-term. The true economic value of different seed mixtures can only be assessed after a far longer time frame – how they perform 10 years after establishment would be an interesting evaluation.
2) *Do more diverse grass leys require different grazing/cutting regimes than Ryegrass to be most effective?* The project maintained sward conditions with protocols that were purposely developed for Ryegrass swards (entry covers below 2500kgDM, residual covers of 1400kgDM, 18-25 day rotation length). These may need to be modified to maximise the performance of more diverse grass species leys.
3) *Should nitrogen and phosphate use be modified with more diverse leys to maintain the species balance?* The nutrient regime of the trial was very much based around the guidance of RB209 for managing Ryegrass swards; maintaining soil P and K status at Index 2 and modest inputs of nitrogen. The comparative performance of Ryegrass and more diverse grass species leys may be very different under a different regime of nutrient inputs.