Report to the Stapledon Memorial Trust

Responses of foliage arthropod fauna to different management strategies

Rocío Rosa García

SERIDA (Servicio Regional de Investigación y Desarrollo Agroalimentario)

Apdo. 13, Ctra. de Oviedo s/n

Villaviciosa 33300

Asturias (Spain)

E-mail: rocior@serida.org

Contact person in UK: Dr Mariecia D. Fraser

IBERS

Aberystwyth, SY23 3EB, UK

Dates of fellowship: from 08/07/2013 until 31/08/2013

1. INTRODUCTION

Concerns over dramatic declines in the extent of British grassland habitats have led to a greater impetus to both protect existing species-rich sites and to extend their distribution through habitat restoration. However, to fully capitalize on the opportunity for restoration on these habitats of high 'conservation value', there is a need for a greater understanding of the management practices and the levels of intervention towards the ultimate goal of restoring a fully functioning ecosystem.

Invertebrates, particularly arthropods, are an important component of the biota of these habitats and their diversity and abundance are known to be influenced by plant species diversity and/or sward structure, both of which can change depending on the management strategy. However few accounts exist on the effects on invertebrate populations of extensive management of these habitats.

This paper summarizes the results obtained from field experiments designed to test the effectiveness of different management strategies to enhance and/or restore the botanical diversity in mid-Wales. The current project tested the effects of the different treatments on the flora and foliage arthropod fauna in order to determine which vegetation parameters are more relevant for the assemblages of arthropods.

2. MATERIALS AND METHODS

2.1. Study areas

Upland-fringe site: Brignant plots

The site is situated within the Cambrian Mountain ESA at an altitude of 310m on free-draining typical brown podzolic soils which receive a mean annual rainfall of 1770 mm/year. The experimental plots were set up in 1995 on a previously improved pasture dominated by grass species and with limited frequency of desirable forb species to test the effectiveness of different extensification managements to enhance botanical diversity. A total of seven separate grassland management regimes were imposed on individual plots of 0.15ha (see Table 1). Treatments were replicated three times in a randomised block design. Treatment P1 was the control and involved continuation of normal intensive management (i.e. limed, fertilised with NPK fertiliser and continually grazed by sheep). Treatments P2-P7 represented six different options for extensification. No NPK fertiliser was applied to the extensification managements, which comprised of a factorial design of three cutting/grazing regimes with or without application of lime. The “+ lime” treatments received an application of lime in 1998 to maintain a soil pH of 6.0. Management treatments have been continued since 1995.

Table 1. Summary of management treatments at the Brignant site.

Treatment:	Fertiliser (F)	Lime (L)
P1 (Fertilizer +Grazing +Lime): CO	+	+
P2(Hay cut and aftermath grazing + Lime): HG+L	-	+
P3. (Grazing - lime): G-L	-	-
P4. (Grazing + Lime): G+L	-	+
P5a. (Hay cut - Lime): H-L	-	-
P5b. (Hay cut + Lime): H+L	-	+
P6. (Hay cut and aftermath grazing -Lime): HG-L	-	-

Acid grassland site: heather restoration plots

The site is located on 71 ha of *Nardus stricta* grassland at an elevation of 305-625 m above sea level in the Cambrian Mountains in Mid Wales. Annual rainfall averages 2000 mm and soils consist of Stagnopodzols. The site was formerly dwarf shrub heath, degraded by past heavy grazing. The area was divided into three blocks which were subdivided into four plots (12 plots in total, see Figure 1). Four treatments were allocated randomly to plots, replicated over the three blocks. The treatments are: low sheep (1.0 ewes per ha for 10 months per year + lamb from May to August); high sheep (1.5 ewes per ha for 10 months per year + lamb from May to August) cattle (0.5 heifers per ha for 2 months in summer only) and mixed grazing (low sheep + cattle).

Figure 1. Map of the heather restoration plots

2.2. Data collection

Arthropod sampling

Invertebrates were sampled from all plots by sweep netting on three separate occasions during July and August 2013. Sweep samples can be obtained more quickly and with less material cost than other techniques such as for pitfall traps, barrier traps, pantraps or night traps (Evans & Bailey, 1993; Evans et al., 1983). At each site, random transects were established and each transect consisted of 50 sweeps taken on 50 consecutive strides using a 40-cm diameter sweep net with a white canvas net bag. All the arthropods captured were stored in vials with ethanol 70% as a preservative.

The sampling technique was adjusted for each experiment according to the plot size and its characteristics (topography, variety of ecosystems, etc.):

Brignant plots**:** Three random transects were established in the Control, Grazing only and hay-cut and aftermath grazing plots while two random transects were allocated in the hay-cut plots to adjust the sampling effort.

Heather restoration plots: Due to the heterogeneity and the bigger size of the plots, they were divided into three different areas: the humid top areas, the medium steep ones and the bottom and again humid areas. Three transects were performed within each area, giving a total of nine transects per plot.

Vegetation sampling

The vegetation of all experimental plots within the Brignant experiment was surveyed at the time of each arthropod sampling event. A total of 40 random measurements of the sward height were performed with a sward stick in each plot. Percentage cover of the main vegetation components (forbs, grasses, moss or bare ground) was estimated in 10 quadrats (50 x 50 cm) randomly allocated in each plot. Simultaneously, the number of flowers present in each quadrat was also recorded.

2.3. Statistical Analyses

Preliminary results are presented for the Brignant plots. To determine the effect of the treatments on fauna abundance and diversity of arthropods involving the Brignant experiment, we applied an analysis of variance for a complete block design for a total of 21 plots. The experiment consisted of four cutting/grazing treatments (T) with or without the application of lime (L).

The cutting/grazing treatments were: control, grazing only, hay-cut and hay-cut and aftermath grazing. The model for the GLM analysis included Block, T, L, and T*L as fixed factors.

Data were Log-transformed when necessary to meet the assumptions of normality and homocedasticity.

Non-metric multi-dimensional scaling (MDS) on an underlying Bray-Curtis dissimilarity matrix was conducted to visualize the spatial relationships between the variables (arthropod groups). The matrix contains similarity coefficients (S) between each pair of samples defined to take the values in the range of 0 to 100%. MDS is a data-reduction technique used to uncover a 'hidden structure' to a set of data. It does not require data that are multinormally distributed and it refers to graphical models that provide a spatial representation of the similarity structure of variables. By using correlations, the relationships (that is, proximities) among variables can be displayed graphically in a 'map.' The relative distance between samples is interpreted as a measure of their similarity. Points that are close together represent samples that are very similar in species/groups composition, and points that are far apart correspond to very different communities. There is also a certain level of stress which is a measure of accuracy in representation of the MDS. By definition, stress level increases with reduced dimensionality and also with increasing quantity of data. The acceptance level of stress for a 2-D MDS graph is set to < 0.2, indicating that the MDS is a good to excellent representation with minimal risk of misinterpretation (Clarke and Gorley, 2001). Finally, Pearson correlations were performed to test the relationships between vegetation variables as well as between fauna and flora data.

3. Results

A total of 12723 arthropods were collected and assigned to ten orders and twenty nine families (Appendix 1). The most abundant orders were Diptera, Hymenoptera and Hemiptera (36%, 26% and 22% of all the captures respectively).

Impact of the cutting/grazing regimes on fauna abundance

When testing the responses of the fauna to the cutting/grazing regimes, the total abundance of arthropods differed marginally between treatments (P=0.072) and the highest captures were obtained in those treatments which involved hay-cut and hay-cut and aftermath grazing (Table 2). When performing the analyses for the different arthropod groups separately, contrasting responses were observed.

The abundances of spiders (Araneae) differed between treatments (P=0.005) and were higher under grazing only than under either hay cut (P=0.008) or hay-cut and aftermath grazing (P=0.093). When analyzing the responses of the abundant money spiders (Linyphiidae), the conventional grazing (control) and the grazing only treatments favoured them compared to the others (P=0.008) with the lowest records occurring in the sites under a hay-cut regimen compared to the control (P=0.007), the grazing only (P=0.035) and the hay-cut and aftermath grazing (P=0.078).

The conventional treatment (control) promoted higher records of several groups such as springtails (Symphypleona) and bugs (Heteroptera). In the case of springtails, their abundance differed between treatments (P<0.001) and was highest in the control than in the rest (P<0.001). The majority of specimens were identified as *Sminthurus viridis* (Linnaeus, 1758), commonly named "clover springtail" or "lucerne flea".

In the case of bugs, their responses to the treatments were rather heterogeneous. Globally, their records were higher in the control than in the grazing only plots (P=0.026) and the hay-cut and aftermath grazing (P<0.001) areas, and more bugs were also collected in the hay-cut sites than in the hay-cut and aftermath grazed ones (P<0.001). Group-dependent responses were also observed within this order. So, while aphids (Aphioidea) differed between treatments (P=0.002) and were lower in the grazing only than in the hay-cut (P<0.001) and the hay-cut and aftermath grazing (P=0.058), delphacids (Delphacidae) also differed between treatments (P=0.039) but abounded more in the sites only grazed compared to the hay-cut and aftermath grazed ones (P=0.027).

The records of the large and diverse family Miridae differed also between treatments (P<0.001) and reached the highest captures in the control, while the smallest ones occurred in the sites under hay-cut and aftermath grazing. This last treatment provided lower records than the control (P<0.001), grazing only (P=0.041) and hay-cut (P=0.024).

Within this family, a deeper analysis of the adults and nymphs revealed that their abundances peaked or were lowest in different sites (Fig. 2). So, while the highest catches of adults took place in the grazed only sites, the nymphs abounded in the control.

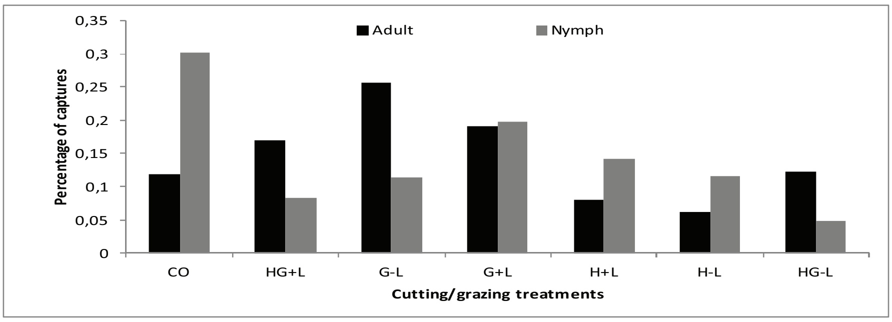

Fig. 2. Percentage of catches of adults and nymphs of Miridae in each site. For abbreviations see Table 1.

Other arthropod groups flourished in areas submitted to hay cut only or hay cut and aftermath grazing. That is the case of beetles (Coleoptera), whose abundances differed between treatments and were highest in the hay-cut and aftermath compared to the rest ($P<0.001$ for each post-hoc analysis). The most abundant family of beetles during the first sampling period were soldier beetles (Cantharidae) and the majority of the specimens were identified as common red soldier beetle or *Rhagonycha fulva* (Scopoli, 1763). This family differed between treatments and clearly dominated in the hay-cut sites compared to any of the other treatments ($P<0.001$).

Regarding the captures of flies (Diptera), they also responded to the treatments ($P<0.001$) and peaked under the hay-cut and hay-cut and aftermath grazing treatments compared to the other ones ($P<0.001$ for the comparison of hay-cut and aftermath with the control and grazing, and $P=0.064$ and $P=0.017$ for the comparison of hay-cut with the control and grazing respectively). Within the flies, a separate analysis was performed for the hoverflies (Syphidae). The abundance of this family differed between treatments ($P<0.001$) and flourished in the sites under hay-cut only and hay-cut and aftermath grazing compared to grazing only ($P=0.042$ and $P=0.001$ respectively). The catches in hay-cut and aftermath grazing also tended to be higher than in the control ($P=0.057$).

The abundance of Hymenoptera differed between treatments ($P=0.042$) and tended to be higher under hay cut than under hay-cut and aftermath grazing ($P=0.052$) or the control ($P=0.090$). This order showed a significant interaction between the cutting/grazing and lime managements ($P=0.020$).

Finally, the occurrence of Lepidoptera was indifferent to the treatments.

Impact of the cutting/grazing regimes on fauna diversity

1. Species Richness Indices.

a) Richness. Species/family richness (usually notated S) of a dataset is the number of different species in the corresponding species list. It pays no attention to frequencies, and so it is not as good at detecting differences as a frequency-based measure would be. In the current study, the family richness did not differ between treatments (Table 2)

b) Simpson's Index. This index differed between treatments ($P=0.021$ for the cutting/grazing and $P=0.007$ for the lime treatment). The absence of lime favoured this index and its highest values occurred in the hay-cut and aftermath grazing areas which were significantly higher than those recorded in the control (P=0.004) and the grazing only (P=0.035) treatments.

2. Species Diversity Indices.

a) Shannon-Wiener Index. The values of this index differed between cutting/grazing treatments (P=0.018) and lime treatments (P=0.002) but not between blocks. So, the highest values occurred under the hay-cut and aftermath grazing treatment, and these were higher than under the control (P=0.001) and the grazing only (P=0.068) treatment but did not differ significantly from the hay-cut only one. This last treatment also marginally higher than the control (P=0.065). No block differences were observed.

b) Fisher´s alpha index. The values of the index differed only marginally between treatments (P=0.90) but were clearly higher in those sites with no lime addition.

3. Species Evenness Indices. Pielou's evenness index. In the study areas, its values differed between cutting/grazing treatments (P=0.002) and lime treatments (P=0.007). The records in the hay-cut and aftermath grazed sites were higher than those observed in the control (P<0.001), the grazing only sites (P=0.007) and the hay-cut only ones (P=0.056). Regarding the effect of lime addition, the values were higher in those sites where lime was not added.

Differences between blocks

The records of the main orders of arthropods differed between the replicate blocks in several cases. Globally, while Symphypleona and Diptera occured abounded more in Block 2, the Coleoptera and Hemiptera reached the highest captures in Block 1 and Araneae in Block 3.

Regarding the diversity indexes, the Richness differed between blocks (P=0.005), achieving higher values in the block 2 (P=0.004) than in block 3 but held similar values as in block 1.

The Simpson index also differed significantly between blocks (P=0.042) and the values were only marginally higher in block 3 than in block 1 (P=0.061). Finally, the Pielou's index varied between blocks (P=0.005), and its records were higher in block 3 than in block 1 (P=0.004).

Multidimensional scaling (MDS)

The MDS technique generated the map shown in Figure 3. The index determined an s-stress value of 0.1, indicating a good fit between the dimensions and mapped distances. As observed in Figure 3, the control sites are displayed towards the right side indicating that they hold a different arthropod community than the other treatments. The closest points to them correspond to treatments which also involve some grazing. The most distinct communities are allocated on the opposite side and correspond with hay-cut and aftermath grazing or hay-cut only ones.

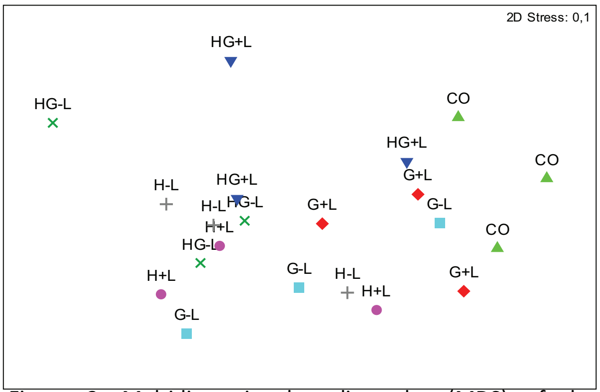

Figure 3. Multidimensional scaling plot (MDS) of the arthropod community composition in a block design with three blocks and six management treatments with three replicates. See Table 1 for abbreviations.

Vegetation parameters

Sward height was similar across cutting/grazing and lime treatments but differed between blocks: it was significantly higher in block 1 (mean of 50.32 cm) than in block 2 (39.44 cm) or block 3 (27.88 cm). The post-hoc analyses between the three blocks were $P<0.0001$ for block 1 versus block 3 and $P<0.001$ for the other two comparisons.

In the case of the main vegetation components (grasses and forbs), they showed opposite responses to the treatments (Table 3): While grasses dominated in the control and grazing only areas, the highest percentages of forbs were recorded in the other two treatments which involved hay-cut. Lime addition per se had no effect on those vegetation parameters but a significant interaction between the cutting/grazing and lime was observed: in both cases lime addition seemed to provide a difference within the hay-cut and aftermath treatments. So, mean percentage of grasses was 58.63 in those sites were lime was added and only 39.10 in the ones with no lime addition (Table 4). Inversely, a greater percentage of forbs occurred in sites with no lime (mean 59.8) than in the ones which received lime addition (41.00).

The differences in the numbers of flowers between sites can provide valuable information of their floral diversity. In the current study this parameter differed significantly between treatments and the highest records were observed (Table 3) in the hay-cut and aftermath grazing (mean of 7.33 flowers) and the only hay-cut areas (mean 6.28). All Post-hoc comparisons were statistically significant (between $P<0.05$ and $P<0.01$). Lime addition had no effect on the number of flowers.

Pearson correlations were performed to test the relationships between vegetation parameters, revealing significant positive and negative ($P<0.001$) correlations between the number of flowers and the percentage of forbs and grasses respectively.

Regarding the relationships between the vegetation and fauna, no correlations were observed between the total abundance of arthropods and vegetation parameters. On the contrary, when analyzing the most common groups of arthropods, interesting responses to the flora parameters were observed. Positive correlations occurred between the number of flowers and the abundances of flies and hoverflies in particular ($P<0.001$) while other groups like spingtails ($P<0.05$) or Hemiptera ($P<0.001$) flourished in areas with lower abundances of flowers. Within the bugs, while aphids correlated positively ($P<0.05$), mirids did it negatively ($P<0.001$).

The percentage of grasses correlated positively with the abundance of spiders, springtails and bugs ($P<0.05$) and negatively with the total abundance of flies, and the abundance of hoverflies and soldier beetles ($P<0.01$). Inversely, the presence of higher percentages of forbs was linked to higher records of flies and hoverflies and soldier beetles ($P<0.01$) and lower records of spiders, springtails and bugs ($P<0.05$). Within the bugs, both leafhoppers and mirids correlated negatively with the presence of forbs ($P=0.061$ and $P<0.05$ respectively). Finally, sward height also related with the arthropod fauna as it correlated negatively with the abundance of spiders ($P<0.01$) but positively with beetles ($P<0.05$).

4. Discussion

The current study indicated that the global abundance of the foliage arthropod fauna was highest in the treatments which involved hay-cut and hay-cut and aftermath grazing, but this study also revealed group-specific responses to the treatments as while some taxa were benefited by the conventional management, others abounded in areas submitted to other strategies. Attending to the diversity of groups which were considered in this project, the contrasting results are coherent as no management strategy alone can provide the wide variety of requirements (food, shelter, humidity, etc.) which might fulfill the needs of all the groups simultaneously. Furthermore, this study also reveals that the areas submitted to different treatments hold different community compositions, as observed in the MDS. Regarding the differences in vegetation between treatments, overall sward height was broadly similar across treatments, but both the number of flowers and the percentage of forbs were higher in areas with hay-cut and hay-cut and aftermath grazing whereas the proliferation of grasses was favoured in the control and the grazing only treatments. Previous surveys in the same study areas revealed that the most successful managements for increasing plant diversity were those incorporating summer cuts/harvests followed by aftermath grazing.

Within the current study, the vegetation parameters (which resulted from the treatments imposed) showed taxon-specific correlations with the arthropod fauna, again, very likely due to the variety of requirements that different arthropod groups might have.

Some of the groups studied in this survey are of special interest due to their implications in ecosystem services. That is the case of hoverflies (Diptera, Syrphidae), probably the most common and important group of pollinators of prairie wildflowers among the various families of flies. In response to their drastic decline (together with other managed and wild pollinators), the Welsh Government has recently developed a Draft Action Plan for pollinators for Wales (issued 9 April 2013). The Plan addresses the value of pollinators to UK agriculture (more than £430 million per year) and the need for some action to arrest their observed decline over the past 30 years. It suggests four target outcomes: diverse and connected flower-rich habitats, healthy pollinator populations, better informed citizens and a sound evidence base on these relevant groups. The usefulness of different management strategies for providing the proper environmental conditions for hoverflies and other groups involved in pollination (directly or incidentally) is considered in this study. So, positive correlations were observed between the number of flowers and the abundances of flies and hoverflies in particular and specific analyses of the flora revealed that the highest numbers of flowers occurred in those sites managed with hay-cut and aftermath grazing or with only hay-cut.

This study also provided relevant information concerning the differences in abundance of another interest arthropod, the lucerne flea, *Sminthurus viridis* (L.) (Collembola: Sminthuridae), between treatments. The lucerne flea can be a serious pest in legume pastures (Bishop et al., 1991). It has a preference for clovers, lucerne and other legumes but may feed on certain weeds and, when in large numbers, can even attack grasses. The effects of feeding range from the minor removal of leaf tissue to complete defoliation, resulting in reductions in both the quality and yield of pastures. In the current study, the highest records of this flea occurred in the control plots, possibly due to the higher presence of grasses in those sites. In fact, its abundance was lowest in the hay-cut plots which were also the ones with lowest presence of grasses. Appropriate grazing management can reduce lucerne flea populations to below damaging thresholds. This may be because shorter pasture lowers the relative humidity, which increases insect mortality and limits food resources (Bishop et al., 2001).

Therefore, although hay cutting with aftermath grazing is shown to be an effective management option for grassland restoration, this study provides evidence that further research is needed to explore the potential for other treatments to deliver biodiversity benefits, especially where cutting is not a practical option.

References

Bishop A.L., McKenzie H.J., Harris A.M., Barchia I.M. 2001. Control strategies for the lucerne flea, *Sminthurus viridis* (L.) (Collembola: Sminthuridae), and their effect on other species in irrigated lucerne in the Hunter dairying region of New South Wales. *Australian Journal of Entomology* 40, 79–84.

Bishop C.A., Krouse M.E., Wine J.J. 1991. Peptide potentiation of calcium channel activity can be seasonally variable. *Journal of experimental biology* 156, 607-610.

Clarke K.R., Gorley R.N. 2001. PRIMER v5: User Manual/Tutorial. PRIMERE:Plymouth Ltd. West Hoe, W.K. 91pp.

Clarke K.R., Warkick R.M. 2001. Change in marine communities: an approach to statistical analysis and interpretation, 2nd edition. PRIMER-E: Plymouth. 144pp.

Evans E.W., Bailey K.W. 1993. Sampling grasshoppers (Orthoptera: Acrididae) in Utah grasslands: pan trapping versus sweep sampling. *Journal of Kansas Entomological Society* 66, 214–222.

Evans E.W., Rogers R.A., Opferman D.J. 1983. Sampling grasshoppers (Orthoptera: Acrididae) on burned and unburned tallgrass prairie: night trapping vs. sweeping. *Environmental Entomology* 12, 1449-1454.

	Control	Grazing	Hay Cut	Hay Cut&Grazing	Treat	Lime	T*L	Block
Total abundance	225.67±21.22	191.28±15.00	242.25±18.38	241.22±15.00	+	ns	ns	ns
Orders								
Araneae (Log)	0.73±0.96	0.79±0.68	0.43±0.84	0.55±0.68	**	ns	ns	***
Coleoptera (Log)	0.40±0.97	0.57±0.69	1.16±0.84	0.72±0.69	***	ns	ns	*
Collembola (Log)	1.68±0.15	0.86±0.11	0.578±0.13	0.70±0.11	***	ns	ns	***
Diptera (Log)	1.53±0.96	1.53±0.68	1.87±0.83	2.03±0.68	***	ns	**	**
Hemiptera	76.89±7.80	48.28±5.51	61.5±6.75	31.11±5.51	***	ns	ns	**
Hymenoptera (Log)	1.43±0.12	1.69±0.86	1.84±0.11	1.47±0.86	*	ns	*	ns
Lepidoptera (Log)	0.15±0.84	0.41±0.59	0.311±0.72	0.36±0.59	ns	ns	ns	ns
Families								
Aphidoidea	8.4±2.33	5.05±1.65	15.5±2.02	11.3±1.64	**	ns	ns	ns
Cantharidae	2.11±1.73	3.22±1.23	14.58±1.50	5.11±1.23	***	ns	ns	+
Delphacidae	1.11±0.54	2.06±0.38	1.08±0.47	0.44±0.38	*	ns	ns	*
Linyphiidae (Log)	0.65±0.10	0.52±0.71	0.19±0.87	0.48±0.71	**	ns	ns	***
Miridae	66.78±7.46	39.33±5.27	43.42±6.46	18.22±5.27	***	+	ns	***
Syrphidae	1.00±0.52	0.61±0.37	2.25±0.45	2.72±0.37	***	ns	ns	ns
Diversity indexes								
Evenness	0.57±0.03	0.64±0.02	0.66±0.03	0.76±0.02	**	**	ns	**
Fisher	2.10±0.33	3.20±0.23	3.34±0.28	3.54±0.23	+	*	ns	ns
Shannon	1.23±0.89	1.46±0.63	1.54±0.77	1.69±0.63	+	**	ns	ns
Simpson	0.60±0.34	0.66±0.24	0.69±0.30	0.76±0.24	*	**	ns	*
Family Richness	9.11±0.71	9.89±0.50	10.83±0.62	9.39±0.50	ns	ns	ns	**

Table 2. Mean abundance and diversity of arthropods ± SEM (standard error of means) for the cutting/grazing treatments and results of the GLM analyses for a complete block design with 3 random transects per plot, 3 blocks, 4 management treatments and 2 lime treatments per block. ns, not significant;+P < 0.1; *P < 0.05; **P < 0.01; ***P < 0.001).

Vegetation parameters	CO	Grazing	Hay-cut	Hay-cut & aftermath grazing	Treat	Lime	T*L	Block
Nº Flowers	0.00 ± 1.35	0.78 ± 0.96	6.28 ± 0.96	7.33 ± 0.96	***	ns	ns	ns
% Grasses	98.37 ± 4.08	94.62 ± 2.88	44.62 ± 2.88	48.87 ± 2.88	***	ns	*	ns
% Forbs	1.33 ± 3.76	3.05 ± 2.66	54.97 ± 2.66	50.37 ± 2.66	***	ns	*	ns
Height	38.58 ± 2.83	35.99 ± 2.00	43.81 ± 2.00	38.16 ± 2.00	0.087	ns	ns	***

Table 3. Mean values of vegetation parameters ± SEM (standard error of means) for the cutting/grazing treatments and results of the GLM analyses for a complete block design with 3 blocks, 4 management treatments and 2 lime treatments per block. ns, not significant;+P < 0.1; *P < 0.05; **P < 0.01; ***P < 0.001).

Vegetation parameters	CO	HG+L	G-L	G+L	H+L	H-L	HG-L	SEM
Height	39.28	40.4	36.9	36.8	43.6	43.6	35.8	2.83
% Grasses	98.37	58.63	95.63	93.60	41.30	47.93	39.10	4.08
% Forbs	1.33	41.00	1.33	4.77	58.2	51.8	59.8	3.76
Nº flowers	0.00	7.60	0.70	0.87	5.53	7.03	7.07	1.35

Table 4. Mean records ± SEM (standard error of means) of vegetation parameters (height, percentage of grasses, percentage of forbs and number of flowers) for each treatment (see table 1 for abbreviations).

Appendix 1. Number of specimens of the main orders and families of arthropods.

Orders and Families	Nº individuals
O. Araneae	**289**
Fam. Araneidae	15
Fam. Linyphiidae	216
Fam. Lycosidae	2
Fam. Tetragnathidae	2
Fam. Theridiidae	17
Fam. Thomisidae	34
O. Coleoptera	**369**
Fam. Apionidae	1
Fam. Cantharidae	344
Fam. Chrysomelidae	6
Fam. Coccinellidae	13
Fam. Kateridae	1
Fam. Staphylinidae	2
O. Diptera	**4535**
Fam. Rhagionidae	27
Fam. Scatophagidae	138
Fam. Stratiomyidae	2
Fam. Syrphidae	96
Fam. Tabanidae	23
Fam. Tipulidae	39
O. Hemiptera	**2859**
Fam. Anthocoridae	1
Fam. Aphididae	557
Fam. Cercopidae	26
Fam. Cicadellidae	42
Fam. Delphacidae	68
Fam. Miridae	2158
Fam. Nabidae	7
O. Hymenoptera	**3314**
Fam. Apidae	3
O. Lepidoptera	**90**
O. Neuroptera	**1**
Fam. Chrysopidae	1
O. Orthoptera	**11**
Fam. Acrididae	11
O. Collembola	**1212**
Fam. Sminthuridae	1212
O. Thysanoptera	**43**

PHOTOGRAPHIC REPORT

THE EXPERIMENTAL SITES


Systems experiments


Brignant experiments

MATERIALS AND METHODS

Capture and identification of arthropod fauna


Capturing arthropods with sweep net


Sorting and identification of arthropod fauna in the laboratory

Vegetation measurements


Measuring sward height


Estimating n° flowers and percentage of main vegetation components in quadrats

CALENDAR OF ACTIVITIES

The following calendars include a summary of the activities developed during the period funded by the Stapledon Memorial Trust.

~ July 2013 ~						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
	1	2	3	4	5	6
7	8 Meeting at National Physical Laboratory (NPL) and tour of facilities*	9 Attendance North Wales Moors Futurescape Workshop**	10 Paperwork at the IBERS, visit to the facilities and start working in the office	11 Bibiographical review and preparation for further experiments	12 Bibiographical review and preparation for further experiments	13
14	15 Bibiographical review and preparation for further experiments	16 Visit the experimental areas where field work will take place	17 Meeting with Dr. Fraser to prepare for field data collection and equipment	18 Sampling invertebrates in 21 Brignant plots	19 Preparation of samples. Bibliographical review	20 Plant data recording 21 Brignant plots: height, nº flowers and % vegetation types
21 Vegetation data introduction in excel data sheets	22 Sorting and identification of arthropods in the laboratory	23 Sorting and identification arthropods in the laboratory	24 Attendance Royal Welsh Show with Dr. Fraser	25 Sorting and identification arthropods in the laboratory	26 Sorting and identification arthropods in the laboratory	27 Visit Snowdonia National Park
28	29 Sorting and identification arthropods in the laboratory	30 Sorting and identification arthropods in the laboratory	31 Visit experimental farm to see the experiments on methane emissions	Notes: * Meeting "Measurements of methane emissions from livestock and their manures" attended by scientists from University of Reading, University of Nottingham, AFBI, SRUC and Rothamsted North Wyke ** Welsh Water Llyn Brenig Visitor Center. Organized by RSPB		

~ August 2013 ~						
Sunday	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**
				1 Sorting and identification arthropods in the laboratory	2 Sorting and identification arthropods in the laboratory	3
4	5 Sorting and identification arthropods in the laboratory	6 Presentation of invited seminar "Livestock grazing, biodiversity and sustainability in northern Spain"	7 Visiting field experiments with site manager regarding the heather restoration project	8 Sampling arthropods in 6 sites Restoration project	9 Sorting and identification arthropods in the laboratory	10
11	12 Vegetation data recording (sward height, nº flowers and % different vegetation types) in 21 Brignant plots	13 Fauna identifications at the laboratory and enter vegetation data	14 Visit sampling sites and meeting with scientists from several institutions to discuss future collaborative projects*	15 Sorting and identification arthropods in the laboratory	16 Sampling arthropods in 21 Brignant plots	17
18	19 Sorting and identification arthropods in the laboratory	20 Sampling arthropods in 6 sites Restoration project	21 Sorting and identification arthropods in the laboratory	22 Sampling arthropods in 8 Restoration project	23 Sorting and identification arthropods in the laboratory and data analyses	24 Sorting and identification arthropods in the laboratory and data analyses
25	26 Sorting and identification arthropods in the laboratory and data analyses	27 Visit sites Restoration project. orting and identification arthropods in laboratory	28 Sampling 4 sites grazed by cattle and/or sheep first and subsequent samplings in 21 Brignant plots	29 Sorting and identification arthropods in the laboratory and data analyses	30 Sorting and identification arthropods in the laboratory and data analyses	Notes: *Scientists:Dr. Fraser, Dr Nigel Critchley (ADAS), Dr Ruth Mitchell (James Hutton Institute) and Dr Andrew Thomas (Aberystwyth University)