UNITED UTILITIES
SUSTAINABLE CATCHMENT MANAGEMENT PROGRAMME

VOLUME 6
RESTORATION OF UPLAND HAY MEADOWS, SPECIES-RICH GRASSLANDS AND RUSH PASTURES

United Utilities

Penny Anderson Associates Ltd
Consultant Ecologists

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RESTORATION OF UPLAND HAY MEADOWS, SPECIES-RICH GRASSLANDS AND RUSH PASTURES

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This project has been undertaken in accordance with PAA policies and procedures on quality assurance.

Signed: Penny Anderson.

VOLUME 6: RESTORATION OF UPLAND HAY MEADOWS, SPECIES-RICH GRASSLANDS AND RUSH PASTURES

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SUMMARY

This report presents the findings of a four year monitoring study of restoration measures that have been implemented on land supporting UK priority Biodiversity Action Plan (BAP) habitats of upland hay meadow and purple moor-grass and rush pastures within United Utilities (UU) Bowland Estate, as well as restoration of rough grazing for birds on UK BAP broad habitats of Neutral Grassland.

The key findings are that the grasslands studied have successfully maintained or increased their original diversity since the baseline collected in 2007. The grassland vegetation types in terms of the National Vegetation Classification (NVC) have not changed – this would not be expected in any case unless dramatic changes had been made (such as herbiciding and re-seeding to restore diversity) over this short time period. There are early indications in all of those that have been entered into the Higher Level Scheme (HLS) restoration and maintenance of species-rich semi-natural grassland treatments, that the dominant species have reduced and a greater representation of the rest of the species has occurred. In general there are more species per quadrat in most of the sites (including rough-grazed rush pasture areas) compared with the baseline in 2007. This is positive in such a short time period. Although the trends are consistent and positive, none are statistically significant – an expected result as such meadows and grasslands change only slowly. The drought conditions in spring 2009 and 2010 would also have contributed to a reduction in dominant grasses not directly associated with changes to management. As each meadow and pasture was different from the others, the detailed results for each are unique and further generalisations can not be made.

HLS treatments monitored were:

- restoration of species-rich semi-natural grassland (HK7) with hay-making (HK18);
- restoration of species-rich semi-natural grassland (HK7) with cattle grazing (HR1);
- maintenance of species-rich semi-natural grassland (HK6);
- restoration of rough grazing for birds (HL8) with cattle grazing (HR1).

Recommendations for further management are made.

1 INTRODUCTION

United Utilities' (UU) Sustainable Catchment Management Programme (SCaMP) is an innovative and large scale project aiming to improve catchment quality in terms of raw drinking water and nature conservation and to ensure a sustainable future for the company's agricultural tenants. The project initially ran for five years (2005 to 2010) across 20,000ha of their Bowland (Lancashire) and Peak District (Derbyshire) landholdings. Although the main habitat focus of SCaMP has been blanket bog, one of the key objectives has been to support UU's Biodiversity Strategy (cascaded from the National BAP), thus areas of woodland, hay meadow, species-rich grassland and rush pastures have also been included in the restoration plans. For areas outside Sites of Special Scientific Interest (SSSIs) - including all the meadows, species-rich grasslands and rush pastures studied here - the broad aim has been to improve the ecological status of valuable wildlife habitats and species.

Unimproved hay meadows and pastures are important as UK priority BAP habitats because their extent has been much reduced through agricultural intensification. Isolated remnant fields persist in the Bowland area and provide locally distinctive examples of the habitat type. Many sites support botanical interest, including locally distinctive species, scarce in Lancashire, and some are recognised SSSIs for the hay meadow communities they support. Upland Hay Meadow vegetation is most characteristic of brown earth soils on level to moderately sloping sites between 200m and 400m altitude, where stands may still be managed in the traditional manner. In this study, semi-natural grasslands brought into restoration management via cattle grazing with or without hay-making included examples of UK priority BAP habitats Upland Hay Meadow, Lowland Calcareous Grassland and Purple Moor-Grass and Rush Pasture. Several of the sites are Biological Heritage Sites in Lancashire for their botanical interest. Reference sites were set up with the aim of ruling out changes that were not as a result of restoration management.

1.1 Background and Aims

This report focuses upon the restoration measures that have been implemented on land supporting UK priority BAP habitats of Upland Hay Meadow, Lowland Calcareous Grassland and Purple Moor-grass and Rush Pastures within United Utilities Bowland Estate, as well as restoration of rough grazing for birds on UK BAP broad habitats of Neutral Grassland. The findings of a four year monitoring study commencing in 2007 are presented. Study sites were selected where a change of management was proposed so that the effects of this change could be studied and reference sites for botanical monitoring were also set up. Management changes were implemented to benefit botanical diversity (and breeding birds) under Environmental Stewardship Entry Level Scheme (ELS) or Higher Level Scheme (HLS) prescriptions. Several reference sites were also established where no change or contrasting management was proposed. Sites were all located within agri-environment schemes in UU's Bowland Estate, Lancashire.

The management of the sites was determined by the options available under the stewardship agreements. For the species-rich semi-natural grasslands, changes in management were aimed at maintaining or restoring conservation value via either hay-making plus cattle grazing or by cattle grazing alone (at revised stocking rates). For the less species-rich rush pastures, the HLS options selected were primarily aimed at restoration of rough grazing for birds via rush management, scrape creation and cattle grazing, but enhancements in botanical diversity were also hoped for from these measures.

In this report, the findings of the monitoring and the management known to have been undertaken are reported. The efficacy of the various management treatments is discussed. Recommendations for future management to conserve and enhance botanical diversity are made, in the light of recent experience and relevant research.

1.2 Site Details

In total, 17 sites have been investigated in this study.

Fourteen vegetation monitoring sites were located in five farms: Croasdale, Halsteads, Catlow, Lamb Hill and Whitendale. Seven of these were in hay meadows or species-rich grasslands and seven were in rush pastures.

In addition, three further sites were surveyed using the same techniques in 2009 only, to provide a comparison for the monitoring sites and a potential baseline for future monitoring. Table 1 (below) sets out the Environmental Stewardship categories for each of the monitoring sites and identifies on which farm they are located.

Table 2 (page 3) details the objectives of each category. The locations of all the sites are illustrated in Figure 1 (page 4).

Table 1 *Environmental Stewardship Categories for the Monitoring Sites, by Farm Location*

Farm	Species-Rich Grassland	HLS					ELS		Scrape Creation
		HK6	HK7	HK18	HL8	HR1	EL3	EL4	
Croasdale	Phynis		•	•					
Halsteads	Hole House Lane N & S		•	•					
	How Hill N & S		•			•			
	Dale House		•			•			
Catlow	The Den (New House Flushes)	•				•			
	Sheep Brows					•	•		
	Copped Hill	•							
UU in hand	Hollins Hollow		•			•			

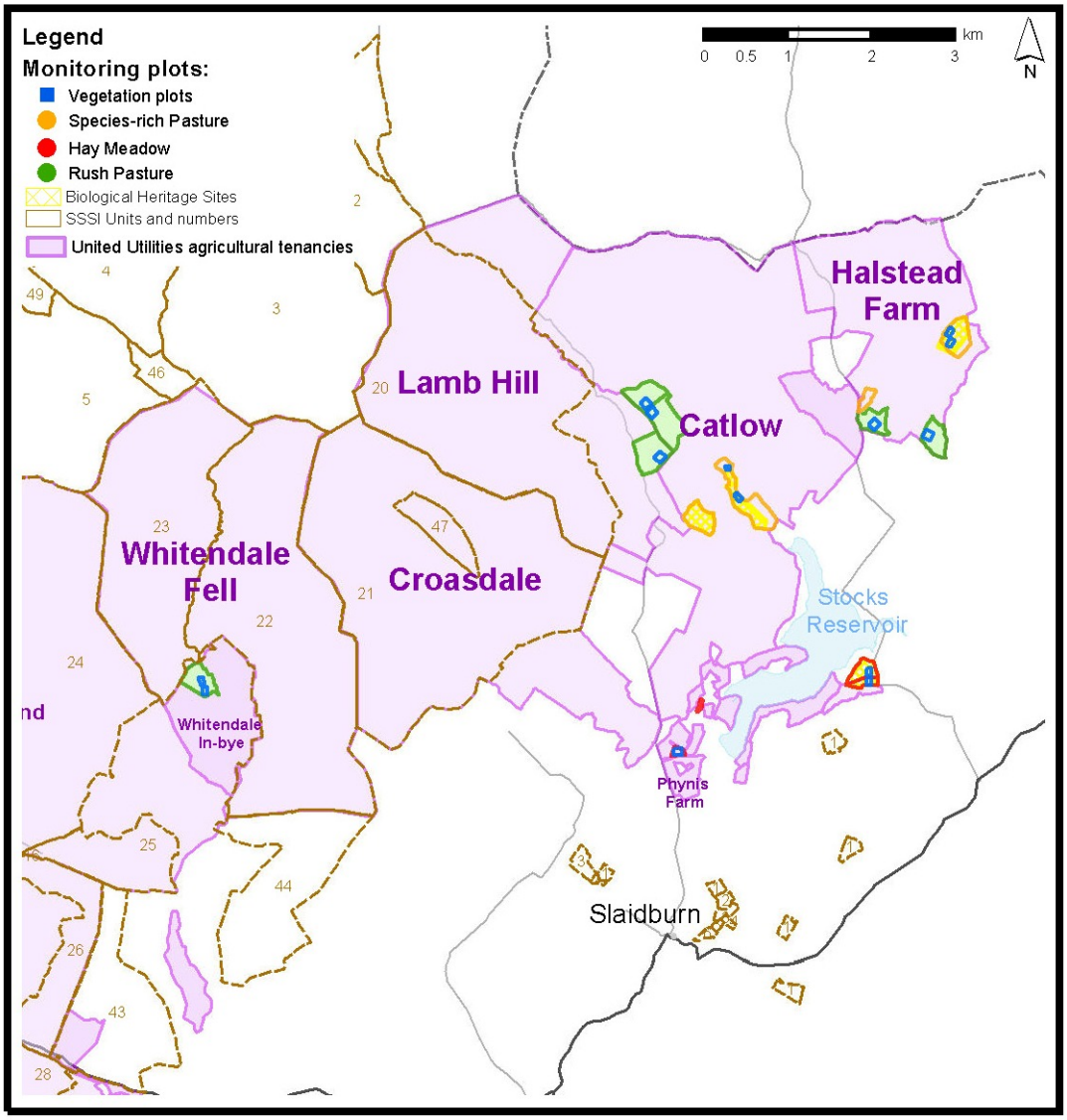
Farm	Rush Pastures	HLS					ELS		Scrape Creation
		HK6	HK7	HK18	HL8	HR1	EL3	EL4	
Halsteads	Cocklet End				•	•			•
	Old Ings				•	•			•
Catlow	Black Sides S				•	•			•
	Black Sides N					•			
Lamb Hill	Low Sides				•				•
Whitendale	Whitendale Inbye Pasture & Reference Plot							•*	•

* Managed as HL8 under additional arrangement with UU.

Table 2 *Objectives of Stewardship Categories*

Category	Title
HK6	Maintenance of species-rich semi-natural grassland
HK7	Restoration of species-rich semi-natural grassland
HK18	Haymaking supplement
HL8	Restoration of rough grazing for birds (+/- scrape creation)
HR1	Supplement for cattle grazing to benefit environmental objectives
EL3	Permanent grassland with very low inputs
EL4	Management of rush pastures
Scrape Creation	Sometimes included with HL8

Figure 1 *Hay Meadow, Species-Rich Grassland and Rush Pasture Monitoring Sites In Bowland*



2 METHODS

2.1 Site Selection

There was a shortage of true upland hay meadow sites to monitor within the Bowland Estate, so a number of species-rich upland pastures were also included in the study, all of which have been entered into HLS or equivalent agreements. In this study, the semi-natural grasslands brought into restoration management via cattle grazing with or without hay-making included examples of UK priority BAP habitats Upland Hay Meadow, Lowland Calcareous Grassland and Purple Moor-Grass and Rush Pasture. Many of these sites were already local County Biological Heritage Sites for Lancashire for their botanical interest. Several rush pastures within HLS and ELS agreements were also included.

Reference sites were also set up with the aim of ruling out sources of change not related to restoration management. However, many of these sites turned out to have limited direct comparability, although they were sometimes of interest in their own right. Reference sites allowed general comments about wider environmental variables, eg. climatic, to be made. Reference sites were: Sheep Brows, Black Sides N, Old Ings and Whitendale Reference Site.

2.2 Data Collection

What follows is a summary of the data collection methods. Full detailed methods are presented in Appendix I, providing necessary information to allow a repeat of the survey to be carried out for further monitoring if desired.

Table 1 (page 2) lists the sites for which data were collected. The location of all 17 sites and survey plots is presented on Figure 1 (page 4). All data collected are held within the SCaMP database. All botanical nomenclature follows Stace (2010) for vascular plants and Smith (2006) for bryophytes (although data on the latter were only collected rigorously in 2009 and 2010).

The detailed data collection methodology was adapted from the Common Standards Monitoring guidance for Lowland Grassland Habitats produced by JNCC (2004). Annual surveys were repeated at a similar time of year for each site to maintain comparability between datasets.

At each site, the methodology included recording the following:

- whole plot data (surveyors; date; general site description; management in past year; grass:forb ratio; rare or notable species; Dafor[1] species list; fixed point photographs; top soil samples collected for analysis for phosphorous (P), potassium (K), magnesium (Mg), pH and ammonium nitrate(NO_2H^4));
- presence-absence quadrats (30 collected, including all vascular species present; vegetation height; % cover bare ground, litter, bryophytes);
- National Vegetation Classification (NVC) quadrats (1 to 3), 2009 only.

The analysis focussed upon the presence or absence of species considered to be key indicators of the desired grassland habitats, which were selected as outlined in Table 3 (page 6).

[1] Dafor is a relative abundance scale, where d=dominant, a=abundant, f=frequent, o=occasional and r=rare.

Table 3 *Selection of Positive and Negative Indicator Species for Bowland Grassland Habitats (based upon JNCC 2004 and other sources)*

Positive Indicators • Occurrence of plant species indicators for NVC communities for species-rich grasslands (ie. the MG3 sweet vernal grass – wood crane's-bill, MG4 meadow fox-tail – great burnet, MG5 crested dog's-tail – black knapweed and MG8 crested dog's-tail – marsh marigold grasslands) and for rush pasture (eg. the M23 soft/sharp-flowered rush – marsh bedstraw, M25 purple moor-grass - tormentil and M26 purple moor-grass – marsh hawk's-beard mires) • Presence of species which are indicators of local distinctiveness, eg. plant species of semi-natural grasslands, swamps and fens (Lancashire County Council 1998).
Negative Indicators • Agricultural weeds (creeping thistle, cow parsley, spear thistle, cleavers, greater plantain, curled dock, common ragwort, common nettle, field horsetail, broad-leaved dock) • Agriculturally favoured species (eg. perennial rye-grass, white clover, timothy, soft brome, Yorkshire fog) • Rank grasses and sedges (eg. false oat-grass, cock's-foot, tufted hair-grass, larger rush species and large sedges) • Incursion and spread of bracken, scrub or tree cover, or of any other undesirable species.

2.3 Data Analysis

Data analysis across all four years of survey was carried out on a site by site basis and then synthesised for the Results and Discussion section by management type in order to draw out trends in the data related to the habitat and management types. Detailed results are presented in a separate report to UU, where the summary of annual survey findings, NVC analyses, dafor species lists, top ten analyses, supplementary data, soils data, statistical tests and fixed point photographs are presented and discussed for each site individually. The full data is held in the SCaMP database.

For whole plot data, summary data on management, site condition, rare species and other site features were analysed for each site over the full survey period. Species lists were used to compile general comments about trends in plant abundance at each site and to examine the dynamics of positive and negative indicator species present.

The results of the soil sample analysis were used to examine parity between years. Fixed Point Photographs were scrutinised for signs of change over time.

An analysis of NVC community affinities was based upon NVC quadrat data collected in 2009. The NVC analyses were be carried out using the MATCH 4 software (Thomson 2004). The main community types were identified for each site, highlighting any existing and potential communities of conservation interest.

An assessment and comparison of the frequency of positive and negative indicators was undertaken for each site, looking at trends in species present in the top ten (T10) most frequent species in the quadrat data over the study period. Within the T10 lists the presence/absence of negative and positive indicators

was considered. Table 4 (below) presents the categories of positive and negative indicators as defined in JNCC (2004) and other sources, and Table 5 (page 8) presents a full list of the positive and negative indicator species used to interpret the results.

In terms of statistics, Detrended Correspondence Analysis (DCA) performed on the quadrat data using CANOCO 4.5 software (Microcomputer Power, USA) to explore the changes in plant species data at each site during the monitoring. Where axes 1 and 2 were found to explain 20% or more of the variability, the analysis was considered to provide a good representation of the data and could be used to draw conclusions about the monitoring. The quadrat data were also analysed for correlation between years using the non-parametric Spearman Rank Correlation Coefficient. This test is widely used where species data are not normally distributed, as here. The correlation coefficients generated were examined for significant positive correlation (ie. little change in the data) and for the amount of variation or scatter which, if increasing, may indicate change. Potential sources of change are discussed.

Ecological targets set out within the HLS (or equivalent) agreements were extracted, and for upland hay meadow and species-rich grasslands which had detailed botanical targets in most cases, these were tabulated for each site. Comments on progress toward these targets were made, based upon the information collected during this study. Views on the efficacy of current management and potential options for the future are discussed below.

Table 4 *Categories of positive and negative indicators for Upland Hay Meadow, Species- Rich Grasslands and Rush Pastures, for use with Table 5 (page 8)*

Abbreviation	Definition
UHM	Upland Hay Meadow Priority BAP Habitat
PMG	Purple Moor-Grass and Rush Pastures Priority BAP Habitat
+	Good indicator of semi/un-improved grassland in Lancashire (LCC 1998)
*	Distinctive species of semi-natural grassland and rush pastures
RP	Rush Pastures
AF	Agriculturally Favoured spp.
AW	Agricultural Weeds
RGS	Rank Grassland Species
SCRUB	Scrub species

Table 5 *List of positive and negative indicators based upon categories outlined in Table 4 (page 7)*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Ash tree seedling	*Fraxinus excelsior*		SCRUB
Autumn hawkbit	*Leontodon autumnalis*	* UHM	
Bitter vetch	*Lathyrus linifolius*	* UHM	
Bramble	*Rubus fruticosus agg.*		SCRUB
Broad-leaved dock	*Rumex obtusifolius*		AW
Broad-leaved ragwort	*Senecio fluviatilis*		Non-native
Bugle	*Ajuga reptans*	*	
Bulbous buttercup	*Ranunculus bulbosus*	*	
Burnet-saxifrage	*Pimpinella saxifraga*	* UHM	
Carnation sedge	*Carex panicea*	*	
Cat's ear	*Hypochaeris radicata*	*	
Cleavers	*Galium aparine*		AW
Cock's foot	*Dactylis glomerata*		RGS
Common birds-foot-trefoil	*Lotus corniculatus*	UHM	
Common cat's-ear	*Hypochaeris radicata*	*	
Common couch	*Elytrigia repens*		RGS
Common knapweed	*Centaurea nigra*	UHM, PMG	
Common marsh-bedstraw	*Galium palustre*	UHM, PMG	
Common nettle	*Urtica dioica*		AW
Common spotted-orchid	*Dactylorhiza fuchsii*	UHM, PMG	
Common twayblade	*Listera ovata*	* +	
Common valerian	*Valeriana officinalis*	PMG	
Common yellow-sedge	*Carex viridula ssp. brachyrhyncha*	+	
Compact rush	*Juncus conglomeratus*		RGS
Corn mint	*Mentha arvensis*	+	
Cow parsley	*Anthriscus sylvestris*		AW
Creeping buttercup	*Ranunculus repens*		AF
Creeping thistle	*Cirsium arvense*		AW
Creeping willow	*Salix repens*	* PMG	

Table 5 *continued*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Crested dog's-tail	*Cynosurus cristatus*	+	
Curled dock	*Rumex crispus*		AW
Dandelion	*Taraxacum officinale agg.*		AW
Devil's-bit scabious	*Succisa pratensis*	* UHM, PMG	
Downy oat-grass	*Helictotrichon pubescens*	+	
Dyers greenweed	*Genista tinctoria*	* UHM	
Eyebright	*Euphrasia officinalis agg.*	UHM	
Fairy flax	*Linum catharticum*	* +	
False oat-grass	*Arrhenatherum elatius*		RGS
Fen bedstraw	*Galium uliginosum*	UHM, PMG	
Field horsetail	*Equisetum arvense*		AW
Field wood-rush	*Luzula campestris*	*	
Flea sedge	*Carex pulicaris*	*	
Floating sweet-grass	*Glyceria fluitans*		RGS
Glaucous sedge	*Carex flacca*	*	
Great burnet	*Sanguisorba officinalis*	* UHM, PMG	
Greater bird's-foot trefoil	*Lotus pedunculatus*	UHM, PMG	
Greater plantain	*Plantago major*		AW
Hard rush	*Juncus inflexus*		RGS
Harebell	*Campanula rotundifolia*	+	
Hawthorn	*Crataegus monogyna*		SCRUB
Heath rush	*Juncus squarrosus*		RGS
Heath speedwell	*Veronica officinalis*	*	
Heath wood-rush	*Luzula multiflora*	*	
Heath-grass	*Danthonia decumbens*	*	
Hogweed	*Heracleum sphondylium*		RGS
Lady's bedstraw	*Galium verum*	UHM	
Lady's-mantle species	*Alchemilla sp.*	UHM	
Lesser pond-sedge	*Carex acutiformis*		RGS
Lesser skullcap	*Scutellaria minor*	+	

Table 5 *continued*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Lesser stitchwort	*Stellaria graminea*	*	
Limestone bedstraw	*Galium sterneri*	+	
Marsh bedstraw	*Galium palustre*	UHM, PMG	
Marsh cinquefoil	*Potentilla palustris*	* UHM, PMG	
Marsh marigold	*Caltha palustris*	* UHM, PMG	
Marsh valerian	*Valeriana dioica*	* UHM, PMG	
Marsh Violet	*Viola palustris*	UHM, PMG	
Meadow oat-grass	*Helictotrichon pratense*	+	
Meadow vetchling	*Lathyrus pratensis*	* UHM	
Meadowsweet	*Filipendula ulmaria*	* UHM, PMG	
Mouse-ear-hawkweed	*Pilosella officinarum*	*	
Narrow buckler-fern	*Dryopteris carthusiana*	+	
Narrow-leaved meadow-grass	*Poa angustifolia*	+	
Oxeye daisy	*Leucanthemum vulgare*	*	
Pale sedge	*Carex pallescens*	+	
Perennial rye-grass	*Lolium perenne*		AF
Pignut	*Conopodium majus*	UHM	
Purple moor-grass	*Molinia caerulea*		RGS
Quaking grass	*Briza media*	*	
Ragged-robin	*Lychnis flos-cuculi*	* UHM, PMG	
Reed canary-grass	*Phalaris arundinacea*		RGS
Rough hawkbit	*Leontodon hispidus*	UHM, PMG	
Rough meadow-grass	*Poa trivialis*		AF
Salad burnet	*Sanguisorba minor*	* UHM	
Saw-wort	*Serratula tinctoria*	* UHM, PMG	
Selfheal	*Prunella vulgaris*	*	
Sharp flowered rush	*Juncus acutiflorus*	PMG	
Sheep's-fescue	*Festuca ovina*	+	
Slender St John's-wort	*Hypericum pulchrum*	*	
Sneezewort	*Achillea ptarmica*	* PMG	

Table 5 *continued*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Soft brome	*Bromus hordeaceus*		AF
Soft rush	*Juncus effusus*		RGS
Spear thistle	*Cirsium vulgare*		AW
Spring sedge	*Carex caryophyllea*	+	
Star sedge	*Carex echinata*	+	
Sweet vernal-grass	*Anthoxanthum odoratum*	+	
Tawny sedge	*Carex hostiana*	*	
Timothy	*Phleum pratense*		RGS, AF
Tormentil	*Potentilla erecta*	UHM, PMG	
Tufted hair-grass	*Deschampsia cespitosa*		RGS
Water avens	*Geum rivale*	* UHM, PMG	
Water mint	*Mentha aquatica*	UHM, PMG	
White clover	*Trifolium repens*		AF
Wild angelica	*Angelica sylvestris*	PMG	
Wood anemone	*Anemone nemorosa*	* UHM	
Yellow oat-grass	*Trisetum flavescens*	*	
Yellow rattle	*Rhinanthus minor*	* UHM	
Yellow sedge	*Carex viridula*	*	
Yorkshire-fog	*Holcus lanatus*		AF

3 RESULTS AND DISCUSSION

This study aimed to monitor the effectiveness of the restoration measures undertaken at each site. To this end, findings are arranged by management treatment (see Table 1 page 2). A summary of the survey findings at the end of the study period (2010) is presented in Additional Information provided to UU, which also contains a more detailed review of the results, charts of supplementary data (eg. vegetation height, numbers of species per quadrat etc) and of the top ten most frequent species in quadrats, as well as details of the NVC analysis, soil results and Canoco and Correlation analyses. No statistically significant trends were identified from the monitoring so far, but early indications of positive change at many sites have been detected. These are discussed and an evaluation of how each site meets its ecological HLS/ELS targets is made for hay meadows and species-rich pastures (summarised in Appendix I). The potential for the future management of the sites is discussed in the final chapter.

3.1 Restoration of Species-Rich Semi-Natural Grassland (HK7) with Hay-Making (HK18) – Phynis, Hole House Lane and Hollins Hollow

The HLS option HK7 is used for restoring species-rich semi-natural grasslands that were species-rich in the past but have suffered from management neglect or have been agriculturally improved. Such grasslands will still have some diversity of grasses and flowers and soil nutrient levels will be low with a circum-neutral pH. Coupled with the HK18 option for hay-making, management must include grazing and cutting for hay; no ploughing, re-seeding or installation of new drainage, and no heavy poaching are permitted. The terms of agreement on hay cutting dates and methods must be followed. Further restoration measures may include scrub management, invasive weed control and seed introduction by an agreed method, eg. green hay spreading.

In this study, two sites were monitored: Phynis on Croasdale Farm and Hole House Lane on Halsteads, the latter supporting two study plots in areas which had previously been differently managed. In addition, a single year of baseline data was collected in 2009 for a further site, Hollins Hollow which is managed in hand and for which there are no documented management objectives although hay cutting has been applied (2008). The location of all sites is presented on Figure 1 (page 4).

In general, objectives for management were to increase botanical diversity, especially wildflowers, and reduce the dominance of grasses in the sward, especially agriculturally favoured species. More specifically, the HLS agreements contain targets to:

- maintain low soil Phosphate index and appropriate pH;
- achieve increases in abundance of high value BAP habitat indicator species;
- achieve cover of wildflowers between 20% and 90%, with 50-60% flowering in May-August;
- keep bare ground to between 1% and 5%;
- keep undesired species cover below 5%;
- maintain populations of locally significant species (eg. saw-wort at Hole House Lane).

Prior to 2007, Phynis was managed as a typical pasture and the predominant NVC community present at the site reflects this recent history: the MG6b perennial rye-grass – crested dog's-tail grassland, sweet

vernal grass sub-community (coefficient of fit 65%), is part of the widespread MG6 suite of grasslands on moist free-draining circum-neutral brown soils across pastures of lowland Britain, which usually supports a rather limited range of broad leaved plants (Rodwell 1992). However Phynis now shows encouraging strong affinities to an MG5a crested dog's-tail - black knapweed grassland (62%) and MG3 Sweet vernal grass - wood crane's-bill grassland (41-53%), both examples of northern upland hay meadow and species-rich pasture communities. MG6b is the most diverse of the sub-communities and is known to develop from such traditional meadows following improvement for agriculture. Coupled with ADAS soil nutrient indices of 'low' to 'very low' (Table 6 below), the site is ideal for restoration to Upland Hay Meadow via HK7 and HK18 HLS options, especially given the existence of a number of positive indicator species within the sward.

Table 6 *Average Soil Analysis Results 2007 to 2010, Hay Meadows, Species-rich Grasslands and Rush Pastures, including ADAS Index Scale Categories*

Site Name	pH	Phosphorus (ppm)		Potassium (ppm)		Magnesium (ppm)		NO_3 (ppm)	
Phynis	5.3	9.1	*Very low / low*	55.4	*Very low / low*	66.0	*Slightly low - medium*	0.5	*Very low*
Hole House Lane N	5.6	4.2	*Very low*	54.2	*Very low / low*	84.4	*Slightly low - medium*	1.4	*Very low*
Hole House Lane S	5.4	4.4	*Very low / low*	65.1	*Low*	84.3	*Slightly low - medium/ Medium - high*	6.4	*Very low*
How Hill S	5.6	14.2	*Low*	132.2	*Low*	123.5	*Medium - high*	14.0	*Very low*
How Hill N	5.1	10.2	*Very low*	126.3	*Slightly low to medium*	133.9	*Medium - high*	2.1	*Very low*
Sheep Brows	4.6	7.6	*Very low*	64.4	*Very low / low*	56.7	*Low*	2.4	*Very low*
The Den	5.2	7.6	*Very low*	61.3	*Very low*	74.2	*Low /slightly low - medium*	1.7	*Very low*
Cocklet End	5.5	9.7	*Very low / low*	95.9	*Low*	186.5	*Medium - high*	1.5	*Very low*
Old Ings	4.3	13.4	*Low*	83.5	*Low*	67.8	*Slightly low - medium*	0.4	*Very low*
Black Sides S	4.7	10.9	*Low*	112.8	*Low / slightly low - medium*	113.3	*Medium - high*	7.3	*Very low*
Black Sides N	4.0	12.5	*Low*	84.9	*Low*	74.1	*Slightly low - medium*	1.8	*Very low*
Low Side	5.2	13.8	*Low / slightly low - medium*	72.3	*Low*	69.0	*Slightly low - medium*	3.4	*Very low*
Whitendale Inbye Pasture	5.5	12.6	*Low*	75.1	*Low*	107.3	*Medium - high*	9.2	*Very low*

Table 6 *continued*

Site Name	pH	Phosphorus (ppm)		Potassium (ppm)		Magnesium (ppm)		NO_3 (ppm)	
Whitendale Inbye Reference	4.5	8.5	*Low*	61.4	*Low*	83.3	*Medium - high*	7.9	*Very low*
Hollins Hollow	6.6	3.7	*Very low*	68.7	*Low*	174.7	*Medium - high*	1.7	*Very low*
Copped Hill	4.7	6.0	*Very low*	32.7	*Very low*	51.7	*Slightly low - medium*	0.6	*Very low*
Dale House Pasture	4.8	11.7	*Low*	130.3	*Slightly low - medium*	76.7	*Slightly low - medium*	3.7	*Very low*

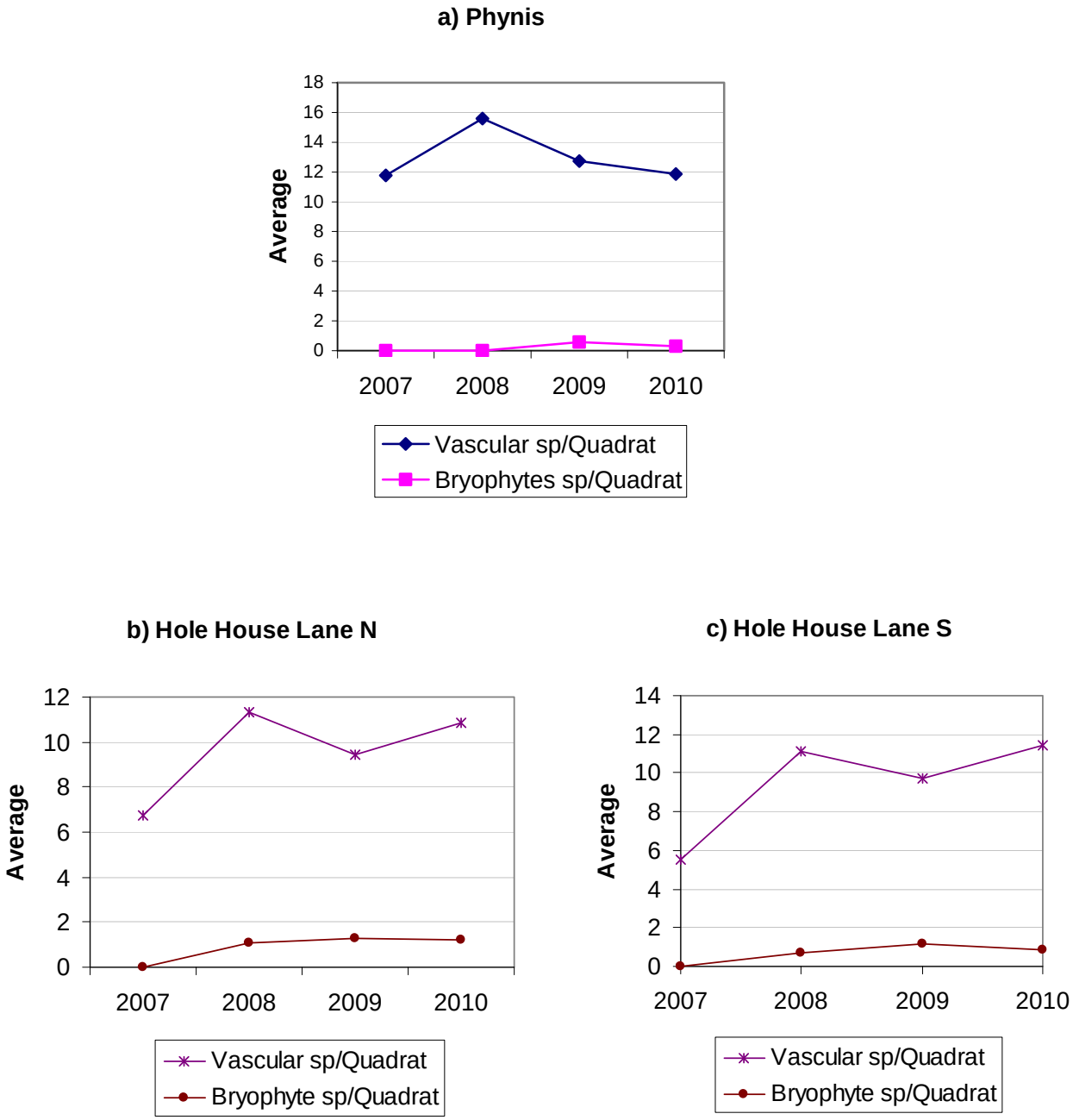
Hole House Lane, in contrast, is not really a hay meadow, but rather an already good example of Purple Moor-grass and Rush Pasture UK priority BAP habitat and is designated as a Biological Heritage Site for Lancashire on botanical grounds. It supports a range of vegetation communities including M25c purple moor-grass – tormentil mire, wild angelica sub-community (41% to 45%) on better drained ground, and M23 soft/sharp-flowered rush – common marsh bedstraw rush-pasture (39%) in lower wetter areas. The field also shows some links to the wetter of the Upland Hay Meadow NVC communities: MG8 crested dog's-tail - marsh marigold grassland (34%), which is characteristic of periodically inundated traditionally managed pasture on moderately base-rich sites. The two plots here allow comparison of change in previously differently managed areas of the same field, which have now been brought under one management scheme.

The number of vascular species per quadrat made a net increase during the study for both Phynis and Hole House Lane, see Figure 2 (page 15), although the annual counts went up and down with peaks for all three sites in 2008. Increases at Hole House Lane are marked, while only slight fro Phynis.

An examination of the ten most frequent species (T10) in each of the yearly suites of quadrats indicates several positive changes in the occurrence of some key species at both sites over time, including a reduction in the dominance of agriculturally favoured grasses. Figure 3 (page 16) illustrate the top ten most frequent species analyses for Phynis and Hole House Lane plots.

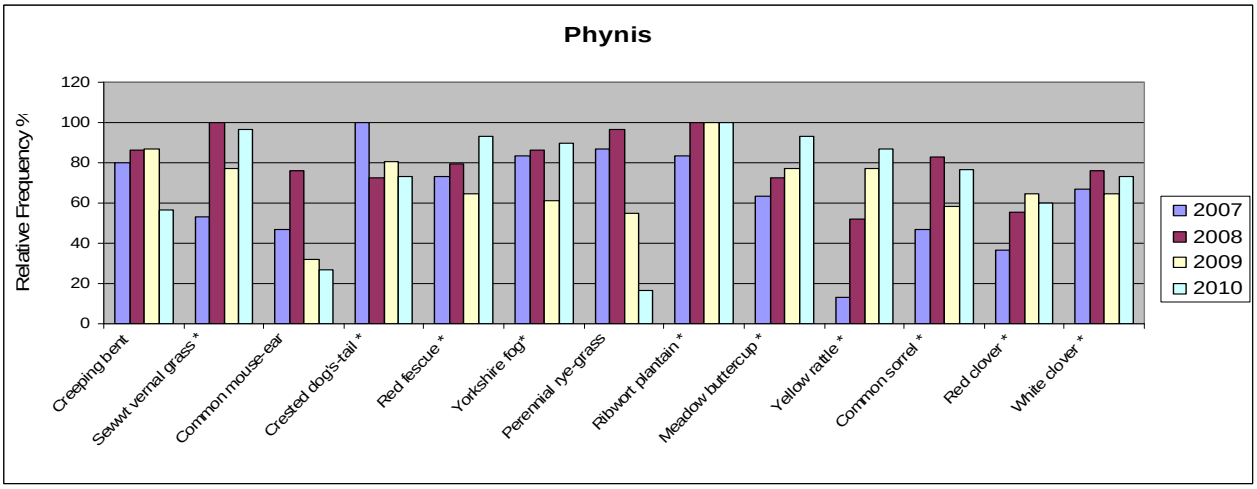
At Phynis, perennial rye-grass abundance plummeted by 2010, while yellow rattle became one of the most frequent species. Dry weather in spring 2009 and 2010 may have contributed to this change as grasses are generally shallow rooted and thus susceptible to early season drought, while yellow rattle is an annual which is semi-parasitic on grasses and white clover (Westbury 2004). Additionally, perennial rye-grass requires adequate supplies of lime and phosphate to persist in MG6b upland pastures (Thomas 1936 in Rodwell 1992). Growth in Yorkshire fog and crested dog's-tail is also reported to be negatively impacted by drought, though signs of this were not evident in the data. Increases in frequency of occurrence of sweet vernal grass were positive as it is characteristic of upland hay meadows. Visual changes in vegetation are shown in the pair of photographs taken in 2007 (Photograph 1 page 17) and 2010 (Photograph 2 page 17) which illustrate a change to a shorter more herb-rich sward after three years of traditional hay-meadow management.

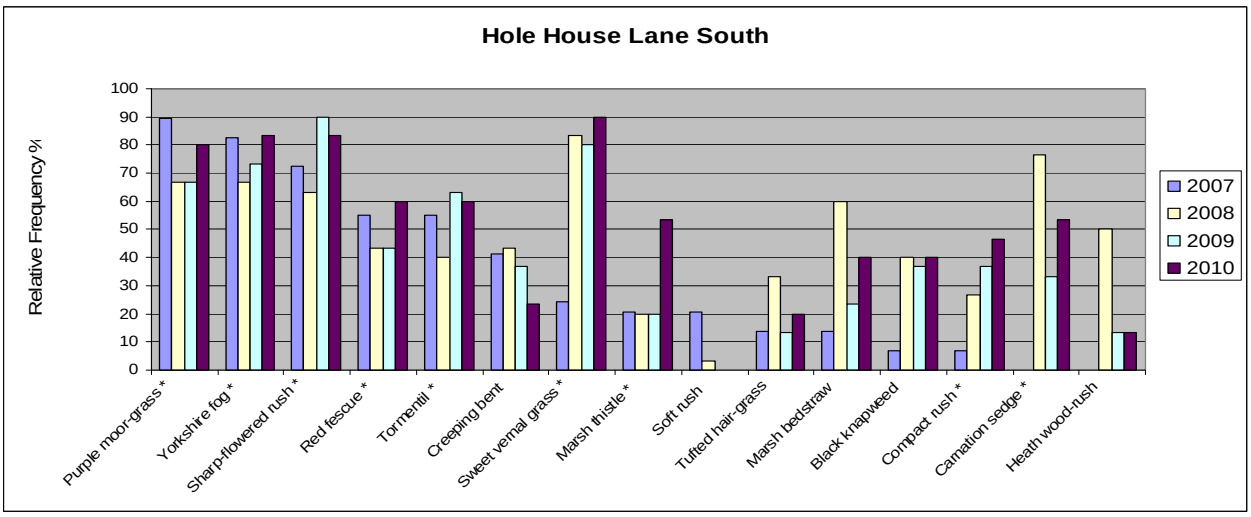
Figure 2 *Number of Vascular and Bryophyte[2] Species per Quadrat for a) Phynis; b) Hole House Lane N and; c) Hole House Lane S plots, 2007 to 2010*

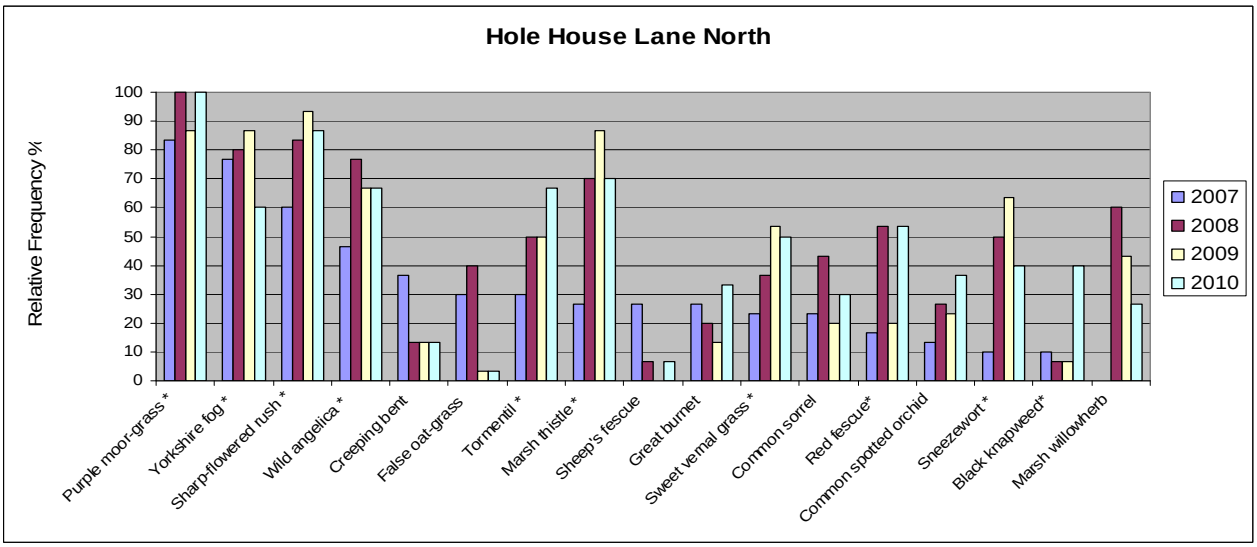


[2] Mosses and liverworts

Figure 3 *Top Ten Most Frequent Species at Phynis, Hole House Lane S and Hole House Lane N Plots 2007 to 2010 (* = 2010 Top 10)*







Photograph 1 *Phynis meadow on 28th June 2007, showing dominance of flowering Yorkshire fog grass and low abundance of wildflowers*

Photograph 2 *Phynis meadow on 20th July 2010, showing a short, more herb-rich sward after three years traditional hay-meadow management*

Across both plots at Hole House Lane, positive indicators common knapweed, carnation sedge, sweet vernal grass and sneezewort moved into the T10 by 2010. Rushes, although present, are not of concern and several less distinctive species fall out of the T10 group. Hole House Lane is a wetter site than Phynis and is unlikely to have suffered the same drought pressures during 2009 and 2010, indeed it was more affected by wet weather later in the year impeding hay cutting and removal.

At both Phynis and Hole House Lane, phosphorous levels are low (ADAS Soil Index = 0 or 1) as are other nutrients (Table 6 page 13), so the restoration programmes set out in the HLS agreements are suitable.

Phynis, supporting a full species list of 65 vascular plants, is progressing well toward restoration objectives, but has narrowly missed the Year 5 target for abundance of high value indicator species in the sward (see Appendix I). Although a total of 14 positive indicators for upland hay meadow (Table 7 page 18) have been recorded at the site during the four years of monitoring, only one (yellow rattle) had achieved more than frequent dafor status, and six were occasional in 2009 or 2010 (sneezewort, black knapweed, common spotted orchid, bird's-foot trefoil, autumn hawkbit and rough hawkbit), the remainder only occurring rarely. In essence this reflects the fact that the sward at Phynis is still dominated, in terms of cover, by agricultural grasses and vigorous broad leaved herbs such as ribwort plantain which, together with common sorrel, are preferentially favoured by the current management as they set seed before the hay cut in June and July (Grime *et al.* 2007).

The HLS agreement for Phynis states that species diversity may be augmented with hay strewing if diversity indicators are not being achieved. Many studies have supported this approach if a local source of suitable material can be found (O'Reilly 2010, Edwards *et al*. 2007, Natural England 2009b, Trueman and Millett 2003). However, they also note that some ground disturbance (eg. by harrowing) may be needed to aid colonisation, efficacy may be enhanced by the presence of yellow rattle to suppress grasses and, while annuals may establish quickly, perennial species may take years.

Hole House Lane meadow's north and south plots support 98 and 77 vascular species respectively and the site is the most diverse within the study. Both plots already meet their five year HLS targets for species diversity (Appendix I). Indeed, diversity levels for both plots are nearing targets for year 10 and the locally significant species saw-wort has moved from occasional in 2007 to frequent/abundant in both plots by 2010. Prior to 2007 the field was split by a fence and the southern part was managed as pasture, while the more diverse northern part has reportedly remained largely unmanaged since 1927. As desired,

the southern area is becoming more like the northern and both now contain frequent species of target mire communities (Table 7 below). Photographs of Hole House Lane North (Photographs 3 and 4 page 19) and South (Photographs 5 and 6 page 20) illustrate a move toward a less grass-dominated sward with more wildflowers evident between 2007 and 2010.

Table 7 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM) and Purple Moor-Grass Rush Pasture (PMG) Recorded at Phynis, Hole House Lane and Hollins Hollow 2007 to 2010 (+ indicates other species of semi-improved grasslands). D=dominant, A=abundant, F=frequent, O=occasional, R=rare. L=locally*

Species	Positive Indicators	DAFOR			
		Phynis	Hole House Lane N	Hole House Lane S	Hollins Hollow
Autumn hawkbit	UHM	r-o			
Bitter vetch	UHM		r-lo	r	
Common birds-foot-trefoil	UHM	lo-o		lo	r-o
Common knapweed	UHM, PMG	r-o	r-la	r-f	o-lf
Common marsh-bedstraw	UHM, PMG		o-lf	r-la	o-lf
Common spotted-orchid	UHM, PMG	r-lo	o-lf	r-lf	
Common valerian	PMG		r-o		
Creeping willow	PMG		r		
Devil's-bit scabious	UHM, PMG		r-lo	r-lo	o-la
Dyers greenweed	UHM		r-lf		
Eyebright	UHM	r-vla			
Fairy flax	+	r		vlo-lo	
Great burnet	UHM, PMG	r-lo	o-f	r-lo	lf
Greater Bird's-foot Trefoil	UHM, PMG	r	r-f	r	o-f
Lady's Mantle species	UHM	r			
Marsh cinquefoil	UHM, PMG		r		
Marsh marigold	UHM, PMG		lo-lf		
Marsh valerian	UHM, PMG		r-lo	r-la	
Meadow vetchling	UHM	r-lo	r-lf	r	o-f
Meadowsweet	UHM, PMG	r	r-la	r-lf	r-lf
Pignut	UHM	r			
Narrow-leaved meadow-grass	+	r			
Ragged-robin	UHM, PMG		o-f		o-lf
Rough hawkbit	UHM, PMG	r-f			
Saw-wort	UHM, PMG		o-a	r-lf	

Table 7 *continued*

Species	Positive Indicators	DAFOR			
		Phynis	Hole House Lane N	Hole House Lane S	Hollins Hollow
Sharp flowered rush	PMG		f-a	lf-la	f-la
Sneezewort	PMG	r-lo	o-f	r-lf	f
Sweet vernal grass	+	f-d	o-la	f-d	f
Tall fescue	UHM				r
Tormentil	UHM, PMG		o-a	f-a	
Water avens	UHM, PMG		r	lo	r
Water mint	UHM, PMG			r-vla	
Wild angelica	PMG		f-a	r-lf	f
Wood anemone	UHM		r-lf		
Yellow rattle	UHM	o-d	lo-lf	r-la	

Photograph 3 *Hole House Lane N on 11th July 2007, showing flowering Yorkshire fog dominant in sward and relatively low occurrence of flowering herbs*

Photograph 4 *Hole House Lane N on 21st July 2010, grass is less prominent, sneezewort, great burnet and marsh thistle are in flower*

Photograph 5 *Hole House Lane S on 11th July 2007, with Yorkshire fog and tall grasses dominant. Evidence of the first cut visible*

Photograph 6 *Hole House Lane S on 20th July 2010, a shorter less grass-dominated sward with wildflowers evident after three years of hay-cutting*

Given the current good condition of the Hole House Lane site, management is geared toward maintenance of the vegetation quality and change is no longer a prime objective. Annual mowing is not required and needs to be undertaken only if arisings can be totally removed. Implementation of hay-making at this site is novel and its effects can be scrutinised for negative consequences at the end of the HLS agreement term.

In summary, positive changes have been observed at two very different sites under the HLS prescriptions for restoration of species-rich grassland with traditional hay-making. Although changes have not yet been shown to be statistically significant, four years is a short time in which to observe trends in grassland communities beyond those which occur annually in response to climatic and other vegetation-affecting factors such as pests and disease and natural population fluctuations. In addition, soil seed banks may be short-lived (Natural England 2009a), so at Phynis in particular, addition of seeds of desired species may be needed to take the meadow to the next stage of restoration achievement. The HLS agreement for Phynis states that: *If species richness of field does not increase over the first four years additional native wildflowers will be introduced via hay strewing / seeding to achieve the indicators of success.* Hay strewing is the next step recommended in the HLS, and needs to be carried out using a suitable local source (eg. Hole House Lane or Langcliff Cross SSSI) in 2011. Other studies have found seed addition to be effective in enhancing diversity: where sourced from a traditionally managed meadow (Smith *et al.* 2002, Losvik and Austad 2002), preferably local (Jones and Hayes 1997); in combination with ground disturbance (Hopkins *et al*. 1999); and in combination with farmyard manure, hay cutting, grazing (Smith *et al.* 2008). More specifically, O'Reilly (2010) recommends hay strewing where yellow rattle is present (or added) to suppress grasses and open the sward for new seed to establish.

Like Hole House Lane, Hollins Hollow is not a typical hay meadow, as it supports communities more akin to UK BAP Purple Moor-grass and Rush Pasture communities of M22 blunt-flowered rush – marsh thistle fen-meadow and M26 purple moor-grass – marsh hawk's-beard mire. It contains a diverse species list of 68 vascular plants, including 15 positive indicators for target communities and 19 negative indicators (Table 7, page 19). The site is currently managed 'in hand' by United Utilities and not included within any HLS scheme at present. However, the vegetation is considered to be in good condition and suitable for conservation management under HK6 or HK7. Photograph 7 (page 21) presents a typical view of this site in 2009, with common spotted orchids in a rush-sedge-grass sward.

Photograph 7 *Hollins Hollow on 22nd July 2009, common spotted orchids in a rush-sedge-grass sward*

3.2 Restoration of Species-Rich Semi-Natural Grassland (HK7) with Cattle Grazing (HR1) – How Hill and Dale House

UK priority BAP habitat types Upland Hay Meadow and Lowland Calcareous Grassland both include quality examples of species-rich semi-natural pastures and the HLS has provisions for managing degraded examples of these to achieve restoration objectives. Where grasslands retain some diversity of grasses and flowers and have low soil nutrient levels, HLS option HK7 can be used in combination with cattle grazing (HR1) where this is thought likely to be beneficial to meeting conservation objectives. Cattle-grazing produces a more varied sward structure than sheep, which is better for plant, invertebrate and bird diversity, and poaching by their hooves creates areas of bare soil where new plants can establish. No ploughing, re-seeding or installation of new drainage is permitted and no heavy poaching allowed. Agreed HLS stocking calendars (covering rates and timings) must be followed and further restoration measures may include scrub management and invasive weed control.

In this study, only one site was monitored for restoration via low inputs and cattle grazing: How Hill, a site which is a Biological Heritage Site for its UK BAP priority habitat Lowland Calcareous Grassland. The field was selected because it offered an opportunity to compare the effectiveness of the HLS options on both species-rich and more agriculturally improved swards within one field. In addition, a single year of baseline data was collected for a further site, Dale House, in 2009. Dale house is considered to be more of a degraded upland hay meadow, having circum-neutral soils. Both sites are located within Halsteads Farm and are included within the HLS agreement.

Restoration objectives at both sites were to increase botanical diversity, especially wildflowers, and reduce the dominance of grasses in the sward, especially agriculturally favoured ones. More specifically, the HLS agreements contain targets to:

- maintain low soil Phosphate index and appropriate pH;
- achieve increases in abundance of high value BAP habitat indicator species;
- achieve cover of wildflowers between 20% and 90%, with 50% flowering in May-July;

- keep bare ground to between 1% and 5%;

- maintain populations of limestone bedstraw (*Provisional Lancashire Red Data List of Vascular Plants*) at How Hill.

Prior to 2007, both How Hill and Dale House were cattle grazed, and only minor reductions in stocking levels have been implemented under the HLS. The dominant NVC community in both sections of How Hill and at Dale House is fairly typical of semi-improved pastures on reasonably well drained soils in the north and west of Britain: MG6b perennial rye-grass – crested dog's-tail grassland, sweet vernal grass sub-community. Affinities to this community were approximately 61% for both parts of How Hill and 62% for Dale House. Both sites showed evidence of agricultural improvement via reseeding fertiliser and lime addition in their affinities of around 50% to communities MG7 Perennial Rye Grass Leys. However, more diverse areas at How Hill South showed similarities to target vegetation communities of lowland calcareous grassland, eg. CG10 sheep's fescue – common bent – wild thyme (42%) and CG2 sheep's fescue – meadow oat-grass (52%), while links to upland hay meadow communities, eg. MG5 sweet vernal grass – black knapweed grassland, were also found there (54%). Dale House showed links to MG8 crested dog's-tail – marsh marigold (56%) and MG3 sweet vernal grass – wood crane's-bill (53%) grasslands – both also NVC communities associated with upland hay meadows.

At How Hill South, a total of 63 vascular plant species were recorded, while at How Hill North, only 50 were present. The Top Ten analysis for 2010 showed little change in either part of the site: at How Hill South, field wood-rush is the only positive indicator, present throughout the monitoring period; at How Hill North, positive indicator sweet vernal grass appears in the T10 only in 2009. At both sites, several negative indicators feature constantly: perennial rye-grass and white clover, augmented by cock's-foot and dandelion at How Hill South, and Yorkshire fog and creeping thistle at How Hill North. The continued occurrence of negative indicators among the most frequently recorded species reflects the slow progress of change where management changes have been minor.

At Dale House, the T10 list for 2009 was similarly dominated by negative species with just one positive indicator (sweet vernal grass).

Generally, HLS targets for phosphate are met across How Hill (see Table 6 page 13), but only part of the site is progressing well toward the botanical targets set (Appendix I). The localised area on the limestone outcrop (How Hill South) meets all the five and 10 year HLS targets but the other part of the site (How Hill North) supports only low abundances of calcareous grassland and hay meadow indicators, no limestone bedstraw and low levels of bare ground to provide colonisation gaps within the heavily grass-dominated sward. A similar pattern to How Hill North was seen in the singe years' data for Dale House, with soil phosphate levels low, but indicator species (for upland hay meadows) not present at target frequencies and agriculturally favoured species still over-dominant in the sward.

The sward at How Hill is shown in Photographs 8 (south) and 9 (north) (page 23), both illustrating the grassy nature of the vegetation at this site, where few wildflowers are evident. The photographs were taken on 2010, but are little different from those taken annually since 2007.

Table 8 (page 23) illustrates the DAFOR abundances of key upland hay meadow and calcareous grassland indicators at How Hill and Dale House.

Photograph 8 *How Hill N on 21st July 2010, showing a grass-dominated sward with creeping thistle and few wildflowers little changed since 2007*

Photograph 9 *How Hill S on 21st July 2010, showing little change to a close-grazed sward with few wildflowers evident*

Table 8 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM) and Purple Moor-Grass Rush Pasture (PMG) Recorded at How Hill 2007 to 2010 and Dale House 2009*

(+ indicates other species of semi-natural grasslands)

Species	Positive Indicators	DAFOR		
		How Hill		Dale House
		S	N	
Autumn hawkbit	UHM	o-f	lr-lo	
Betony	UHM, PMG			r
Bird's-foot trefoil	UHM	o-f	r	lo
Burnet-saxifrage	UHM	r-o		
Common knapweed	UHM, PMG	r		
Common valerian	PMG	r		
Downy oat-grass	+	o-lf	lo	
Eyebright	UHM	r-lf	r-o	
Fairy flax	+	r-lo		
Great burnet	UHM, PMG			lo
Greater bird's-foot trefoil	UHM, PMG			o
Harebell	+	o-lf	r-lo-lf	
Lady's bedstraw	UHM	o-lf	r	
Limestone bedstraw	+	r-lf		

Table 8 *continued*

Species	Positive Indicators	DAFOR		
		How Hill		Dale House
		S	N	
Meadow oat-grass	+	r-lo	r-lo	
Meadow vetchling	UHM	r		o
Oxeye daisy	+	r-lo		
Pignut	UHM	r	r	lf
Quaking-grass	+	r-lo	r	
Rough hawkbit	UHM, PMG	r		
Salad burnet	UHM	r-lf	r	
Selfheal	+	o-f	r-lf	
Sheep's-fescue	+	f-a	r-lo	
Spring sedge	+	o-f	r-lo	
Sweet vernal-grass	+	o-a	o-f	o-f
Tormentil	UHM, PMG	r		lr

In summary, data collected to date at How Hill suggest that, while BAP indicator species are present across the site, abundances are not increasing to target levels in the more improved parts of the field under the current management. However, the condition of the more diverse areas is being maintained. Other studies have found grazing alone to be ineffective in enhancing diversity on some species-poor grasslands (Pywell *et al.* 2007), and to be slow in others (Walker *et al.* 2004), eg. to take more than 10 years (Smith *et al.* 2003). A lack of significant change in the pastures studied here may be due to the slow progress of change in grazed systems over the relatively short term of this study (four years).

3.3 Maintenance of Species-Rich Semi-Natural Grassland (HK6) – The Den and Copped Hill

The HLS option HK6 is aimed at maintaining grasslands that are already species-rich and in good condition by continuing, or making adjustments to, the current management (Natural England 2010). The only monitoring site included under this option is New House Flushes, known locally as The Den. A single year of baseline data was collected for a second site, Copped Hill, in 2009. Both sites lie within Catlow Farm and are Biological Heritage Sites for Lancashire on botanical grounds.

The vegetation at both sites is highly variable and both sites are very different form each other. However, the most interesting communities present at both are examples of UK BAP priority habitat Lowland Purple-Moor Grass and Rush Pastures, including communities which occur in moderately base-rich conditions. Under the HLS, management must include grazing (and/or cutting for hay); no ploughing, re-seeding, or installation of new drainage; and no heavy poaching. More specifically, the HLS agreements for The Den and Copped Hill contain targets to:

The Den

- maintain low soil Phosphate index;
- maintain/increase the extent of habitats of interest as identified;
- maintain appropriate abundance of high value BAP habitat indicator species;
- maintain cover of wildflowers between 20% and 90%, with 50% flowering in May-July.

Copped Hill

- maintain low soil Phosphate index;
- maintain appropriate abundance of high value BAP habitat indicator species;
- maintain soil pH between 5.5 and 7;
- maintain frequent and flowering bird's-eye primrose, cover wildflowers between 40% and 90%, with 50% flowering in May-July;
- keep bare ground to between 1% and 5%.

Management prior to 2007 appears to have been similar at both sites: grazed by cattle and sheep. The Den was one of the most diverse sites in the study, recording a total of 89 vascular species. NVC communities were linked to mire vegetation; especially M26b purple moor-grass – marsh hawk's-beard mire, red fescue sub-community (50%) and M23a soft/sharp-flowered rush – common marsh bedstraw rush pasture, sharp-flowered rush sub-community (46%). M26 occurs on moderately base-rich and calcareous peats in the northern Pennine uplands, and its presence on these flushed slopes reflects base-rich water seepages. Such vegetation can persist under traditional pasture management. M23 is less botanically interesting and is typical of sloping ground on moderately acid to neutral peaty and mineral soils. Soil pH for The Den averaged at 6.17 reflecting base-rich factors (Table 6 page 13).

At The Den, the top ten list encompassed 22 species, reflecting the very varied nature of the site, but making it difficult to draw out trends in key species from the data. Sweet vernal grass, tormentil, creeping bent and Yorkshire fog are present in all years, with the first two species representing positive indicators and the last being negative. Overall, the T10 list contains eight positive indicators and five negative ones, including creeping thistle. Figure 4 (page 26) presents the top ten most frequent species recorded in quadrats each year. Table 9 (page 27) presents a DAFOR list of the positive indicators recorded at The Den. Photograph 10 (page 28) shows a cattle-grazed tall rush and sedge-dominated sward with marsh thistle, little changed since 2007.

The Den meets its key ecological HLS objectives (Appendix I) on all counts, including for frequency of positive indicator species and for proportions of grasses to forbs in the sward.

Figure 4 *Top Ten Most Frequent Species at The Den, Halsteads, 2007 to 2010 (* = 2010 Top 10)*

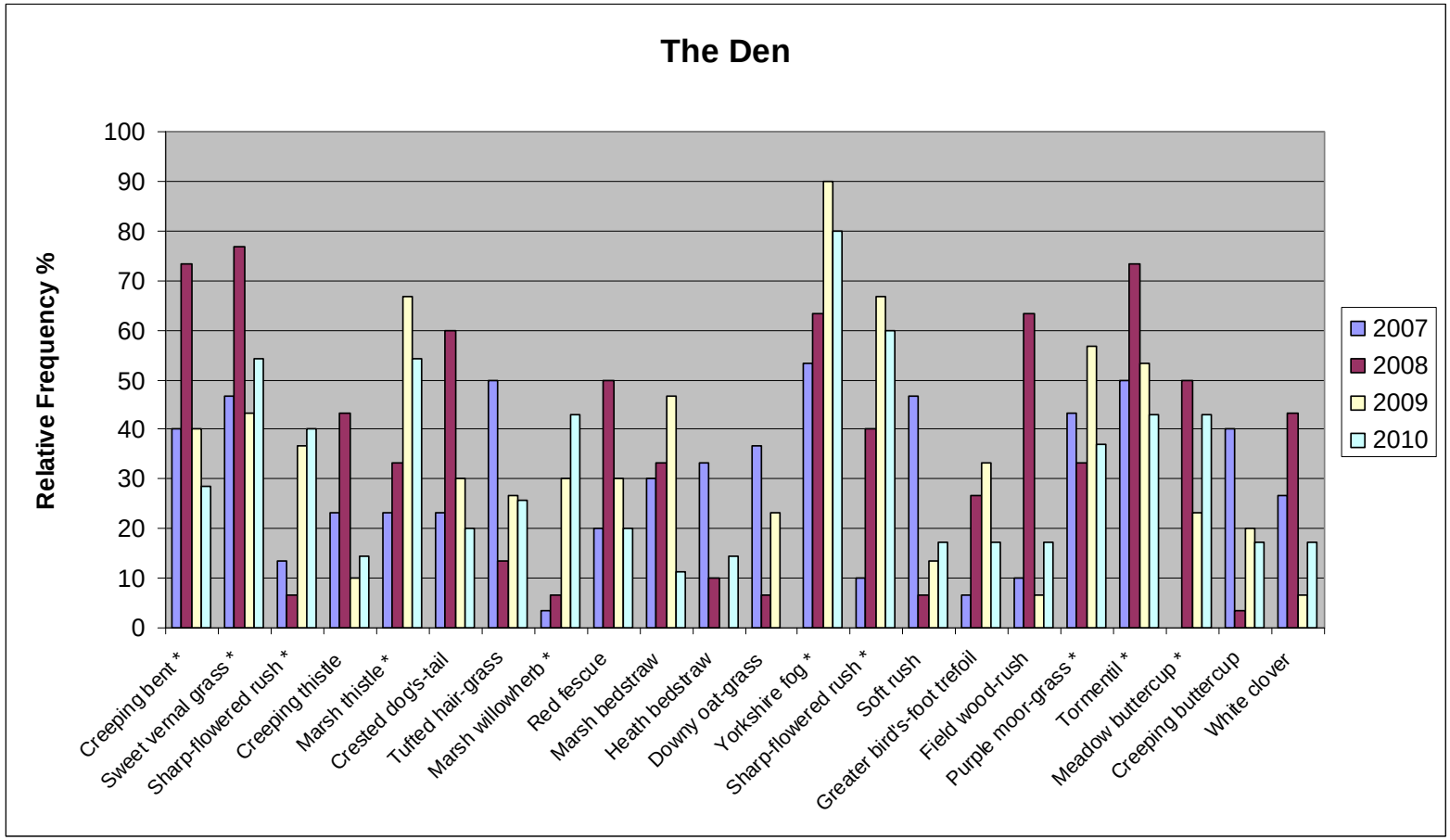


Table 9 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM) and Purple Moor-Grass Rush Pasture (PMG) Recorded at The Den 2007 to 2010*

(+ indicates other species of semi-natural grasslands)

Species	Positive Indicators	DAFOR
Bitter vetch	UHM	r
Bugle	+	r-la
Carnation sedge	+	r-a
Cat's ear	+	r-la
Common knapweed	UHM, PMG	r
Common marsh-bedstraw	UHM, PMG	r-f
Common yellow-sedge	+	r
Corn mint	+	r
Crested dog's-tail	+	r-f
Downy oat-grass	+	lo-lf
Fairy flax	+	vr-lo
Field wood-rush	+	r-lf
Flea sedge	+	r-lf
Glaucous sedge	+	r-lf
Heath speedwell	+	r
Heath-grass	+	r-o
Lesser skullcap	+	r-lo
Lesser stitchwort	+	r
Marsh valerian	UHM, PMG	r
Meadow oat grass	+	r
Meadow vetchling	UHM	lo
Meadowsweet	UHM, PMG	r-lf
Pale sedge	+	lf
Quaking-grass	+	r-f
Ragged robin	UHM, PMG	r

Table 9 *continued*

Species	Positive Indicators	DAFOR
Selfheal	+	r-lf
Sharp flowered rush	PMG	f-ld
Sheep's-fescue	+	r-la
Sneezewort	PMG	r-lf
Spring sedge	+	r-o
Star sedge	+	r-vla
Sweet vernal-grass	+	f-a
Tawny sedge	+	r

Photograph 10 *The Den on 22nd July 2010, with a tall rush and sedge-dominated sward with marsh thistle, showing little change since 2007*

Overall, the vegetation at Copped Hill remains in acceptable condition, supporting a total of 77 vascular plants. The quadrat data from Copped Hill contained six positive indicators in the top ten most frequently encountered species. In the DAFOR list, a total of 17 positive indicators for BAP habitats were recorded across the whole field including bird's-eye primrose and creeping willow (both rare). A further 22 indicators of semi-natural/old grasslands and mires were also present reflecting the high botanical interest of the site. A list of the positive indicators recorded at Copped Hill is presented in Table 10 (page 29).

Table 10 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM) and Purple Moor-Grass Rush Pasture (PMG) and Other Semi-natural Grasslands Recorded at Copped Hill, 2009*

(+ indicates other species of semi-natural grasslands)

Species	Positive Indicators	DAFOR
Autumn hawk-bit	UHM	r
Bilberry	Heaths	r
Bird's-eye primrose	BAP calcareous grassland	r
Bristle club-rush	+	r
Carnation sedge	+	f-la
Common butterwort	UHM	r
Common cotton-grass	Mires	r
Common milkwort	UHM	r
Cranberry	Mires	r
Creeping cinquefoil	UHM, PMG	r
Creeping willow	PMG	r
Deergrass	Mires	r-lo
Devil's-bit scabious	UHM, PMG	o-f
Eyebright species	UHM	lf
Fairy flax	+	r
Field wood-rush	+	lo
Flea sedge	+	f
Heath wood-rush	+	o
Heather	PMG	o-lf
Lesser spearwort	UHM	o
Lousewort	PMG	f
Marsh cinquefoil	UHM, PMG	o
Marsh valerian	UHM, PMG	o-f
Quaking-grass	+	o
Ragged-robin	UHM, PMG	o-lf
Selfheal	+	o-f
Sharp flowered rush	PMG	o-ld
Sheep's-fescue	+	o

Table 10 *continued*

Species	Positive Indicators	DAFOR
Star sedge	+	o
Sweet vernal-grass	+	lo-ld
Tawny sedge	+	o-f
Tormentil	UHM, PMG	f
Yellow sedge	+	o-lf

Copped Hill appears to maintain a high botanical diversity of BAP indicators, but bird's-eye primrose was rare not frequent, on site in 2009. Soil pH was distinctly acid at 4.7 rather than the target 5.5 to 7. However the abundance and range of acid-loving plants suggests that this level may be set too low and that the soils may actually be naturally acidic here, or becoming so. Bird's-eye primrose is confined to damp or boggy locations so is potentially vulnerable to poaching. Cattle-poaching was noted on site, particularly associated with the flushed botanically rich slopes around the stone footpath (Photograph 11 below) and along the stream banks.

Photograph 11 *Copped Hill Pasture on 22nd July 2009, showing typical flushed vegetation with cattle poaching along path edge. Stream lies in trees to right of frame.*

3.4 Permanent Grassland with Very Low Inputs (EL3) with Cattle Grazing (HR1) – Sheep Brows

Sheep Brows was included in the study to act as a reference plot for other sites in the area as no management change at all was proposed. It is located in Catlow Farm. The habitat equates to Upland Pasture, but is not of sufficient quality to qualify as a priority UK BAP habitat type.

The field is managed under ELS as permanent grassland with very low inputs (EL3) plus a supplement for cattle grazing to benefit environmental objectives (HR1). This option is used for permanent grassland

managed without fertiliser to provide higher value for wildlife. Management must include retention as grass, no ploughing, cultivation or re-seeding. Grazing or cutting must aim to remove last year's grass growth, avoiding bird breeding period April to June and removing all cuttings. Sward heights are prescribed and control of certain injurious weeds and scrub may be carried out. Harrowing is permitted outside of April to June and no supplementary feeding must take place. Farmyard manure and lime may be applied during the growing season.

The NVC analysis undertaken in 2009 indicates a good fit to the U1 sheep's fescue – creeping bent – sheep's sorrel grassland (53%), characteristic of base and nutrient-poor summer-parched soils where grazing and disturbance create a short, tussocky, open sward (Rodwell 1992). This seems an appropriate vegetation community for this plot, closely grazed as it is by both sheep and rabbits. The average soil pH of 4.5 is acidic (see Table 6 page 13). All the analyses suggest very little change at Sheep Brows, with the same four species remaining the most frequent throughout the survey period (creeping bent, sheep's fescue, heath bedstraw and field wood-rush). This is the expected outcome for a site in stable ecological condition with no change in management. Five species considered to be positive indicators of semi-improved grassland are present, plus two negative ones: soft rush in particular, although a valid component of many vegetation types, can become dominant under certain management conditions and needs to be monitored at this site. A summary of the positive indicator species present at Sheep Brows is presented in Table 11 (below). Photograph 12 (page 32) shows typical vegetation at Sheep Brows, with rushes in a short grass-dominated sward little changed since 2007.

Table 11 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM and Purple Moor-Grass Rush Pasture (PMG) Recorded at Sheep Brows, 2007 to 2010*

(+ indicates other species of semi-natural grassland)

Species	Positive Indicators	DAFOR
Carnation sedge	+	r
Crested dog's-tail	+	r-lo
Field wood-rush	+	o-a
Glaucous sedge	+	r
Heath speedwell	+	r
Heath-grass	+	vr-lo
Marsh bedstraw	UHM, PMG	r-lf
Meadow vetchling	UHM	r
Mouse-ear hawkweed	+	lo
Sharp-flowered rush	PMG	r
Sheep's-fescue	+	a-ld
Soft-rush		r-ld
Sweet vernal-grass	+	r-lo
Tormentil	UHM, PMG	o-f

Photograph 12 *Sheep Brows* on 22*nd July 2010, with rushes in a short grass-dominated sward little changed since 2007*

A finding of 'no change' at this site was expected and is useful: in the absence of site-based changes such as to management regimes, any vegetation change would be a response to wider environmental alterations in Bowland, potentially affecting other sites. Management at Sheep Brows should continue as it is, to maintain the existing nature of the site, although diversification options could also be considered.

3.5 Restoration of Rough Grazing for Birds (HL8) with Cattle Grazing (HR1)

The HL8 option for restoration of rough grazing is used within HLS schemes to provide rough grassland habitat for upland birds, particularly breeding waders. Management usually includes grazing with cattle and/or sheep at agreed stocking densities (0.4 to 1 Livestock Unit[3] per hectare) between 31st March and 20th June. Outside this period, stocking densities are managed to achieve desired sward height. Restoration is usually tailored to each site and may include extension of wet marshy vegetation eg. via scrape creation, or blocking of surface drains, ditches and grips. In this study the cattle grazing supplement HR1 was also used.

On the pastures included in this study, restoration objectives were primarily aimed at improving habitats for ground nesting birds via rush management and creation of wet scrapes. Birds targeted included priority BAP species northern lapwing (*Vanellus vanellus*) and Eurasian curlew (*Numenius arquata*). Although these do not form part of the HLS targets, botanical gains were also hoped for, hence the monitoring, to see whether management changes would result in a move toward a more diverse sward with a richer array of wildflowers more appropriate for Upland Hay Meadows or Purple Moor-Grass and Rush Pasture priority UK BAP habitats.

The monitoring outlined in this study ran alongside a study by RSPB which aimed to monitor the response in bird abundance to management changes taking place across the whole United Utilities SCaMP area in both Bowland and the Peak District (Stephen *et al*. 2010). However, due to the wide

[3] Livestock Unit: UK government 2006 = 1 dairy cow.

scope of the monitoring for birds, the findings could not be tallied directly to fields where botanical monitoring was taking place, so the impacts of restoration management for birds could not be identified at the field-scale.

The fields monitored were varied and have been divided into several categories, according to the existing botanical nature of the sites and their potential:

- fields already botanically interesting where this should be maintained;
- fields with potential for management as upland hay meadow and species-rich pasture; and
- fields with low botanical interest and lower potential for enhancement.

Table 12 (below) lists the sites according to these categories. The findings at each site are discussed below.

Table 12 *Rough Grazing Fields under HL8 and HR1 Assigned to Categories Based upon their Botanical Diversity*

Sites with existing botanical interest	Sites with potential for botanical enhancement	Sites with lower potential for enhancement
Old Ings Black Sides North	Cocklet End Low Sides	Black Sides South Whitendale Pasture Whitendale Reference Plot

Old Ings and Black Sides North

These two fields were found to support semi-natural vegetation of value for its botanical communities, especially for the variety of mosses including *Sphagnum* bog-mosses. Both are cattle grazed, and under HL8, scrapes have been created at Old Ings, although no rush treatment has been implemented to date. At Black Sides North, only included in the HLS for HR1 cattle grazing, scrape creation and rush treatment were not part of the management programme. Management at both sites is considered to have changed little under the HLS and as such the sites are included in the study as reference sites where no change would be expected to the vegetation.

The vegetation at Old Ings (Halsteads) shows some key characteristics of the UK BAP priority habitat Purple Moor-grass and Rush Pasture. The NVC revealed variable vegetation with elements of both upland grassland and rush pasture communities: the U6 heath rush – sheep's fescue grassland (47%) and U5 mat grass – heath bedstraw grassland (44%) reflect past drainage and over-grazing, while affinities to the M23 soft/sharp-flowered rush – common marsh-bedstraw rush pasture (42%)(Rodwell 1991) suggest remnants of past mire vegetation, which may have been quite diverse and interesting potentially owing to base-rich water seepage from limestone present in the area.

Black Sides North (Catlow) exhibits the UK BAP broad habitat type 'Acid Grassland' which is characterised by vegetation dominated by grasses and herbs on a range of lime-deficient soils. The NVC shows parity with Old Ings in the occurrence of U5 (59%) and U6 (55%) communities, both typical of man-induced grasslands growing in the moist cool north-western uplands on base-poor low fertility soils - these poorer quality upland grazings are now usually grazed by sheep (although cattle were probably more important in centuries past, Rodwell 1992). An affinity to U2 (48%) may suggest the grassland has

derived from more mire-like vegetation (as does the presence of bilberry, heather and several *Sphagnum* bog-mosses). The peaty nature of the soils here supports this assessment (see Table 6 page 13).

Vascular diversity at Old Ings included 51 species, plus a further 14 bryophyte species. Of this total list, 19 species were considered to be positive indicators for purple moor-grass or upland hay meadow UK priority BAP habitats, or old semi-natural grasslands (Table 13 below). Species present included common lousewort, sneezewort, autumn hawkbit, common marsh-bedstraw, greater bird's-foot trefoil and lesser spearwort. The grass:forb ratio was 80:20, but the grassy element of the sward contained a great variety of species including five sedges. A slight climb in number of vascular species recorded per quadrat was seen during the monitoring period. Photographs 13 and 14 (page 35) illustrate the tall rushy sward at this site in 2007 which was seen to be more varied and tussocky in 2010, taken to be the beneficial result of cattle grazing on site.

Vascular diversity at Black Sides North included 48 species (Table 13), plus a further 17 bryophytes including six species of *Sphagnum* bog-moss. Species present included 21 positive indicators of target habitats, including a range of sedges, common lousewort, autumn hawkbit, common milkwort, heather, bilberry and cranberry. The grass:forb ratio ranged between 75:25 and 90:10, although again the 'grass' component included many desirable sedge and grass species. Negative indicators were present at both sites, but not of concern. Photograph 15 (page 36) illustrates the diverse sedge-grass-rush sward in 2010, which is underlain by mosses and has been seen to become slightly more uniform since 2007.

Overall, no significant changes were detected at either site. An analysis of the top 10 most frequent species in the quadrats showed few trends either. These are expected results, given the sites were included to provide reference data rather than monitor management change. The abundance and range of *Sphagnum* bog-mosses at both sites reflects the potential for future ecological benefits from re-wetting these habitats, via measures such as grip-blocking. Such measures would also help to prevent the loss of carbon stores and support carbon sequestration in the future.

Table 13 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM and Purple Moor-Grass Rush Pasture (PMG) Recorded at Black Sides North and Old Ings, 2007 to 2010*

Black Sides North		
Species	**Positive Indicators**	**DAFOR**
Carnation sedge	+	r-lo
Field wood-rush	+	r-lo
Heath speedwell	+	r-lo
Heath wood-rush	+	r-ld
Selfheal	+	r
Lousewort	PMG	r
Autumn hawkbit	UHM	r
Crested dog's-tail	+	r
Narrow buckler fern	+	o-lf
Sheep's-fescue	+	o-la
Spring sedge	+	r

Old Ings		
Species	**Positive Indicators**	**DAFOR**
Carnation sedge	+	o-la
Cat's-ear	+	r
Field wood-rush	+	r-f
Glaucous sedge	+	r-la
Heath wood-rush	+	r-lf
Lesser stitchwort	+	r
Common lousewort	PMG	r-lf
Sneezewort	PMG	r
Autumn hawkbit	UHM	r
Crested dog's-tail	+	r-o
Sheep's-fescue	+	o-la

Table 13 *continued*

Black Sides North		
Species	**Positive Indicators**	**DAFOR**
Star sedge	+	r-lf
Sweet vernal-grass	+	r-f
Bilberry	Heaths	r-lf
Common cotton-grass	Mires	r
Cranberry	Mires	r-vlo
Heather	PMG	r
Sharp-flowered rush	PMG	r
Bog-moss species	PMG	r
Common milkwort	UHM	lf
Lesser spearwort	UHM	r
Tormentil	UHM, PMG	f-ld

Old Ings		
Species	**Positive Indicators**	**DAFOR**
Star sedge	+	r-la
Sweet vernal-grass	+	o-la
Sharp-flowered rush	PMG	o-la
Bog-moss	PMG	r
Lesser spearwort	UHM	r-lf
Common knapweed	UHM, PMG	r
Common marsh-bedstraw	UHM, PMG	vlr-lo
Greater bird's-foot trefoil	UHM, PMG	r-lf
Tormentil	UHM, PMG	f-a

Photograph 13 *Old Ings on 31st July 2007, with a tall grass-rush sward*

Photograph 14 *Old Ings on 21st July 2010, showing greater impact of grazing, creating more tussocky vegetation*

Photograph 15 *Black Sides N* on *28th July 2010, diverse sedge-grass-rush sward underlain by mosses, becoming slightly more uniform since 2007, maybe due to reduced grazing*

Cocklet End and Low Sides

Cocklet End and Low Sides support semi-improved grassland with vestigial characters of upland hay meadow or species-rich pasture communities and with potential for restoration to these UK BAP priority habitats. Both fields are cattle grazed under HL8 and HR1, with additional scrape creation having taken place since 2007. Neither field contains UK priority BAP habitats at present, although they do represent examples of the broad habitat type 'Neutral Grassland', albeit with prominent sharp-flowered and other rush species throughout.

At both Cocklet End (Halsteads) and Low Sides (Lamb Hill), the NVC classification lies firmly within the MG6b perennial rye-grass – crested dog's-tail grassland, sweet vernal grass sub-community (50% and 52% respectively). The MG6 community is typical of semi-improved pastures on reasonably well drained soils in the north and west of Britain, but the sweet vernal grass sub-community is the richer version and is characterised by typical hay meadow grass and occasional herbs (Rodwell 1992). At Cocklet End, affinities are also shown to the upland hay meadow vegetation of MG3 sweet vernal grass – wood crane's-bill grassland (c. 39%). At Low Sides, links to former upland hay meadow are also evident in the affiliation to MG5 crested dog's-tail – black knapweed (c.42%) and MG8 crested dog's-tail – marsh marigold (c.45%) grasslands. At both sites the circum-neutral pH (5.2 to 5.5) would fit with this association (Table 6 page 13).

At Cocklet End the grass:forb ratio has remained constant at 95:5 throughout the survey period, and overall the site is relatively species-poor and repetitive. The site supports a total of 48 vascular species, of which five are positive indicators for target habitats, including the forbs sneezewort, marsh bedstraw, autumn hawkbit and greater bird's-foot trefoil (Table 14 page 37). A further nine species are indicative of old grasslands. The list of 13 negative species includes agriculturally favoured grasses Yorkshire fog and tufted hair-grass. The main rush species are sharp-flowered and compact, but levels are not of concern at present.

Table 14 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM and Purple Moor-Grass Rush Pasture (PMG) and Other Semi-natural Grassland Species Recorded at Low Sides and Cocklet End 2007 to 2010*

Cocklet End		
Species	**Positive Indicator**	**DAFOR**
Carnation sedge	+	r-lf
Common cat's-ear	+	r-o
Field wood-rush	+	r-o
Glaucous sedge	+	r
Lesser stitchwort	+	r
Selfheal	+	r-lo
Sneezewort	PMG	r
Autumn hawkbit	UHM	r-lo
Crested dog's-tail	+	o-la
Sheep's-fescue	+	r-f
Sweet vernal-grass	+	f-a
Sharp-flowered rush	PMG	r-lf
Common marsh-bedstraw	UHM, PMG	r
Greater bird's-foot trefoil	UHM, PMG	lo

Low Sides		
Species	**Positive Indicator**	**DAFOR**
Bulbous buttercup	+	r
Carnation sedge	+	r-lf
Field wood-rush	+	r-f
Glaucous sedge	+	r
Heath wood-rush	+	r
Lesser stitchwort	+	r-lo
Selfheal	+	r-lo
Sneezewort	PMG	r-lf
Autumn hawkbit	UHM	r-o
Crested dog's tail	+	f-a-d
Sheep's-fescue	+	r-f
Sweet vernal-grass	+	f-a-d
Sharp-flowered rush	PMG	f-a-d
Bird's-foot trefoil	UHM	r
Lesser spearwort	UHM	r
Common marsh-bedstraw	UHM, PMG	r-lo
Greater Bird's-foot-trefoil	UHM, PMG	r-lf
Tormentil	UHM, PMG	r

Neither site showed statistically significant changes, nor did the number of species per quadrat change notably. Overall, potential for significant botanical and BAP habitat gains exist at both fields, under appropriate management. However, current management is likely to retain the *status quo* as found in other studies of similar habitats (eg. Pywell *et al.* 2007, Walker *et al.* 2004 and Smith *et al.* 2003).

Black Sides South and Whitendale

These two fields support low-diversity grassland with low potential for botanical enhancements to be realised. Black Sides South is grazed under HL8 and HR1, while Whitendale is managed under ELS option EL4 - but this is being upgraded to HL8 under an additional agreement with UU. At both Whitendale and Black Sides South, intensive rush management has been undertaken via a combination of cutting and herbicide treatment. Scrapes have also been created at both sites. Whitendale was selected for SCaMP because it presented an opportunity where a 'Reference' site with no rush treatment and a rush treatment area ('Pasture') study plot could be set up within the same field, with the benefit of being able to compare directly between the two management regimes. Neither site supports UK priority BAP habitats, although both would all fall within the broad habitat type 'Improved Grassland'.

Black Sides South lies on the cusp of an MG10 Yorkshire fog – soft rush rush-pasture and the more interesting M23 soft rush – common marsh-bedstraw rush-pasture, with very similar affinities of 44% found to each in the data. Both communities are typical of drainage-impeded, base-poor to circum-neutral soils, although overall, MG10 pasture seems the most likely category for the vegetation at the present time, frequent as it is in the north and west of Britain. As management on this field is rotated through a three year cycle, surveys following cutting would probably reflect the MG10 grassland community more strongly, while in the third year, before cutting has taken place, the rush-pasture dominates. Strong affinity to the M23 soft/sharp-flowered rush – common marsh-bedstraw rush-pasture community in the 2009 NVC analysis reflects the dominance of rush in the three year management cycle immediately before cutting which took place following the survey, but suggests that Black Sides South may have potential, through appropriate management, to be restored to Purple Moor-Grass and Rush Pasture priority UK BAP habitat in the longer term.

At Whitendale, the Pasture plot is a localised area of damp mesotrophic grassland, converging toward MG6 perennial rye-grass – crested dog's-tail grassland (50%) because of drainage, fertiliser applications and liming. Affinities to MG7 perennial rye-grass leys (c.42%) point strongly to the introduction of agricultural seed such as white clover and rye-grass in the past. Rush management across the whole field (excluding the reference area) has been annual via herbicide and cutting where possible. Thistles and nettles have also been managed by herbicide.

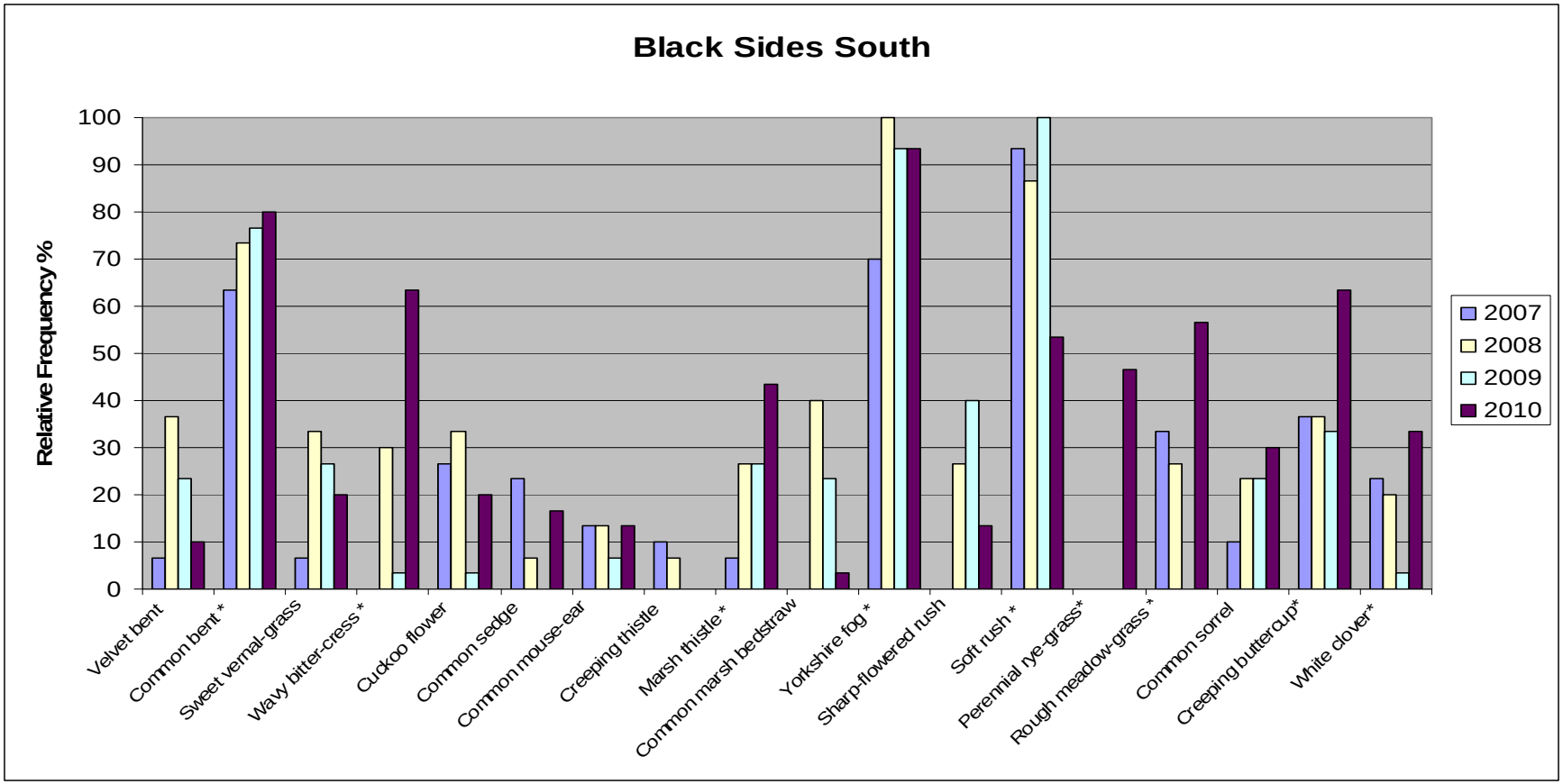
Contrastingly, the reference plot, located to the south, supports an example of the MG10a Yorkshire fog – soft rush rush-pasture, typical sub-community (40%) - a mesotrophic grassland of permanently wet grazed pastures over a wide range of mineral soils across the British lowlands and upland fringes. The typical sub-community occurs in slightly acid soil conditions, and an average soil pH of 4.43 fits with this description. Strong affinities were also shown here to U4 sheep's fescue – creeping bent – heath bedstraw community (38%) and M23 soft/sharp-flowered rush - common marsh-bedstraw rush-pasture (38%), and less-so to M27 meadowsweet – wild angelica mire (35%). The latter affinities reflect localised patches of *Sphagnum* bog-mosses. Comparison with the adjacent Whitendale Pasture shows how intensive management can rapidly move vegetation from one type to another.

Table 15 (page 39) lists the positive indicators of upland hay meadows and purple moor-grass rush pasture recorded at Black Sides South and Whitendale between 2007 and 2010. At Black Sides South, the grass:forb ratio remained between 90:10 and 99:1 during the monitoring period. Overall, vascular diversity was low, with only 43 vascular species recorded. Of these, positive UK BAP habitat indicators numbered just five, with a further seven species of old and semi-improved grasslands. Negative indicators included 10 species in total including a range of frequent to abundant agriculturally favoured species. Negative species also featured strongly in the top 10 most frequent in the quadrat data (see Figure 5 page 40).

Table 15 *DAFOR of Positive Indicators of Upland Hay Meadows (UHM and Purple Moor-Grass Rush Pasture (PMG) Recorded at Black Sides South and Whitendale 2007 to 2010*

Whitendale	**Positive Indicator**	**Reference**	**Pasture**
		DAFOR	
Bog moss	PMG	r	
Common cottongrass	Mires	r	
Crested dog's-tail	+	r-lo	r
Field wood-rush	+	r-o	
Hare's-tail cottongrass	Mires	r	
Heath speedwell	+	r-o	
Lesser spearwort	UHM	r	r
Lesser stitchwort	+		r-o
Marsh bedstraw	UHM PMG	r	
Selfheal	+	r-lf	r
Sharp flowered rush	PMG	r-o	
Sheep's fescue	+	lf	
Star sedge	+	r-lf	
Sweet vernal-grass	+	f-a	r-f
Black Sides S	**Positive Indicator**	**DAFOR**	
Autumn hawkbit	UHM	vlr-r	
Bugle	+	r-lf	
Common marsh-bedstraw	UHM PMG	r-o	
Crested dog's-tail	+	r-lo	
Field wood-rush	+	r	
Harebell	+	r	
Lousewort	PMG	r	
Selfheal	+	vlr-o	
Sharp flowered rush	PMG	r-a-ld	
Sheep's fescue	+	f-a	
Sweet vernal-grass	+	r-a	
Tormentil	UHM PMG	r	

Figure 5 *Top Ten Most Frequent Species at Black Sides South, Catlow, 2007 to 2010 (* = 2010 Top 10)*



Both Whitendale plots showed grass:forb ratio of 90:10, although white clover was more evident on the Pasture site, and a wider range of grasses and some sedges made up the 'grass' component of the reference plot. On the Pasture, botanical diversity was low, with a total of 33 vascular plants recorded. No positive indicators of target UK BAP habitats were present, although five species of old and semi-improved grasslands were rare to occasional. Negative species numbered 11 and included many agriculturally favoured, weed and rank grassland species. On the reference plot, a total of 45 vascular plants were recorded of which five positive vascular UK BAP habitat indicators were present plus three *Sphagnum* moss species. In addition, a further seven species of old and semi-natural grasslands were also evident. Negative species numbered 10, including Yorkshire fog and soft rush.

Overall, although soil pH and nutrients are low across these sites, the low diversity indicates a lower level of suitability to more ambitious botanical enhancements with a view to progressing priority BAP habitat target delivery. However, there is some potential for botanical enhancement/restoration at all sites, and significant benefits could be achieved though targeted seed addition might be required in this type of site.

4 CONCLUSIONS

The key findings are that the grasslands studied have successfully maintained or increased their original diversity since the baseline collected in 2007. The grassland vegetation types in terms of the NVC have not changed – this would not be expected in any case unless dramatic changes had been made (such as herbiciding and re-seeding to restore diversity) over this short time period. There are early indications in all of those that have been entered into the HLS treatments that the dominant species have reduced and a greater representation of the rest of the species has occurred. In general there are more species per quadrat in most of the sites compared with the baseline in 2007. This is positive in such a short time period. Although the trends are consistent and positive, none are statistically significant which means that they could also have happened just by chance and not as a result of the management. However, a lack of significant change over a period of four years is also a result that would be expected as such meadows and grasslands change only slowly. The drought conditions in spring 2009 and 2010 would also have contributed to a reduction in dominant grasses not directly associated with changes to management. As the meadows and pastures differed from each other, the detailed results for each are unique and further generalisations can not be made.

4.1 Restoration of Species-Rich Semi-Natural Grassland (HK7) with Hay-Making (HK18)

Three plots under these HLS treatments were monitored, one in Phynis and two in Hole House Lane meadow. All showed a slight reduction in perennial rye-grass dominance between the baseline and 2010 surveys and a slight increase in the number of species per quadrat, although no trends were significant statistically. Only Phynis (in Croasdale) was suitable for yellow rattle – a useful semi-parasite that helps reduce grass dominance. This gained ground very effectively and assisted in the apparent increase in diversity, see Photographs 1 and 2 (page 17). Hole House Lane N was a very botanically rich site to start with, so in reality 'no change' would be the desired objective of management here, while at Hole House Lane S which had previously been managed as a pasture, increasing parity with the northern part of the site was sought. The pairs of photographs for both parts of the site Photographs 3 and 4 (North) and Photographs 5 and 6 (South) (pages 19 and 20 respectively) demonstrate change toward this objective.

A further single survey conducted at Hollins Hollow (Photograph 7) (page 21) revealed a site which is currently managed 'in hand' by United Utilities, but which supports an array of BAP grassland indicators and would be suitable for conservation management under HLS HK6 or HK7.

4.2 Restoration of Species-Rich Semi-Natural Grassland (HK7) with Cattle Grazing (HR1)

Two areas within one field entered under this combination of measures were monitored, at How Hill. In both parts the current management has resulted in little change. In the more diverse plot, this means that diversity has been maintained which is positive. However, in the more species-poor area, little change means that HLS targets for positive indicators of Lowland Calcareous Grassland UK priority BAP habitat in the sward are not being met (Table 16 page 43), although the species are present at low abundances throughout the area and diversity per quadrat has increased slightly during the study period. Photographs 8 and 9) (page 23) illustrate the short-cropped structure of How Hill pasture which has shown little visible change during the monitoring. A third area on Dale House Pasture, surveyed just once in 2009, shows many similar characteristics to the poorer area of How Hill (though it represents a degraded example of different UK BAP habitat: Upland Hay Meadow) – see Photograph 16 (page 49).

Table 16 *Evaluation of Progress Toward Ecological Targets for Hay Meadows and Species-rich Pastures within HLS in Bowland (pink=meets target)*

	Phynis	**Hole House Lane (North)**	**Hole House Lane (South)**	**How Hill South (Kiln)**	**How Hill North**	**Dale House**	**The Den (New House Flushes)**	**Sheep Brows**	**Copped Hill**	**Hollins Hollow**
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
HLS Prescription	HK7, HK18 - restoration of species-rich, semi-natural grassland plus supplement for haymaking	HK7, HK18 - restoration of species-rich, semi-natural grassland plus supplement for haymaking		HK7, HR1 - restoration of species-rich, semi-natural grassland, plus cattle grazing supplement		HK7, HR1 - restoration of species-rich, semi-natural grassland plus cattle grazing supplement	HK6, HR1 - maintenance of species-rich, semi-natural grassland, plus cattle grazing supplement	EL3, HR1	HK6 - maintenance of species-rich, semi-natural grassland; with targets for BAP purple moor-grass and rush pasture	N/A, but targets should be set to maintain interest (eg. HK6) for BAP habitat purple moor-grass and rush pasture
HLS Target 1	Soil Phosphate Index should be 0 or 1	Soil Phosphate Index should be 0 or 1	Soil Phosphate Index should be 0 or 1	Soil Phosphate Index should be 0 or 1		Soil Phosphate Index should be 0 or 1	Soil Phosphate Index should be 0 or 1		Soil Phosphate Index should be 0 or 1	Soil Phosphate Index should be 0 or 1
Comment	*YES. ADAS index 0 (Very Low)*	*YES. ADAS index 0 (Very Low)*	*YES. ADAS index 0 (Very Low)*	*YES. ADAS index 1 (Low)*	*YES. ADAS index 0 (Very Low)*	*YES. ADAS Index value 1 (Low)*	*YES. ADAS Index 0 (Very Low)*		*YES. ADAS Index 0 (Very Low)*	*YES. ADAS Index 0 (Very Low)*

	Phynis	Hole House Lane (North)	Hole House Lane (South)	How Hill South (Kiln)	How Hill North	Dale House	The Den (New House Flushes)	Sheep Brows	Copped Hill	Hollins Hollow
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
HLS Target 2	By year 5 at least 2 high value indicator species for BAP grassland habitats: upland hay meadows and upland calcareous grassland, purple moor-grass & rush pastures and fen & lowland meadows should be frequent and 2 occasional in the sward.	By year 5 at least 2 high value indicator species: great burnet, common valerian, ragged robin, sneezewort, wild angelica, common marsh bedstraw, greater bird's-foot trefoil, devil's bit scabious and meadowsweet for BAP grassland habitat Purple Moor-grass & Rush Pasture should be frequent and 2 occasional in the sward.		By year 5 at least 2 high value indicator species for BAP grassland habitat: Lowland Calcareous Grassland should be frequent and 2 occasional in the sward.		By year 5 at least 2 high value indicator species for BAP grassland habitat: Upland Hay Meadow should be frequent and 2 occasional in the sward.	The extent of habitats of interest within the grassland as identified within the BHS citation should be maintained or increased.		At least 3 high-value indicator species of BAP grassland habitat Purple Moor Grass and Rush Pasture should be frequent and 2 occasional in the sward	At least 3 high-value indicator species of BAP grassland habitat Purple Moor Grass and Rush Pasture should be frequent and 2 occasional in the sward
Comment	*NEARLY. Year 4: yellow rattle a-d; black knapweed, rough hawk-bit, bird's-foot trefoil o. A further 5 spp are r.*	*YES. All 9 listed species present in N part, and 7 in S part, at dafors of r-a. Many additional positive indicators also present, eg. marsh valerian.*		*YES. 15 calcareous grassland indicators recorded 2007-10, of which 7 were at least locally f in 2010.*	*NO. 7 calcareous grassland indicators present 2007-10, all r at least once during period but only 2 spp recorded in 2010. Therefore not frequent enough.*	*NO. 1 positive indicator lf (pignut) 4 are lo-o (meadow vetchling, bird's-foot trefoil, greater bird's-foot trefoil, great burnet) and 2 lr-r (tormentil & betony)*	*Habitat extent maintained*		*YES. 11 vascular indicators of PMG at abundances of f or more, plus 6 species Sphagnum moss present.*	*YES. 11 vascular indicators of PMG at abundances of f or more.*

	Phynis	Hole House Lane (North)	Hole House Lane (South)	How Hill South (Kiln)	How Hill North	Dale House	The Den (New House Flushes)	Sheep Brows	Copped Hill	Hollins Hollow
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
HLS Target 3	Cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between 20% and 90%. At least 60% of wildflowers should be flowering between May-August.	By year 10, at least 10 high-value indicators for the BAP habitat feature Purple moor grass and rush pasture should be frequent in the sward.		By year 10, at least 4 high-value indicators for BAP grassland Lowland Calcareous Grassland should be occasional in the sward.		By year 10, at least 4 high-value indicators for BAP grassland Upland Hay Meadow should be frequent in the sward.	At least 2 high-value indicators for BAP grassland Lowland Pastures should be frequent and 2 occasional in the sward		Soil pH should be between 5.5 and 7	Cover of patches of bare ground should be between 1 and 5%.
Comment	*YES. Undesirable species not problematic at this site. Hay cut at end July/early August will preclude later flowering species.*	*YES. 12 positive indicators of PMG already frequent to abundant in sward in 2010, with a total of 42 positive indicators for PMG & UHM lverall recorded from site. Looks likely to achieve target.*		*YES, already achieved by 2010, need to maintain to 2015. See above*	*NO for this part of field - target not yet achieved though species present so may be possible by 2015*	*NO. Year 10 not reached yet so target still possible to achieve, as positive indicators are present at low abundances.*	*YES. 11 species considered positive indicators frequent in 2010 (41 positive indicators recorded 2007-10)*		*NO. pH = 4.7*	*YES. Bare ground = c. 2% cover in 2009*

	Phynis	Hole House Lane (North)	Hole House Lane (South)	How Hill South (Kiln)	How Hill North	Dale House	The Den (New House Flushes)	Sheep Brows	Copped Hill	Hollins Hollow
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
HLS Target 4	By year 3, cover of bare ground between 1% and 5%.	In all years, populations of locally significant species: Saw-wort should be maintained.		In all years, populations of nationally scarce species: limestone bedstraw should be maintained.		By year 5, cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between 20% and 90%. At least 50% wildflowers should be flowering in May-July.	Cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between 20% and 90%. At least 50% wildflowers should be flowering in May-June.		By year 3, bird's-eye primrose should be frequent and flowering. Cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between40% and 90%. At least 50% of wildflowers should be flowering during May-July.	

	Phynis	Hole House Lane (North)	Hole House Lane (South)	How Hill South (Kiln)	How Hill North	Dale House	The Den (New House Flushes)	Sheep Brows	Copped Hill	Hollins Hollow
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
Comment	*YES. Bare ground at low % cover (<1%)*	*YES. Saw-wort moved from o to f-a in dafor lists, and in both N and S plots, frequency of occurrence in quadrats increased. Other locally significant species present include pale sedge*		*YES. Localised population around limestone outcrops reasonably abundant.*	*NO. Species yet to be recorded in this area*	*NO. Grass:forb ratio 80:20-90:10, but without white clover, the ratio of wildflowers would be significantly lower*	*YES. Present grass:forb ratio is 70:30 to 90:10. Sward dominated by sedges, grasses and rushes.*		*NO. bird's-eye primrose rare in 2009. Grass:forb ratio probably c. 60:40 in flushed areas but much more grass dominated elsewhere - meets criteria locally.*	
HLS Target 5	Cover of undesirable species such as creeping thistle, spear thistle, curled & broad-leaved docks, common ragwort and common nettle < 5%. Use agreed control methods.	By year 5, cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between 20% and 90%. At least 50% wildflowers should be flowering in May-July.		By year 5, cover of wildflowers in the sward (excluding undesirable species but including rushes and sedges) should be between 20% and 90%. At least 50% wildflowers should be flowering in May-July.		By year 2, cover of patches of bare ground should be between 1 and 5%.	Cover of bare ground should be between 1 and 5%.		Cover of patches of bare ground should be between 1 and 5%.	

	Phynis	Hole House Lane (North)	Hole House Lane (South)	How Hill South (Kiln)	How Hill North	Dale House	The Den (New House Flushes)	Sheep Brows	Copped Hill	Hollins Hollow
Tenancy	Croasdale	Halsteads	Halsteads	Halsteads	Halsteads	Halsteads	Catlow	Catlow	Catlow	UU In Hand
Comment	*YES. Undesirable species not an issue*	*YES. % cover forbs is between 25% and 40%. Most wildflowers in flower at time of survey (July)*		*YES. grass:forb ratio = 50:50 in places. Flowering times probably achieved.*	*NO. Still 95:5 with grass dominating.*	*NO. Bare ground 0.5% in 2009*	*YES. C 2% bare ground present*		*YES. Bare ground was c. 13% within study plot, but lower on dome of hill, so perhaps averages out to acceptable levels across whole site.*	
HLS Target 6		By year 2, cover of patches of bare ground should be between 1 and 5%.		By year 2, cover of patches of bare ground should be between 1 and 5%.						
Comment		*NO. Bare ground at <1% for both parts of field.*		*YES. c. 1.3% cover bare ground.*	*NO. Extent of bare ground is negligible (<1%) so few colonisation gaps.*					

Photograph 16 *Dale House Pasture on 22nd July 2009, short and grassy cattle grazed sward*

4.3 Maintenance of Species-Rich Semi-Natural Grassland (HK6)

The single monitoring site to which these measures apply is The Den, which is part of the New House Flushes Biological Heritage Site. Here, a low increase in species per quadrat was observed (not significant) and little other change in sward structure, as evidenced by Photograph 10 (page 28). Overall, The Den has maintained its high level of botanical diversity and meets all its HLS targets – a positive outcome. A nearby field, Sheep Brows was surveyed for comparison but managed in a similar way with very low inputs under EL3 and HR1 shows comparable trends but few other changes.

A third field, Copped Hill, was surveyed in 2009 only and found to fall just short of its HLS targets at that time especially for abundance of bird's-eye primrose which was rare not frequent. Poaching was indentified as a potential management issues at this site, see Photograph 11 (page 30).

4.4 Restoration of Rough Grazing for Birds (HL8) with Cattle Grazing (HR1)

Of the seven sites adopting rush pasture management, HL8, restoration through rush management and scrape creation has been applied to six plots in five fields, with rush management being carried out in four fields and the cattle grazing supplement also applied to four areas.

Restoration objectives were aimed at improving habitats for breeding birds and the HLS does not specifically set targets for enhanced botanical interest for these sites. However, it was hoped that the implementation of cattle grazing, rush management and scrape creation might lead to increases in botanical diversity. Fields monitored were grouped into those that were already botanically interesting and supported UK priority BAP habitat, those with potential for restoration to UK priority BAP habitats eg. Upland Hay Meadow, and those of low botanical interest with lower potential for enhancement.

There were two already botanically interesting sites, representing examples of UK BAP priority habitat Purple Moor-grass and Rush Pasture and broad habitat type Acid Grassland – Old Ings and Black Sides North respectively. Both sites were included as reference sites and as such management has changed little under the current HLS, as confirmed by the monitoring which found no significant changes though a low increase in vascular diversity was seen at both sites. Photographs 13, 14 and 15 (pages 35 and 36) illustrate the low-productivity swards typical of these sites during the monitoring study. Black Sides North shows some suitability for restoration to UK priority Blanket Bog habitat.

Two fields supported semi-improved grassland with vestigial characters of upland hay meadow of species-rich pasture communities with potential for restoration to these UK priority BAP habitats: Cocklet End and Low Sides. A move to cattle grazing was experienced at both sites under the HLS, scrapes have been created (see Photograph 17 below), and rush treatment has been carried out in some areas. Both sites have reasonable diversity though the abundance of BAP grassland indicator species is low and agriculturally favoured species dominate. In particular, at Low Sides (Photograph 18 below), key indicator sneezewort increased in abundance to locally frequent by 2010, and other positive wildflower species were also present at lower abundances. No significant change has been found at either site during the monitoring, though diversity per quadrat was seen to increase slightly.

Photograph 17 *Cocklet End on 21st July 2010, field is still grass-dominated rushy pasture with scrapes created in 2008*

Photograph 18 *Low Sides on 28th July 2010, with rushes in a short grassy sward with few wildflowers save marsh thistle. Little change since 2007. Mowing commenced this year is likely to be beneficial*

The remaining three plots, located in two fields, were classified as having low botanical interest and hence lower potential for enhancement. Two sites were in Whitendale Inbye (Photographs 19 and 20 page 51) and the third at Black Sides South (Catlow) (Photographs 21 and 22 page 51). At all sites cattle grazing has been coupled with rush management and scrape creation (though not on the reference area at Whitendale during the term of the study). Again, change was not significant though low increases in quadrat diversity were recorded. Sites were considered to offer some potential for botanical enhancements but the gains possible without seed introduction would be expected to be limited.

Photograph 19 *Whitendale Reference Plot on 27th July 2010, rushes remain dense and vigorous though treated in 2007 then left*

Photograph 20 *Whitendale Pasture on 27th July 2010, rushes have been eradicated since treatment commenced in 2007*

Photograph 21 *Black Sides S on 16th July 2009, showing rush growth on 3rd year after cutting*

Photograph 22 *Black Sides S on 28th July 2010, a species-poor sward following cutting late 2009 leaving thick mats of litter*

5 FURTHER MANAGEMENT

The findings of the monitoring since 2007 have indicated additional further management measures over and beyond those outlined within the HLS and ELS schemes may deliver conservation benefits. These are supported by the study and are targeted at achieving maximum gains for biodiversity and UK BAP habitats (and species), especially where indications are good for UK priority BAP habitats Upland Hay Meadows and Species-rich Grasslands and Purple Moor-grass and Rush Pastures. The recommendations are listed by site.

5.1 Phynis

The HLS agreement for Phynis states that: '*If species richness of field does not increase over the first 4 years additional native wildflowers will be introduced via hay strewing / seeding to achieve the indicators of success*'. Hay strewing is the next step recommended in the HLS, and could be carried out using a nearly local source (eg. an SSSI such as Langcliff Cross SSSI) in 2011.

Rodwell (1992) notes that choking of drains within stands of MG6 may lead eventually to the development of MG10 Yorkshire fog - rush communities (generally of lesser conservation interest than precursor communities such as MG5) and would be a retrograde step in ecological terms. At nearby Langcliff Cross SSSI meadow, achievement of favourable condition by 2008 is considered by NE to have been underpinned by drain restoration carried out at the site in 2005 (comment on Natural England website: Condition of SSSI units Feb 2011). Langcliff Cross contains seven indicator species of MG3 grassland namely, knapweed, pignut, eyebright, meadow vetchling, autumn hawkbit, yellow rattle and great burnet and is considered to be a good example of the type of habitat which Phynis could support. Therefore consideration could also be given to restoring field drains in a similar way at Phynis, although this should only be considered if restoration targets continue to be missed and impeded drainage was recognised as the cause. Information should be sought from Natural England on the decision process undertaken at Langcliff Cross. Increases in abundance of sharp-flowered or soft rush at Phynis could be an early indicator of impeded drainage, and neither species is seen to be particularly problematic at this stage.

5.2 Hole House Lane

Although the site is entered into the HLS for 'restoration' management, the vegetation at the site is already rich and varied and supports an array of indicators of local distinctiveness. Care should be taken not to over manage the site, but rather to address issues so that it can maintain and improve its biodiversity. This might mean only aiming to achieve a hay cut one year in three, grazing a little more or less dependant upon fodder availability and bare ground targets (small amounts of bare ground from poaching provide colonisation gaps for desirable forbs). Mowing should not take place unless sure of removal of arisings.

5.3 Hollins Hollow

Hollins Hollow is not included within any HLS scheme at present, but the vegetation is considered to be in good condition and suitable for conservation management. It is understood that a hay cut and removal was made in 2008 at this site, but conservation management via light cattle grazing may be sufficient to maintain existing interest. However, hay cutting after mid-July in dry years may help to further enhance the interest of the site.

5.4 How Hill and Dale House

Rodwell (1992) notes that in older pastures allocated to the MG6 type, a return to more traditional organic manuring and withdrawal of summer grazing may assist the re-establishment of upland hay meadow vegetation where certain meadow species persist, but once desirable species are gone, extensive[4] management alone is not usually sufficient to restore grassland diversity (Natural England 2009a). Therefore, unless withdrawal of summer grazing is possible at How Hill, targeted seed addition from local sources may be needed to deliver already agreed HLS targets to the timetables set at both How Hill North and Dale House; an approach which is advocated in the literature (O'Reilly 2010, Edwards *et al.* 2007, Natural England 2009b, Trueman and Millett 2003). Applications of farmyard manure at 24 tonnes per hectare per year have been shown to reduce species diversity in hay meadows in Cumbria and Monmouthshire, and lower application rates maintained diversity variously dependent upon their previous management (Kirkham *et al.* 2008).

5.5 The Den

The flushed area forming The Den (New House Flushes Biological Heritage Site) spans two fields, the northern part of which is contained by a stock-proof fence. The southern part (where the sample area lies) is part of a much larger field, mostly rushy pasture, all of which is grazed as one field. To best manage the flushes as a whole, it would be beneficial to fence off this second area where the steep slope to the River Hodder gives way to more gently sloping rushy pasture above. Thus the grazing and trampling pressure on the flush could be more closely controlled and the risk of proliferation of soft rush reduced. Creeping thistle may need further management within this area.

5.6 Copped Hill

At Copped Hill, soil pH falls below target levels, but it is thought that the site is probably naturally acidic and that the current soil pH may be appropriate. However, the low abundance of bird's-eye primrose is a more genuine matter for concern. Management changes, perhaps via a reduction in grazing or further limiting of grazing periods in the flowering and seed-setting season for the species, may be able to restore bird's-eye primrose to its former abundance. In addition, measures need to be taken to reduce poaching during wet weather conditions. Indeed such measures may also benefit other parts of the site as high levels of erosion along the stream banks were also noted.

5.7 Sheep Brows

Management at Sheep Brows could continue as it is, to maintain the existing nature of the site. However, Sheep Brows could potentially be improved botanically by hay-strewing from a more diverse site, such as Phynis (Croasdale), and perhaps from a lightening of grazing pressure and some rush treatment. However, as the site is quite acid, any seed addition may need to be accompanied by lime application and harrowing to break up the dense grassy mat.

5.8 Old Ings

Old Ings is a variable field with localised botanical interest where further drainage, liming and nutrient additions should be avoided. The botanical diversity of this field, which contains 14 bryophyte species, needs to be maintained after the end of the SCaMP monitoring study. The methods would include: maintenance of water levels - no further drainage, and blocking of existing drains/grips; a cessation of any inputs of fertiliser and lime; a grazing regime as advised under HLS; localised soft rush control re-

[4] Extensive management refers to low input regimes with light grazing.

instated, ensuring that cut material is removed, and that herbicide is applied by weed-wipe to target species only.

5.9 Black Sides North

Cattle grazing at Black Sides North could have a potential role in reducing the cover of mat grass to increase species diversity and such a move would be interesting to monitor. The presence of heather and bilberry indicates potential suitability for restoration to a mire habitat, eg. UK priority BAP habitat Blanket Bog. To encourage development of this habitat and to maintain the good range of mosses, blocking of derelict grips could be considered. Future monitoring could include looking for increased *Sphagnum* bog-moss cover following grip blocking measures. It may take time to return the area to blanket bog mire vegetation, but such measures may also provide better conditions for breeding birds - especially waders - in the more immediate future through increased wetting effects.

5.10 Cocklet End and Low Sides

At both Cocklet End and Low sides, the ideal management would be under HK7 with HK18 hay cutting, as both sites are easily accessible for this. Soil pH is suitable for hay meadow and species-rich grassland restoration, as are low soil nutrient levels. Vestigial meadow herbs persist at both sites, but at low abundances. The objectives would be to achieve BAP indicators for Upland Hay Meadow and/or Purple Moor-grass and Rush Pasture habitats.

Negative species such as Yorkshire fog and white clover could be managed at both sites by yellow rattle seed, as the species has been shown to parasitize the first two (Westbury 2004) which are dominant in the sward. One-off liming might assist with yellow rattle application, and further diversification may be achieved by hay strewing / seeding to achieve indicators of success for hay meadow restoration (eg. Phynis in Table 16 page 43).

5.11 Black Sides South

At Black Sides South, a suitable botanical objective would be to restore Purple Moor-grass and Rush Pasture UK priority BAP habitat at this site. To diversify the sward, the vegetation needs to be cut with the removal of arisings annually for five years or more, plus reduced farm yard manure application ideally to none or, less desirably, a single low level application one year in five.

5.12 Whitendale

At Whitendale Inbye, marsh thistles should not be cut as these are not a target species for control. If increases in species diversity are desired for Whitendale, all farm yard manure and lime applications should ideally cease. While pH would be suitable for yellow rattle introduction in the Pasture area, some scarifying may be needed beforehand to create colonisation gaps for seed. Restoration of purple moor-grass and rush pasture or mire habitats could also be encouraged through blocking of transverse ditches to attenuate water flows. Wooden sluices would probably be most effective. However, because of the length and number of drains (five), this may be costly. A more localised option (and therefore cheaper) would be to block the top section of each drain to retain wetter conditions in the far western corner of the field.

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APPENDIX I

Detailed Data Collection Methods

APPENDIX I - DETAILED DATA COLLECTION METHODS

Introduction

This document forms part of the Additional Information provided to United Utilities in support of their report on Scamp BAP habitats Upland Hay Meadows, Species-rich Grasslands and Rush Pastures.

All botanical nomenclature follows Stace (2010) for vascular plants and Smith (2006) for bryophytes (although data on the latter were only collected rigorously in 2009 and 2010). A full list of the species encountered at each site is presented in the SCaMP database.

Hay Meadows, Species-Rich Grasslands and Rush Pastures Survey Methodology

The detailed data collection methodology was adapted from the Common Standards Monitoring guidance for Lowland Grassland Habitats produced by JNCC (2004). Annual surveys were repeated at a similar time of year for each site to maintain comparability between datasets.

For each site the following data was recorded. This data was handled and analysed as outlined below.

Whole Plot Data

Each year, data was collected at each site on: surveyors; date; general site description; management in past year; grass:forb ratio; rare or notable species; and other general comments.

A full dafor[1] list was collected each year, supplemented with additional species from the presence/absence and NVC quadrat data.

In addition, fixed point photos were taken each year. Fixed point photos were compiled into time-series for each site, selecting the most characteristic view to illustrate site features and condition.

Three top soil samples were taken at each site. These were analysed for available P, K, Mg, pH and for bio-available Nitrogen (NO_3NH^4), using standard techniques from an accredited laboratory.

Presence/Absence Quadrats

Sample plots were set out using GPS to locate approximately the same area each year. Canes were used to mark corners and midpoInts along each axis. Sample plots ranged in size from 50m x 50m to 100m x 100m, depending upon the site, and record of the plot size was made each year.

Within each sample plot, thirty 50cm x 50cm quadrats were recorded, noting presence of all vascular species as well as vegetation height (cm); % cover bare ground, % cover moss, and % cover dead plant litter. The presence of more abundant moss species was also recorded in most cases. Quadrat locations were determined using random number tables to generate coordinates and then pacing these out. The aim was to sample the sample plot area in an unbiased way.

[1] The dafor scale: d=dominant, a=abundant, f=frequent, o=occasional, r=rare.

National Vegetation Classification

Quadrat data specifically for use in determining associations with the National Vegetation Classification (NVC) were collected in 2009 only. The method followed the standard procedure for data collection, as set out in Rodwell (1991, 1992), in which a 2m x 2m quadrat was set out and DOMIN scores for all vascular and bryophyte species encountered were recorded. At each site, up to three representative quadrats were collected, depending upon the variability present at that site.

In the 2008 progress report, presence/absence quadrat data was used to generate interim NVC associations, but this approach is not the accepted method, and the 2009 data presented in this report supersede any classifications made previously.

Data Handling and Analysis

Whole Plot Data

Summary tables containing notes on management, site condition, rare species and other site features were compiled for each site, covering the full survey period.

Species lists and Dafor scores were compiled for 2007 to 2010 for each site. These lists contained all species recorded at each site in quadrat data and additional dafor records.

The presence of positive and negative indicator species was also highlighted, especially where these occurred at high frequencies in the data or had increased notably during the study period. Sources of information on potential indicator species included: Common Standards Monitoring Guidance for Lowland Grassland Habitats (JNCC 2004); Biological Heritage Sites Guidelines for Site Selection (Lancashire County Council 1998); botanical identification guides and professional expertise. Table 1 (below) summarises the selection of positive and negative indicator species for Bowland grassland habitats. Dafor lists were used to compile general comments about trends in plant abundance at each site and to examine the dynamics of positive and negative indicator species present.

Table 1 *Selection of positive and negative indicator species for Bowland grassland habitats (based upon JNCC 2004 and other sources)*

Positive Indicators
Occurrence of plant species indicators for NVC communities for species-rich grasslands (ie. MG3, MG4, MG5 and MG8) and for rush pasture (ie. M22, M23, M24, M25 and M26)
Presence of species which are indicators of local distinctiveness, eg. plant species of semi-natural grasslands, swamps and fens (Lancashire County Council 1998).
Negative Indicators
Agricultural weeds (creeping thistle, cow parsley, spear thistle, cleavers, greater plantain, curled dock, common ragwort, common nettle, field horsetail, broad-leaved dock)
Agriculturally favoured species (eg. perennial rye-grass, white clover, timothy, soft brome, Yorkshire fog)
Rank grasses and sedges (eg. false oat-grass, cock's-foot, tufted hair-grass, larger rush species and large sedges)
Incursion and spread of bracken, scrub or tree cover, or of any other undesirable species.

A full list of all species encountered in the monitoring study and categorisation of positive and negative indicators is presented in Table 2 (below).

Table 2 *Species of positive and negative indicators for upland hay meadows, species-rich grasslands and rush pastures in Bowland, from a range of sources*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Vascular Plants			
Ash tree seedling	*Fraxinus excelsior*		SCRUB
Autumn hawkbit	*Leontodon autumnalis*	* UHM	
Bilberry	*Vaccinium myrtillus*	Heaths, particularly H12	
Bird's-foot primrose	*Primula farinosa*	* UHM/calcareous grassland	
Bird's-foot trefoil	*Lotus corniculatus*	UHM	
Bitter vetch	*Lathyrus linifolius*	* UHM	
Bramble	*Rubus fruticosus agg.*		SCRUB
Broad-leaved dock	*Rumex obtusifolius*		AW
Broad-leaved ragwort	*Senecio fluviatilis*		Non-native
Bugle	*Ajuga reptans*	*	
Bulbous buttercup	*Ranunculus bulbosa*	*	
Burnet-saxifrage	*Pimpinella saxifraga*	* UHM	
Carnation sedge	*Carex panicea*	*	
Cat's ear	*Hypochaeris radicata*	*	
Cleavers	*Galium aparine*		AW
Cock's-foot	*Dactylis glomerata*		RGS
Common cottongrass	*Eriophorum angustifolium*	Mires	
Common couch	*Elytrigia repens*		RGS
Common knapweed	*Centaurea nigra*	UHM, PMG	
Common marsh-bedstraw	*Galium palustre*	UHM, PMG	
Common milkwort	*Polygala vulgaris*	UHM	
Common nettle	*Urtica dioica*		AW
Common spotted-orchid	*Dactylorhiza fuchsii*	UHM, PMG	
Common twayblade	*Listera ovata*	*	
Common valerian	*Valeriana officinalis*	PMG	
Compact rush	*Juncus conglomeratus*		RGS
Corn mint	*Mentha arvensis*	*	
Cow parsley	*Anthriscus sylvestris*		AW
Cranberry	*Vaccinium oxycoccos*	Mires, particularly bogs	
Creeping buttercup	*Ranunculus repens*		AF
Creeping thistle	*Cirsium arvense*		AW
Creeping willow	*Salix repens*	* PMG	
Crested dog's-tail	*Cynosurus cristatus*	*	
Curled dock	*Rumex crispus*		AW
Dandelion	*Taraxacum officinale* agg.		AW
Deergrass	*Trichophorum germanicum*	Mires, particularly bogs	
Devil's-bit scabious	*Succisa pratensis*	* UHM, PMG	

Table 2 *continued*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Downy oat-grass	*Helictotrichon pubescens*	*	
Dyers greenweed	*Genista tinctoria*	* UHM	
Eyebright	*Euphrasia nemorosa agg.*	UHM	
Eyebright	*Euphrasia officinalis agg.*	UHM	
Fairy flax	*Linum catharticum*	*	
False oat-grass	*Arrhenatherum elatius*		RGS
Fen bedstraw	*Galium uliginosum*	UHM, PMG	
Field horsetail	*Equisetum arvense*		AW
Field wood-rush	*Luzula campestris*	*	
Flea sedge	*Carex pulicaris*	*	
Floating sweet-grass	*Glyceria fluitans*		RGS
Glaucous sedge	*Carex flacca*	*	
Great burnet	*Sanguisorba officinalis*	* UHM, PMG	
Greater bird's-foot trefoil	*Lotus pedunculatus*	UHM, PMG	
Greater plantain	*Plantago major*		AW
Hard rush	*Juncus inflexus*		RGS
Harebell	*Campanula rotundifolia*	*	
Hare's-tail cottongrass	*Eriophorum vaginatum*	Mires	
Hawthorn	*Crataegus monogyna*		SCRUB
Heath rush	*Juncus squarrosus*		RGS
Heath speedwell	*Veronica officinalis*	*	
Heath wood-rush	*Luzula multiflora*	*	
Heather	*Calluna vulgaris*	PMG	
Heath-grass	*Danthonia decumbens*	*	
Hogweed	*Heracleum sphondylium*		RGS
Lady's bedstraw	*Galium verum*	UHM	
Lady's-mantle spp (not *A. mollis*)	*Alchemilla sp.*	UHM	
Lesser pond-sedge	*Carex acutiformis*		RGS
Lesser skullcap	*Scutellaria minor*	*	
Lesser spearwort	*Ranunculus flammula*	UHM	
Lesser stitchwort	*Stellaria graminea*	*	
Limestone bedstraw	*Galium sterneri*	*	
Long-stalked yellow-sedge	*Carex viridula ssp. brachyrhyncha*	*	
Lousewort	*Pedicularis sylvatica*	* PMG	
Marsh cinquefoil	*Potentilla palustris*	* UHM, PMG	
Marsh marigold	*Caltha palustris*	* UHM, PMG	
Marsh valerian	*Valeriana dioica*	* UHM, PMG	
Marsh Violet	*Viola palustris*	UHM, PMG	
Meadow oat-grass	*Helictotrichon pratense*	*	
Meadow vetchling	*Lathyrus pratensis*	* UHM	
Meadowsweet	*Filipendula ulmaria*	* UHM, PMG	
Mouse-ear hawkweed	*Pilosella officinarum*	*	

Table 2 *continued*

Common Name	Scientific Name	Positive Indicators	Negative Indicators
Narrow buckler-fern	*Dryopteris carthusiana*	*	
Narrow-leaved meadow-grass	*Poa angustifolia*	*	
Oxeye daisy	*Leucanthemum vulgare*	*	
Pale sedge	*Carex pallescens*	*	
Perennial rye-grass	*Lolium perenne*		AF
Pignut	*Conopodium majus*	UHM	
Purple moor-grass	*Molinia caerulea*		RGS
Quaking-grass	*Briza media*	*	
Ragged-robin	*Lychnis flos-cuculi*	* UHM, PMG	
Reed canary-grass	*Phalaris arundinacea*		RGS
Rough hawkbit	*Leontodon hispidus*	UHM, PMG	
Rough meadow-grass	*Poa trivialis*		AF
Salad burnet	*Sanguisorba minor*	* UHM	
Saw-wort	*Serratula tinctoria*	* UHM, PMG	
Selfheal	*Prunella vulgaris*	*	
Sharp flowered rush	*Juncus acutiflorus*	PMG	
Sheep's-fescue	*Festuca ovina*	*	
Slender St John's-wort	*Hypericum pulchrum*	*	
Sneezewort	*Achillea ptarmica*	* PMG	
Soft brome	*Bromus hordeaceus*		AF
Soft-rush	*Juncus effusus*		RGS
Spear thistle	*Cirsium vulgare*		AW
Spring sedge	*Carex caryophyllea*	*	
Star sedge	*Carex echinata*	*	
Sweet vernal-grass	*Anthoxanthum odoratum*	*	
Tawny sedge	*Carex hostiana*	*	
Timothy Grass	*Phleum pratense*		RGS, AF
Tormentil	*Potentilla erecta*	UHM, PMG	
Tufted hair-grass	*Deschampsia cespitosa*		RGS
Water avens	*Geum rivale*	* UHM, PMG	
Water mint	*Mentha aquatica*	UHM, PMG	
White clover	*Trifolium repens*		AF
Wild angelica	*Angelica sylvestris*	PMG	
Wood anemone	*Anemone nemorosa*	* UHM	
Yellow oat-grass	*Trisetum flavescens*	*	
Yellow rattle	*Rhinanthus minor*	* UHM	
Yellow sedge	*Carex viridula*	*	
Yorkshire fog	*Holcus lanatus*		AF
Mosses			
Bog moss	*Sphagnum* species	PMG	

Table 2 *continued*

Key	
AF - Agriculturally Favoured	UHM - Upland Hay Meadow/Species-rich Grassland
AW - Agricultural Weeds	PMG - Purple Moor Grass & Rush Pastures priority BAP habitat
RGS - Rank Grassland Species	SCRUB - Scrub
* distinctive species/indicators of unimproved grassland/rush pasture	RP - Rush Pastures

The results of the soil sample analysis were tabulated and mean values per year calculated. Parity between years was sought, to ensure that alterations in vegetation were not due to soil chemistry change.

Fixed Point Photos were taken at alls ties in all years, and these were examined for change over time. Where time-series illustrated change this was discussed and illustrated in the report, but otherwise pictures were simple added to the database for future reference. Dramatic visual change was not really expected at most sites, where management alterations were relatively subtle.

NVC

An analysis of NVC community affinities was based upon NVC quadrat data collected in 2009. The NVC analyses were be carried out using the MATCH 4 software (Thomson 2004). A summary of the analysis was tabulated for presentation in Appendix, listing the main community types identified for each site and highlighting any existing and potential communities of conservation interest.

Presence/Absence Data

Excel spreadsheets of all botanical quadrat data were compiled containing data from 2007, 2008, 2009 and 2010 surveys. Botanical data was separated into vascular plants and bryophytes and only the vascular data was included in the following analyses.

Top Ten Species

An assessment and comparison of the frequency of positive and negative indicators of condition for the habitats was undertaken for each site, looking at trends in species present in the T10 over the study period. T10 species were tabulated and graphed, the presence/absence of negative and positive indicators was examined, and conclusions drawn.

DCA

Detrended Correspondence Analysis (DCA) performed using CANOCO 4.5 software (Microcomputer Power, USA) was used to explore the changes in plant species data at each site over the monitoring period 2007 to 2010. Analysis was performed using a standard run within the CANOCO software package, setting data from 2008 to 2010 as supplementary to the 2007 baseline. Rare species were down-weighted to reduce their influence on the resulting ordination diagram. The reasoning behind this is explained in Jongman *et al*. (1995). Where axes 1 and 2 were found to explain 20% or more of the variability, the analysis was taken to provide a good representation of the data, and was used to draw conclusions about the monitoring.

Spearman Rank Correlation

The quadrat data were analysed for correlation between years using the non-parametric Spearman Rank Correlation Coefficient. This test is widely used where species data are not normally distributed, as here. The correlation coefficients generated were examined for significant positive correlation (ie. little change

in the data) and for the amount of variation or scatter which, if increasing, may indicate change. Potential sources of change are discussed.

Comparison with HLS Targets

HLS (or equivalent) targets were extracted directly from the stewardship agreements and tabulated for each site. Comments on progress toward these targets were made, based upon the information collected during this study. Views on the efficacy of current management and potential options for the future are presented in the Discussion chapter.

Literature Review

A desk-based literature review was undertaken, accumulating both web-based and printed resources relating to the management of upland hay meadows and pastures. Search terms used singly and in combination were: hay, meadow, management, upland, rush, pasture, species-rich.

These papers were organised according to the topics covered, as follows:

- papers that recommend sward enhancement methods in general;
- papers on grazing;
- papers recommending seeding;
- papers recommending hay strewing;
- papers recommending plug planting;
- papers on *Molinia* pastures;
- papers on soil fertility limiting species richness;
- papers on yellow rattle use in restoration;
- papers on soil seed banks and their relevance to restoration;
- papers on cutting / mowing.

Relevant material was used to inform and support existing management and proposals for future management within the summary of the Hay Meadow, Species-Rich Grassland and Rush Pasture report.

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