

BURRENLIFE: FARMING FOR CONSERVATION



Forage quality of semi natural calcareous grasslands and heaths of the Burren.

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Introduction

The Burren is a unique farmed landscape of limestone pavement, grasslands, heaths and wetlands located in the west of Ireland. Approximately 30,000 ha are designated as special areas of conservation (SAC), forming part of Europe's Natura 2000 ecological network of protected sites. Low-intensity farming practices, in particular winter grazing with minimal external inputs, are important in maintaining the good ecological status of the Burren's semi-natural grasslands and heaths (Dunford 2002). Over the past 30 years agriculture in the Burren has undergone substantial change, including the switch from store cattle to suckler beef production and concentration of agricultural activity on agriculturally improved grasslands. The higher nutritional requirements of in-calf cows resulted in many farmers introducing silage onto winter grazed areas (winterage) or housing animals over the winter. Silage feeding leads to animals foraging far less, leading to undergrazing and point source pollution around feeding sites, while the housing of animals results in the abandonment of winter-grazed grasslands and the loss of important management traditions. This on farm polarisation of activity i.e. abandonment of areas of marginal agricultural value (semi-natural vegetation) and intensification of improved agricultural grasslands is an increasing threat to their biodiversity.

The grassland and heath communities of the Burren are amongst the rarest and most vulnerable in Britain and Ireland. Their conservation value depends on halting the ongoing encroachment of scrub in which targeted winter and late summer grazing play an important role (Parr et al. 2009). The lack of knowledge of the nutritional value of semi-natural forages has contributed to the reluctance to use and integrate them into livestock feeding systems (Bruinenberg et al. 2002). However, there is potential for their integration in particular into meat production systems (Peeters and Janssens 1998), despite their lower nutritional value compared to intensive agricultural grasslands (Tallowin and Jefferson 1999, Bruinenberg et al. 2002, Donath et al. 2004). BurrenLIFE, an EU LIFE-Nature funded project has been set up to develop a new model of sustainable agricultural management for the priority habitats of the Burren. BurrenLIFE aims to encourage sustainable grazing levels on conservation grasslands while meeting the nutritional needs of the grazing animal. This paper aims to answer three questions:

1. What is the forage quality of the calcareous grasslands and heaths of the Burren?
2. Are there variations in forage quality during the main grazing seasons of late summer and winter?
3. Does the forage quality meet the nutritional requirements of the suckler cow, which is the most prevalent livestock type grazing these areas?

Methods

The study was carried out in the Burren region of the west of Ireland which is a glaciated karst landscape extending over approximately 720 km² (Latitude 53° 02'N, Longitude 09° 05'W, 20-330m above sea level). The climate of the Burren is mild with mean daily temperatures of 8.9°C. July and August are warmest with mean daily temperatures greater than 14°C and January and February coolest, with mean daily temperatures less than 5°C. Rainfall is high, the yearly average being 1525 mm. The wettest months are between

October and January with approximately 160 mm of rainfall per month. The soils of the area are mainly rendzina and shallow brown earths over lower carboniferous limestone bedrock.

Twenty BurrenLIFE monitor farms were selected across the Burren region using criteria such as SAC area, types of habitat, grazing levels and farming system. BurrenLIFE monitor farms cover 3097 ha of which 2486 ha are designated as SAC. The grasslands and heaths on these farms were divided into 5 broad types based on previous research, which are: (a) *Molinia caerulea* dominant, (b) *Dryas octopetala* dominant (c) *Sesleria caerulea* and *Festuca* sp. dominant, (d) *Calluna vulgaris* approximately 25% cover and (e) *Anthoxanthum odoratum*, *Cynosurus cristatus* and *Dactylis glomerata* dominant. 50 sample areas representing these vegetation types were selected across the monitor farms. Samples were collected every two months during the late summer and winter grazing periods between August and April, from December 2005 until August 2008 inclusive. Samples were also taken in June 2008. Sample locations were located using a GPS and approximately 500 g of forage were cut using grass clippers to ground level. Depending on the productivity of the site and grazing level this required cutting an area varying from 0.25m² to 25m². Samples were analysed for ash, N (Kjeldahl nitrogen), crude protein (CP) (N x 6.25), oven dry matter, acid detergent fibre (ADF) and neutral detergent fibre (NDF) (Van Soest analysis) at the Agri-Food and Biosciences Institute, Northern Ireland. Trace mineral analysis was carried out at the Macaulay Institute, Scotland on samples collected in December 2006 and 2007 using inductively coupled plasma-mass spectroscopy (ICP-MS) to ascertain elemental concentrations (Cu, Mn, Mo, Se, Zn, Ca, K, Mg, and P).

The vascular plant species in 2 x 2 m quadrats at each sampling site were recorded and their cover estimated using the Domin scale (Mueller-Dombois and Ellenberg 1974) during June and July 2007. These data were used to accurately assign each sampling location to a vegetation type using two way hierarchical cluster analysis (PC-ORD vers. 5: relative Euclidean distance measure and wards linkage method), with indicator species analysis used to provide a quantitative and objective point to prune the cluster analysis dendrogram (McCune and Grace 2002).

The general linear model univariate procedure in SPSS version 14 was used to perform a two factor analysis of variance (GLM Anova) to test significant differences in forage quality variables between date and plant community. The Tamhane's T2 post-hoc multiple comparison test was carried out to determine significant differences between groups.

Results

Vegetation types

A total of 108 species of vascular plants were recorded in 50 2 x 2m quadrats. Cluster analysis divided the 50 quadrats into 6 vegetation types, based on lowest average p-value (mean = 0.24) and highest number of significant indicators (Total no. of significant indicators = 40) using indicator species analysis (Table 1).

Table 1. Vegetation types distinguished using cluster analysis and indicator species analysis.

Vegetation type	No. of Quadrats	Average species richness	Indicator species p<0.05
Molinia grassland	5	24	<i>Molinia caerulea</i> , <i>Lathyrus linifolius</i> .
Sesleria grassland	7	20	<i>Sesleria caerulea</i> , <i>Teucrium scorodonia</i> , <i>Hedera helix</i> , <i>Thymus polytrichus</i> , <i>Corylus avellana</i> .
Dryas heath	12	28	<i>Carex flacca</i> , <i>Dryas octopetala</i> , <i>Asperula cynanchica</i> , <i>Calluna vulgaris</i> , <i>Viola riviniana</i> .
Sesleria-Festuca grassland	10	33	<i>Galium verum</i> , <i>Achillea millefolium</i> , <i>Koeleria macrantha</i> , <i>Festuca rubra/ovina</i> , <i>Succisa pratensis</i> , <i>Linum catharticum</i> , <i>Campanula rotundifolia</i> .
Cynosurus-Centaurea grassland	12	34	<i>Plantago lanceolata</i> , <i>Euphrasia sp.</i> , <i>Centaurea nigra</i> , <i>Leontodon autumnalis</i> , <i>Prunella vulgaris</i> , <i>Lotus corniculatus</i> , <i>Anthoxanthum odoratum</i> , <i>Taraxacum officinale</i> , <i>Ranunculus bulbosus</i> , <i>Pteridium aquilinum</i> .
Enriched Cynosurus-Centaurea grassland	4	20	<i>Dactylis glomerata</i> , <i>Ranunculus acris</i> , <i>Cerastium fontanum</i> , <i>Lolium perenne</i> , <i>Potentilla anserina</i> , <i>Rumex acetosa</i> , <i>Poa pratensis/trivialis</i> , <i>Cirsium arvense</i> , <i>Agrostis canina</i> , <i>Holcus lanatus</i> , <i>Daucus carota</i> .

Forage quality

There are large variations between vegetation types in DM, Ash, ADF, NDF and CP with Molinia grassland, Sesleria grassland and Dryas heath having the lowest mean CP and highest mean ADF and NDF values (Table 2). All forage quality variables are significantly correlated ($p=0.01$) (Table 3) with CP values increasing as ADF and NDF values decrease. CP values increase and ADF and NDF decrease in the Sesleria-Festuca grassland and the Cynosurus-Centaurea grassland and CP is at its highest and ADF and NDF lowest in the enriched Cynosurus-Centaurea grassland. There is also large variation in forage quality during the year. The general pattern is that CP values are lowest and ADF and NDF values highest during the months of December and February, with CP increasing and corresponding decrease in ADF and NDF in April and August, with highest CP and lowest NDF and ADF in June (Fig. 1).

Table 2. Mean \pm s.e.m. of forage quality variables for each vegetation type.

Vegetation type	N	DM g kg ⁻¹	Ash g kg ⁻¹ DM	ADF g kg ⁻¹ DM	NDF g kg ⁻¹ DM	CP g kg ⁻¹ DM
Molinia grassland	72	393.1 \pm 20.1	34.1 \pm 1.4	414.8 \pm 6.1	766.2 \pm 7.6	76.4 \pm 3.6
Sesleria grassland	105	377.6 \pm 10.8	39.6 \pm 1.6	401.3 \pm 5.5	689.8 \pm 7.9	73.2 \pm 2.1
Dryas heath	177	363.6 \pm 8.8	41.6 \pm 0.9	402.1 \pm 4.4	673.6 \pm 6.8	76.4 \pm 1.3
Sesleria-Festuca grassland	144	330.8 \pm 9.3	46.2 \pm 1.1	381.3 \pm 5.6	651.4 \pm 9.7	87.2 \pm 1.4
Cynosurus-Centaurea grassland	180	293.6 \pm 8.4	59.2 \pm 1.4	373.3 \pm 4.2	665.5 \pm 6.3	97.9 \pm 1.7
Enriched Cynosurus-Centaurea grassland	60	263.3 \pm 16.2	67.2 \pm 3.3	345.4 \pm 7.4	650.7 \pm 10.9	119.4 \pm 4.6
Total	738	336.8 \pm 4.7	47.9 \pm 0.7	387.5 \pm 2.3	676.7 \pm 3.5	86.8 \pm 1.0

Table 3: Spearman rank correlation coefficients for forage quality variables

			DM g/kg F	Ash g/kg DM	ADF g/kg DM	NDF g/kg DM	CPg/kg DM
Spearman's rho	DM g/kg F	Correlation Coefficient	1.000	-.400**	.368**	.337**	-.347**
		N	738	737	734	734	735
	Ash g/kg DM	Correlation Coefficient	-.400**	1.000	-.690**	-.667**	.729**
		N	737	737	734	734	735
	ADF g/kg DM	Correlation Coefficient	.368**	-.690**	1.000	.807**	-.634**
		N	734	734	734	734	732
	NDF g/kg DM	Correlation Coefficient	.337**	-.667**	.807**	1.000	-.504**
		N	734	734	734	734	732
	CP g/kg DM	Correlation Coefficient	-.347**	.729**	-.634**	-.504**	1.000
		N	735	735	732	732	735

** Correlation is significant at the 0.01 level (2-tailed).

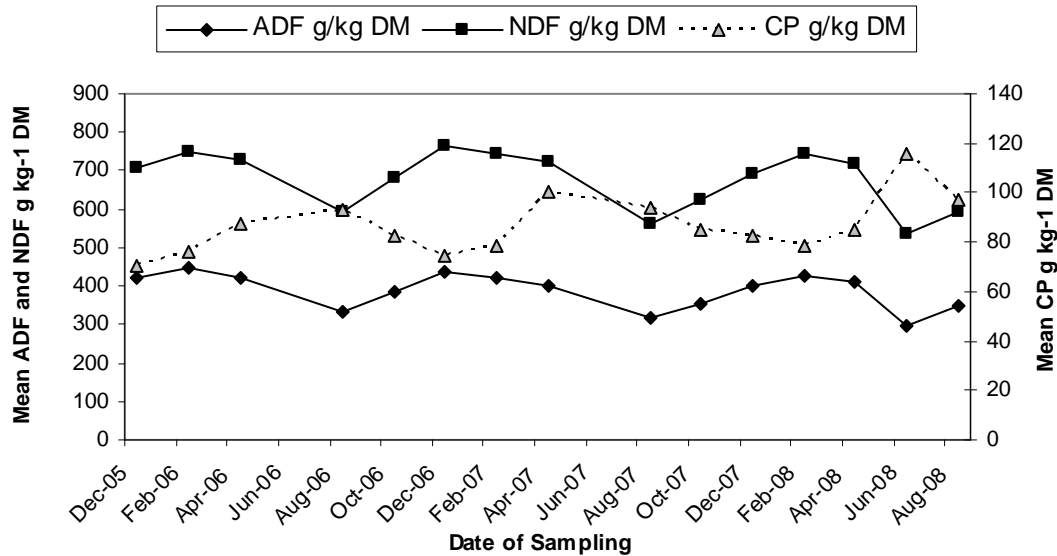


Fig 1. Mean CP, ADF and NDF from December 05 to August 08.

GLM Anova was performed on CP and ADF as dependent variables to test if significant differences occurred in forage quality between vegetation type and sampling date. Results showed that both vegetation type and sampling date have a significant effect ($p < 0.001$) on both CP (Table 4) and ADF (Table 5) and that there is a strong interaction effect between vegetation type and sampling date. This is illustrated for CP in figure 2, where parallel line would indicate no interaction effect between date and vegetation type on CP. It is clear that difference in forage quality between vegetation types is not consistent between dates. For example Molinia which has much lower CP values than the Cynosurus-Centaurea grasslands from October to April has similar/higher CP values during June and August sampling dates.

Table 4: GLM univariate analysis of variance to test significant difference in CP between date and vegetation type.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	281099.441 ^a	89	3158.421	8.901	.000	.551
Intercept	4782508.434	1	4782508.434	13477.822	.000	.954
Date	86291.722	14	6163.694	17.370	.000	.274
Comm_lab	132915.232	5	26583.046	74.915	.000	.367
Date * Comm_lab	55777.006	70	796.814	2.246	.000	.196
Error	228873.623	645	354.843			
Total	6050690.036	735				
Corrected Total	509973.064	734				

^a R Squared = .551 (Adjusted R Squared = .489)

Table 5: GLM univariate analysis of variance to test significant difference in ADF between date and vegetation type.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1912907.402 ^a	89	21493.342	16.612	.000	.697
Intercept	91576616.890	1	91576616.890	70780.762	.000	.991
Date	1122655.950	14	80189.711	61.980	.000	.574
Comm_lab	263283.601	5	52656.720	40.699	.000	.240
Date * Comm_lab	161564.139	70	2308.059	1.784	.000	.162
Error	833211.451	644	1293.807			
Total	112965843.910	734				
Corrected Total	2746118.852	733				

^a R Squared = .697 (Adjusted R Squared = .655)

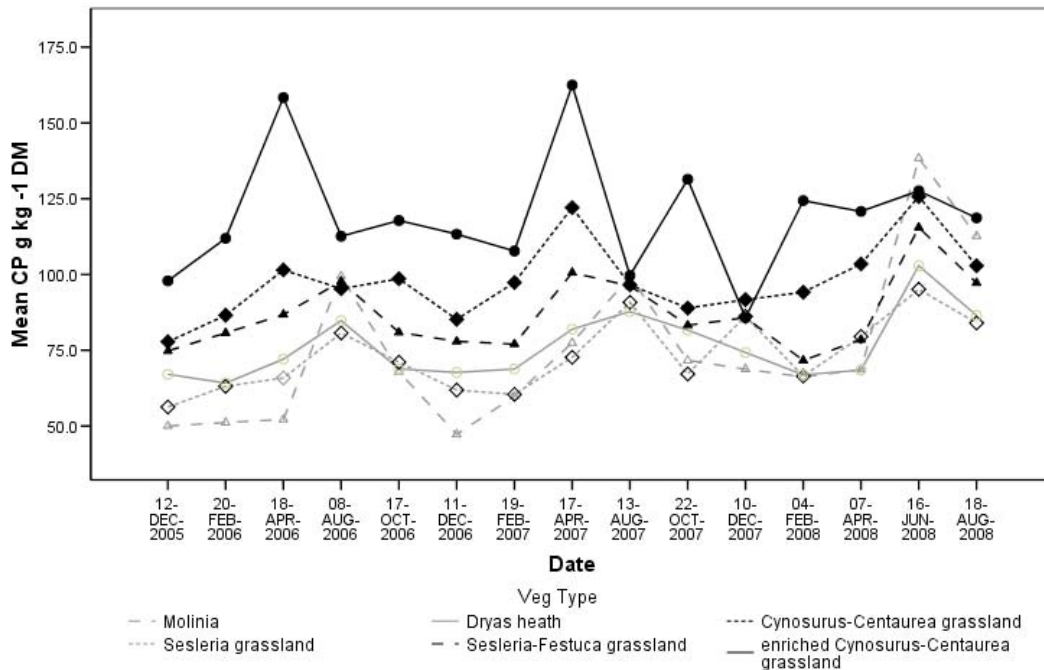


Fig. 2. Mean crude protein levels from December 2005 to August 2008.

Tamhane T2 post hoc multiple comparison tests show that there is a significant difference in mean CP between the Cynosurus-Centaurea grassland and the enriched Cynosurus-Centaurea grassland and all other vegetation type (Table 6). The mean CP for Sesleria-Festuca grassland is significantly different from the mean CP for all other vegetation types except Molinia, while there is no significant difference in the mean CP for the Molinia grassland, Sesleria grassland and Dryas heath. Tamhane T2 post hoc multiple comparison for ADF shows a slightly different pattern between vegetation types (Table 7). The mean ADF for enriched Cynosurus-Centaurea grassland is significantly different from all other vegetation type. However, the mean ADF for Cynosurus-Centaurea

grassland is not significantly different from that for the Sesleria-Festuca grassland but is significantly different from the other vegetation types. The mean ADF for Sesleria grassland and Dryas heath are significantly different from the Cynosurus-Centaurea grassland and the enriched Cynosurus-Centaurea grasslands.

Table 6: Tamhane post hoc multiple comparisons test showing mean difference in CP between vegetation types.

(I) Vegetation Type	Mean Difference (I-J) (J) Vegetation Type					
	Molinia	Sesleria grassland	Dryas heath	Sesleria- Festuca grassland	Cynosurus- Centaurea grassland	enriched Cynosurus- Centaurea grassland
Molinia		3.208	-0.029	-10.817	-21.457(*)	-42.948(*)
Sesleria grassland	-3.208		-3.238	-14.026(*)	-24.666(*)	-46.156(*)
Dryas heath	0.029	3.238		-10.788(*)	-21.428(*)	-42.918(*)
Sesleria-Festuca grassland	10.817	14.026(*)	10.788(*)		-10.640(*)	-32.130(*)
Cynosurus-Centaurea grassland	21.457(*)	24.666(*)	21.428(*)	10.640(*)		-21.490(*)
enriched Cynosurus- Centaurea grassland	42.948(*)	46.156(*)	42.918(*)	32.130(*)	21.490(*)	

* The mean difference is significant at the .05 level.

Table 7: Tamhane post hoc multiple comparisons test showing mean difference in ADF between vegetation types.

(I) Vegetation Type	Mean Difference (I-J) (J) Vegetation Type					
	Molinia	Sesleria grassland	Dryas heath	Sesleria- Festuca grassland	Cynosurus- Centaurea grassland	enriched Cynosurus- Centaurea grassland
Molinia		13.489	12.717	33.522(*)	41.534(*)	69.459(*)
Sesleria grassland	-13.489		-0.772	20.033	28.045(*)	55.969(*)
Dryas heath	-12.717	0.772		20.805	28.817(*)	56.741(*)
Sesleria-Festuca grassland	-33.522(*)	-20.033	-20.805		8.012	35.937(*)
Cynosurus-Centaurea grassland	-41.534(*)	-28.045(*)	-28.817(*)	-8.012		27.924(*)
enriched Cynosurus- Centaurea grassland	-69.459(*)	-55.969(*)	-56.741(*)	-35.937(*)	-27.924(*)	

*The mean difference is significant at the .05 level.

Tamhane post hoc multiple comparisons test showing mean difference in CP and ADF between dates (Appendix 1) highlights that forage quality is significantly lower (i.e. low CP values and high ADF values) in the months of December and February compared to the months of April, June, August and October, with June 08 having significantly better forage quality results than all other sampling dates.

A similar pattern in forage quality to that exhibited by the CP and fibre variables is evident in the mineral concentrations with significant differences in mineral

concentration between different vegetation types ($p = 0.01$). The mineral content generally increasing as you go from the Molinia grassland, Sesleria grassland and Dryas heath to the Sesleria-Festuca grassland, the Cynosurus-Centaurea grassland and the enriched Cynosurus-Centaurea grassland. However, the pattern is not consistent between minerals. Cu, Mo, K, Mg and P following above trend but Ca concentrations for example are highest in the Sesleria grassland, Dryas heath and Sesleria-Festuca grassland (Table 8).

Table 8. Mean \pm s.e.m. of forage mineral concentrations for each vegetation type. Numbers in brackets show detection limit of analysis and number of samples below detection limit where applicable.

Vegetation type	N	Cu mg kg ⁻¹ DM (0.02)	Mn mg kg ⁻¹ DM (0.01)	Mo mg kg ⁻¹ DM (0.01)	Se mg kg ⁻¹ DM (0.05)	Zn mg kg ⁻¹ DM (0.003)	Ca mg kg ⁻¹ DM (0.20)	K mg kg ⁻¹ DM (2.00)	Mg mg kg ⁻¹ DM (0.05)	P mg kg ⁻¹ DM (1.00)
Molinia grassland	9	3.0 \pm 0.2	192.6 \pm 47.9	1.0 \pm 0.3	0.2 \pm . (8)	29.5 \pm 2.8	3381 \pm 487	3819 \pm 787	1012 \pm 78	472.9 \pm 97.5
Sesleria grassland	14	3.1 \pm 0.2	89.8 \pm 8.2	0.7 \pm 0.2 (3)	0.3 \pm 0.1 (8)	25.0 \pm 1.4	7087 \pm 470	5129 \pm 359	1225 \pm 60	731.4 \pm 77.8
Dryas heath	24	3.3 \pm 0.2	112.8 \pm 16.0	1.1 \pm 0.2 (3)	0.2 \pm 0.0 (15)	24.8 \pm 1.1	7598 \pm 372	5417 \pm 310	1369 \pm 48	671.2 \pm 37.7
Sesleria-Festuca grassland	20	4.2 \pm 0.1	118.4 \pm 9.3	1.6 \pm 0.2 (1)	0.2 \pm 0.0 (15)	30.9 \pm 2.1	7445 \pm 414	7311 \pm 445	1623 \pm 51	990.1 \pm 78.9
Cynosurus- Centaurea grassland	24	4.8 \pm 0.2	189.1 \pm 28.0	2.1 \pm 0.5	0.2 \pm 0.0 (17)	32.1 \pm 1.8	5813 \pm 327	9268 \pm 711	1579 \pm 58	1319.6 \pm 134.0
Enriched Cynosurus- Centaurea grassland	8	5.7 \pm 0.6	279.4 \pm 71.1	2.7 \pm 0.6	0.4 \pm 0.1 (3)	33.5 \pm 3.1	4479 \pm 505	11334 \pm 1022	1663 \pm 40	1855.0 \pm 196.7
Total	99	4.0 \pm 0.1	149.9 \pm 11.8	1.5 \pm 0.2	0.2 \pm 0.0 (66)	29.0 \pm 0.8	6427 \pm 216	7025 \pm 323	1442 \pm 31	979.0 \pm 56.9

Discussion

Forage quality and vegetation types.

The vegetation areas sampled within this study can be classified into 6 different vegetation types i.e. *Molinia* grassland, *Sesleria* grassland, *Dryas* heath, *Sesleria-Festuca* grassland, *Cynosurus-Centaurea* grassland and enriched *Cynosurus-Centaurea* grassland. The *Molinia* grassland and the *Dryas* heath types can be considered analogous to the *Dryas octopetala* community and Calluna heath: sub-community calcareous *Molinia* respectively, of Parr et al. 2009, who classified a wide range of grassland and heath communities of conservation interest found within the Burren uplands. The *Sesleria* grassland can be considered analogous to the *Sesleria caerulea* - *Breutelia chrysocoma* group of Parr et al. 2009. While the *Sesleria-Festuca* grassland, *Cynosurus-Centaurea* grassland and enriched *Cynosurus-Centaurea* grassland are analogous to sub-communities of the *Dactylis glomerata-Holcus lanatus* community of Parr et al. 2009. Within the national vegetation classification of Britain, these approximate the M25b (*Molinia caerulea-Potentilla erecta* mire, *Anthoxanthum odoratum* sub-community), CG9 (*Sesleria caerulea-Galium sternerii* grassland), CG13 (*Dryas octopetala-Carex flacca* heath), intermediate between CG9/MG5 (*Sesleria caerulea-Festuca* grassland), MG5b (*Cynosurus cristatus-Centaurea nigra*, *Galium verum* sub-community) and an enriched MG5 (*Cynosurus cristatus-Centaurea nigra* with weedy element) vegetation communities of the national vegetation classification of Britain (Rodwell et al. 1991, 1992).

These vegetation types are significantly different in terms of their forage quality based on CP and ADF values in this study. They can be split into two broad groups with respect to their forage quality. *Molinia* grassland, *Sesleria* grassland and *Dryas* heath are of lower quality (lower CP and higher ADF), while the *Sesleria-Festuca* grassland, *Cynosurus-Centaurea* grassland and enriched *Cynosurus-Centaurea* grassland have higher forage quality (relatively higher CP and lower ADF). The first group are described as “weak winterages” as these are considered less productive and grazed only in winter in the Burren. The second group can be termed “strong winterages” as these are considered more productive and are usually grazed in winter but are sometimes grazed lightly in summer in the Burren (Parr et al. 2009). The weak winterage group had yearly average CP values ranging from 73 to 76 g kg⁻¹ DM and average ADF values ranging from 402 to 415 g kg⁻¹ DM. The stronger winterage areas had average CP values ranging from 87 to 119 g kg⁻¹ DM and average ADF values ranging from 345 to 385 g kg⁻¹ DM. These correspond to the range of values recorded in other studies for semi-natural grasslands (Peeters and Janssens 1998, Tallowin and Jefferson 1999, Kesting et al. 2009).

Variations in forage quality during grazing season.

The results highlight a significant seasonal variation in forage quality. The general pattern is that forage quality is lowest during the months of December and February, with higher quality from April to August, with highest forage quality in June. It must be noted that

June sampling only took place in 2008 due to available resources. Sampling dates in other years focused on the main grazing period for calcareous grasslands and heaths of the Burren of late summer and winter. The seasonal variations in forage quality exhibited in this study are typical of the seasonal variations highlighted in other studies, with decreasing forage quality as plant species mature due to increases in proportion of cell wall components of lower digestibility, increasing ratio of stem to leaf and loss of cell contents (Wallisdevries 1996, Bruinenberg et al. 2002, Coleman and Henry 2002, Pontes et al. 2007).

There are differences in the seasonal variations exhibited by different vegetation types as indicated by the significant interaction between sampling date and vegetation communities. This may be a reflection of differences in phenological stage of the constituent species at a given sampling date (Bruinenberg et al. 2002, Pontes et al. 2007). For example *Molinia caerulea* which is the dominant species of the *Molinia* grassland is a late heading species (July/August) with the main period of leaf extension in June and July (Taylor et al. 2001), which corresponds to the period of highest forage quality of the *Molinia* grasslands in this study. Unusual among temperate grass species growth ceases over the winter, with all leaves dead by November and onset of growth is delayed until spring (Taylor et al. 2001). This accounts for the very low forage quality of this vegetation type during the months of December and February. In contrast to this, species such as *Sesleria caerulea*, *Festuca rubra/ovina* and *Anthoxanthum odoratum* have relatively early heading dates (April/May) (O'Donovan 2001, Pontes et al. 2007).

Forage quality and the nutritional requirements of suckler cows.

A system of winter grazing of limestone grasslands and heaths has developed over many centuries in the Burren (Dunford 2002). This may be a response to the lack of water on these areas during summer, despite high rainfall levels where the karst environment results in little available surface water. Over the last 30 years a suckler beef production system has evolved as the main agricultural activity in the Burren. Within this system beef cows usual calf in March/April and calves remain with the cow until weaning in September/October. At this stage cows are removed from the lower more productive improved agricultural grassland to upland limestone grassland and heath areas known locally as winterages, where they remain until the end of April. From January until the end of April, farmers usually import silage onto winterage areas to supplement the available forage. This leads to animals congregating around feeding points leading to point source pollution and reduced grazing pressure on the winterage which in turns can have negative effects on habitat quality (Dunford 2002, Parr et al. 2009). As the majority of limestone grasslands and heaths of the Burren are designated as SACs, their conservation status must be maintained in favourable condition and sustainable winter grazing plays an essential role. However, for the winterage areas to be grazed within the existing suckler beef production system it is essential that we know if the forage quality of these areas meets the nutritional requirement of the suckler cow.

For beef production crude protein values of 120 g kg⁻¹ DM is normally recommended. Crude protein values below 70 g kg⁻¹ DM have been shown to limit fiber digestion in the rumen which limits dry matter intake (Allison 1985). Results above show that weak

winterage areas in particular have CP levels close to this critical value of 70 g kg⁻¹ DM, and for the months of December to February fall below this value.

In terms of the energy needs of a suckler cow the French feed unit system can be used to represent the energy requirements for maintenance, pregnancy and lactation (Fig. 3). Within this system 1 UFL (feed unit for lactation) = 1700 kcal NEL/kg (net energy for milk production) = 1 kg barley (Jarrige 1989). Equations are not available for conversion of above forage quality variables to UFL, therefore comparisons of average ADF and CP values (Fig. 2) recorded in this study were made with published (Jarrige 1989) and unpublished (Teagasc forage database) feed tables to enable comparison of forage quality with energy requirements of the suckler cow (Fig. 3). The feed tables for hays of natural grasslands (Jarrige 1989) were used as the listed ADF and CP values were similar to the present study. Little is known about the intakes of these forages or species rich grasslands in general (Peeters and Janssens 1998). However, intakes from forages from semi-natural grasslands are found to be lower than that from improved rye grass and clover swards (Bruinenberg et al. 2002). As a result an intake of 10kg DM per cow per day is assumed. At this intake level it is evident (Fig. 3) that the average Burren winterage is not of sufficient quality to meet the energy requirements of the suckler cow

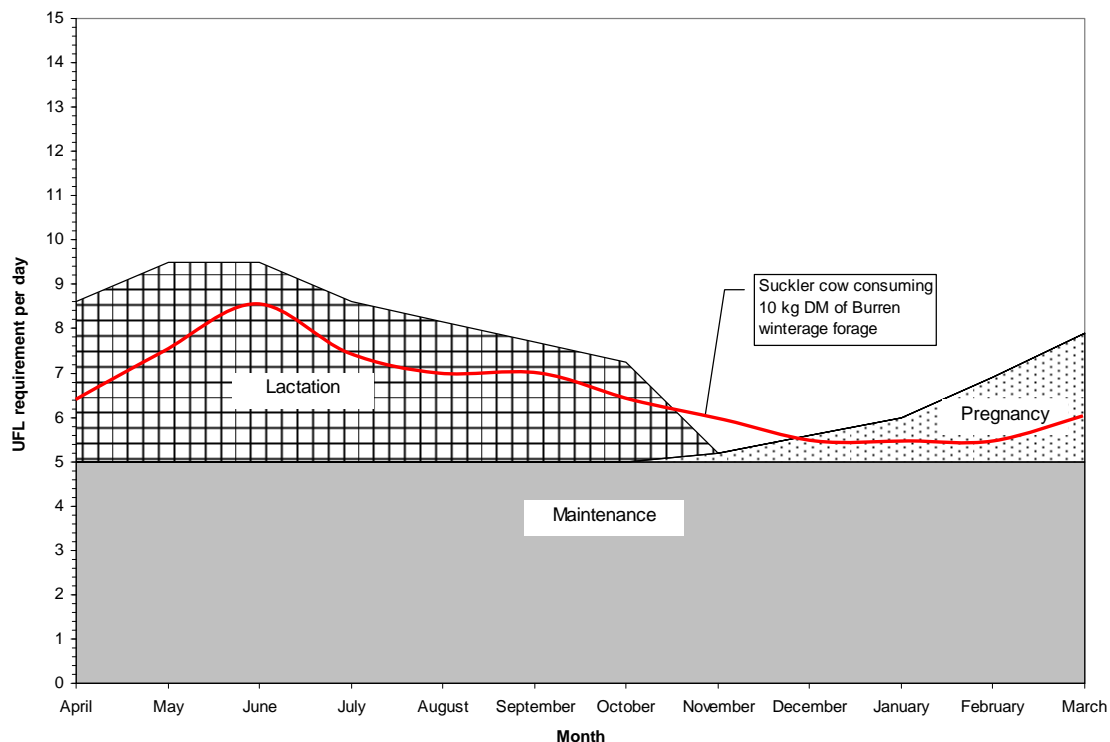


Fig. 3. Graph of monthly energy needs of suckler cow for maintenance, pregnancy and lactation (adapted from Peeters and Janssens 1998) using energy values from Jarrige 1989. Assumes Suckler cow weighing 550 kg, calving in March/April, calf birth weight = 45 kg, suckling calf for 6 months, weaning weight (October) of calf 250kg. Average daily milk yield 8 kg, starting at 8 kg going to 10kg turnout onto spring grass (1st May), falling to 4 kg at weaning. The red line indicates the amount of energy supplied to suckler cow consuming 10 kg DM of forage from a Burren winterage of average forage quality.

during lactation or late pregnancy. However, it must be noted that farmers have adapted their system, as mentioned earlier, so that suckler cows have access to more productive

swards during lactation (summer grazing period). Even if grazing is homogeneous (animals do not select for patches of higher nutritional value) as has been suggested for heterogeneous semi natural grasslands (Dumont et al. 2007), the forage consumed by the suckler cow may be of higher nutritional quality than the average forage quality suggested by forage analysis due to the heterogeneity in Burren vegetation communities.

The majority of Burren winterage areas are a mix of vegetation communities which merge and intersperse (Parr et al. 2009). As winterage areas are usually grazed from October through to April the results suggest that a winterage of average forage quality should be sufficient to meet the energy requirements of the suckler cow in October and November once the calf is weaned. This is confirmed by condition scoring of animals by the authors (results unpublished); who found that condition of suckler cows grazing winterage was either maintained or increased until December provided that the stocking rate was such that animals had access to sufficient forage. Later in the winter grazing season (January to April) as forage quality decreases, animals tend to lose body condition.

The situation can be exacerbated at this time of year due to reduced forage availability, resulting in less opportunity for diet selection of the animal to increase diet nutritional quality. From January to March, the diet of a suckler cow in late pregnancy on an average quality winterage can be 0.5 to 2 UFL below energy requirement for maintenance and pregnancy (Fig. 3). The situation is exacerbated if the suckler cow has calved on the winterage due to higher energy requirements for lactation with the predicted deficit in energy requirement of a lactating suckler cow on an average quality winterage of 2.5 to 3 UFL.

The results of the mineral analysis of Burren winterage samples are compared to the recommended mineral requirements in beef diets (Rogers et al. 2000). This highlights that Burren winterages during winter are below recommended mineral concentration for Cu (<5 mg kg⁻¹ DM, except enriched *Cynosurus-Centaurea* grassland), Se (0.24 mg kg⁻¹ DM, high proportion of samples below laboratory detection limit), Mg (< 2 g kg⁻¹ DM), and P (< 2 g kg⁻¹ DM). The wide Ca:P ratio recorded in the mineral analysis (>7:1 for the majority of vegetation types) is greater than the recommended ratio of 2:1 (ARC 1980) and may result in inadequate utilization of certain essential trace minerals (ADAS 1975, Tallowin and Jefferson 1999). Low trace mineral status of semi-natural grassland in terms of P and Mg has been also recorded from a range of semi-natural grassland communities in the UK (Tallowin and Jefferson 1999).

However, it must be noted that the biodiversity of semi-natural grassland is dependent on low soil nutrient availability, in particular soil P (Tallowin and Jefferson 1999, Isselstein et al. 2005). On forages with low P levels as recorded in this study, non-lactating and low growth rate animals are unlikely to suffer adverse effects from consuming diets with marginally sub-optimal P content (Tallowin and Jefferson 1999). Trace mineral analysis of blood from animals grazing these forages at the end of the grazing season by BurrenLIFE (unpublished data) have shown no evidence of P deficiency. Blood analysis did highlight that approximately 1 in 5 samples were low in Cu, I and Mg, while 9 out of 10 samples were below normal range in Se.

Conclusions

Different vegetation types of Burren limestone grasslands and heaths are significantly different in their forage quality in terms of protein, fibre, energy and trace minerals status. These vegetation types can be split into two broad groups i.e. the “weak winterages” composed of *Molinia* grassland, *Sesleria* grassland and *Dryas* heath of lower quality and the “strong winterages” composed of the *Sesleria-Festuca* grassland, *Cynosurus-Centaurea* grassland and enriched *Cynosurus-Centaurea* grassland of relatively higher forage quality. The results highlight a significant seasonal variation in forage quality with lowest forage quality during the months of December and February. Forage quality is highest during late spring and summer (April to August).

Targeted winter and late summer grazing is an important factor in the maintenance of biodiversity of limestone grasslands and heaths of the Burren. Grazing these areas during late summer and winter to maintain their conservation status can be achieved with the use of non lactating dry cows in early pregnancy or steers with low growth rate requirements. Animals with higher nutritional requirements such as lactating suckler cows or cows in late pregnancy requires some level of complementary feeding to balance the dietary protein, energy and mineral deficits especially during the months of lowest forage quality (January to April).

Supplementary feeding of silage during this period will increase the protein and energy content of the diet but will do little to balance the trace mineral deficit in the forage, due to the general low mineral status of silage. There are also environmental problems associated with silage feeding including point source pollution due to congregation of animals around feeding points. Concentrates with an energy value of 0.97 UFL kg⁻¹ DM, protein of 14% and containing the full recommended daily allowances of vitamins and minerals, at feeding rates of 2–3 kg per day have been trialed by BurrenLIFE. Feeding this concentrate ration complements the existing available forage and can meet the nutritional requirements of suckler cows in late pregnancy. Animal do not congregate around feeding points and have to forage for the bulk of their diet. Any additional nutrient input to species rich grasslands may pose a risk to the species rich grasslands of the Burren. However, the nutrient inputs have been quantified (See BurrenLIFE Risk of Nutrient Export Report) and have proven to be much lower than the nutrient loadings from the current silage feeding systems practiced in the area.

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Appendix 1: Tamhane post hoc multiple comparisons test showing mean difference in CP and ADF between dates.

		CP Mean Difference (I-J)													
(I) Date	(J) Date														
	Dec-05	Feb-06	Apr-06	Aug-06	Oct-06	Dec-06	Feb-07	Apr-07	Aug-07	Oct-07	Dec-07	Feb-08	Apr-08	Jun-08	Aug-08
Dec-05		-4.980	-16.372	-22.253(*)	-11.773	-3.969	-7.574	-29.247(*)	-23.339(*)	-13.907	-12.021	-8.032	-13.865	-44.975(*)	-26.653(*)
Feb-06	4.980		-11.392	-17.273(*)	-6.792	1.012	-2.594	-24.266(*)	-18.359(*)	-8.927	-7.041	-3.052	-8.885	-39.995(*)	-21.672(*)
Apr-06	16.372	11.392		-5.881	4.599	12.403	8.798	-12.875	-6.967	2.464	4.351	8.339	2.506	-28.604(*)	-10.281
Aug-06	22.253(*)	17.273(*)	5.881		10.480	18.284(*)	14.679(*)	-6.994	-1.086	8.346	10.232	14.221	8.388	-22.722(*)	-4.400
Oct-06	11.773	6.792	-4.599	-10.480		7.804	4.199	-17.474	-11.566	-2.135	-0.248	3.740	-2.093	-33.203(*)	-14.880(*)
Dec-06	3.969	-1.012	-12.403	-18.284(*)	-7.804		-3.605	-25.278(*)	-19.370(*)	-9.939	-8.052	-4.064	-9.897	-41.007(*)	-22.684(*)
Feb-07	7.574	2.594	-8.798	-14.679(*)	-4.199	3.605		-21.673	-15.765	-6.334	-4.447	-0.459	-6.292	-37.402(*)	-19.079(*)
Apr-07	29.247(*)	24.266(*)	12.875	6.994	17.474	25.278(*)	21.673		5.908	15.339	17.226	21.214	15.381	-15.729	2.594
Aug-07	23.339(*)	18.359(*)	6.967	1.086	11.566	19.370(*)	15.765	-5.908		9.431	11.318	15.306	9.473	-21.637(*)	-3.314
Oct-07	13.907	8.927	-2.464	-8.346	2.135	9.939	6.334	-15.339	-9.431		1.886	5.875	0.042	-31.068(*)	-12.745
Dec-07	12.021	7.041	-4.351	-10.232	0.248	8.052	4.447	-17.226	-11.318	-1.886		3.989	-1.844	-32.954(*)	-14.632(*)
Feb-08	8.032	3.052	-8.339	-14.221	-3.740	4.064	0.459	-21.214	-15.306	-5.875	-3.989		-5.833	-36.943(*)	-18.620(*)
Apr-08	13.865	8.885	-2.506	-8.388	2.093	9.897	6.292	-15.381	-9.473	-0.042	1.844	5.833		-31.110(*)	-12.787
Jun-08	44.975(*)	39.995(*)	28.604(*)	22.722(*)	33.203(*)	41.007(*)	37.402(*)	15.729	21.637(*)	31.068(*)	32.954(*)	36.943(*)	31.110(*)		18.323(*)
Aug-08	26.653(*)	21.672(*)	10.281	4.400	14.880(*)	22.684(*)	19.079(*)	-2.594	3.314	12.745	14.632(*)	18.620(*)	12.787	-18.323(*)	

		ADF Mean Difference (I-J)													
(I) Date	(J) Date														
	Dec-05	Feb-06	Apr-06	Aug-06	Oct-06	Dec-06	Feb-07	Apr-07	Aug-07	Oct-07	Dec-07	Feb-08	Apr-08	Jun-08	Aug-08
Dec-05		-23.400	1.250	89.719(*)	36.498(*)	-14.962	-0.480	22.184	105.844(*)	66.608(*)	20.790	-3.154	13.916	124.408(*)	74.972(*)
Feb-06	23.400		24.650	113.119(*)	59.898(*)	8.438	22.920	45.584(*)	129.244(*)	90.008(*)	44.190(*)	20.246	37.316(*)	147.808(*)	98.372(*)
Apr-06	-1.250	-24.650		88.469(*)	35.248	-16.212	-1.730	20.934	104.594(*)	65.358(*)	19.540	-4.404	12.666	123.158(*)	73.722(*)
Aug-06	-89.719(*)	-113.119(*)	-88.469(*)		-53.220(*)	-104.680(*)	-90.198(*)	-67.535(*)	16.126	-23.110(*)	-68.928(*)	-92.872(*)	-75.802(*)	34.690(*)	-14.746
Oct-06	-36.498(*)	-59.898(*)	-35.248	53.220(*)		-51.460(*)	-36.978(*)	-14.315	69.346(*)	30.110	-15.708	-39.652(*)	-22.582	87.910(*)	38.474(*)
Dec-06	14.962	-8.438	16.212	104.680(*)	51.460(*)		14.482	37.145(*)	120.806(*)	81.570(*)	35.752(*)	11.808	28.878	139.370(*)	89.934(*)
Feb-07	0.480	-22.920	1.730	90.198(*)	36.978(*)	-14.482		22.663	106.324(*)	67.088(*)	21.270	-2.674	14.396	124.888(*)	75.452(*)
Apr-07	-22.184	-45.584(*)	-20.934	67.535(*)	14.315	-37.145(*)	-22.663		83.661(*)	44.425(*)	-1.393	-25.337	-8.267	102.225(*)	52.789(*)
Aug-07	-105.844(*)	-129.244(*)	-104.594(*)	-16.126	-69.346(*)	-120.806(*)	-106.324(*)	-83.661(*)		-39.236(*)	-85.054(*)	-108.998(*)	-91.928(*)	18.564	-30.872(*)
Oct-07	-66.608(*)	-90.008(*)	-65.358(*)	23.110(*)	-30.110	-81.570(*)	-67.088(*)	-44.425(*)	39.236(*)		-45.818(*)	-69.762(*)	-52.692(*)	57.800(*)	8.364
Dec-07	-20.790	-44.190(*)	-19.540	68.928(*)	15.708	-35.752(*)	-21.270	1.393	85.054(*)	45.818(*)		-23.944	-6.874	103.618(*)	54.182(*)
Feb-08	3.154	-20.246	4.404	92.872(*)	39.652(*)	-11.808	2.674	25.337	108.998(*)	69.762(*)	23.944		17.070	127.562(*)	78.126(*)
Apr-08	-13.916	-37.316(*)	-12.666	75.802(*)	22.582	-28.878	-14.396	8.267	91.928(*)	52.692(*)	6.874	-17.070		110.492(*)	61.056(*)
Jun-08	-124.408(*)	-147.808(*)	-123.158(*)	-34.690(*)	-87.910(*)	-139.370(*)	-124.888(*)	-102.225(*)	-18.564	-57.800(*)	-103.618(*)	-127.562(*)	-110.492(*)		-49.436(*)
Aug-08	-74.972(*)	-98.372(*)	-73.722(*)	14.746	-38.474(*)	-89.934(*)	-75.452(*)	-52.789(*)	30.872(*)	-8.364	-54.182(*)	-78.126(*)	-61.056(*)	49.436(*)	

*. The mean difference is significant at the .05 level.