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An analysis of survey data from upland hay meadows in the North Pennines AONB

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. The views in this report are those of the authors and do not necessarily represent those of Natural England.

Background

There is evidence from various sources that the quality of species-rich upland hay meadow vegetation has declined in recent decades, even in sites that are under conservation management agreements. In addition, some important species-rich grassland communities in upland hay meadows remain poorly described and therefore inaccessible to nature conservation staff.

Comprehensive surveys of upland hay meadows in the North Pennines were undertaken in the early 1980s by the NCC. More recently, the Hay Time project undertook surveys of a large number of upland hay meadows in the North Pennines. This was the most comprehensive survey of upland hay meadow vegetation in the area since the NCC survey.

This large volume of data gave the opportunity to conduct a detailed analysis of the current composition of upland hay meadow vegetation. It also allowed some comparisons to be made with a similar-sized dataset from roughly 25 years earlier.

These analyses help to clarify some current grey areas relating to the diversity of upland hay meadow vegetation. Several types of species-rich upland hay meadow vegetation that are currently poorly described and/or understood are described in some detail. These data will help to broaden the technical definition of the upland hay meadows UKBAP priority habitat.

The recent changes in vegetation composition highlighted by comparisons with previous data, raise some particular topics worth researching further relating to upland hay meadow management. This could help inform future research aimed at improving the management prescriptions and guidance for SSSIs and meadows in HLS.

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Further information
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Summary
Section 1 explains the survey methodology and data collection protocol used and explains how the data is presented in the floristic tables. Section 2 presents all of the data, which are divided between the 4 main meadow vegetation types. The differences between these 4 main types are described. Section 3 presents the data on MG7 and describes the two sub-communities of MG7 found in North Pennines meadows. Section 4 presents the data on MG6 which are divided between three variants of MG6b. These are described and the conservation importance of the richest variant (MG6b-iii) is highlighted. Section 5 presents the data on MG3. The data are followed by a discussion on changes in MG3 vegetation in recent decades and possible causes for some of these changes. The three sub-communities of MG3 are described and the conservation significance of MG3c is highlighted. Section 6 presents the data on MG8, which are divided between 4 variants of MG8. The conservation importance of the richest type of MG8, which includes populations of northern-montane species (MG8n) is highlighted. Section 7 presents the results of soil sampling and analysis done from a subset of the meadows and discusses some of the significant results. Section 8 presents an overview of the main types of vegetation found in upland hay meadows and includes brief descriptions on types of vegetation not covered in the preceding sections. Section 9 highlights some remaining major gaps in our knowledge of British upland hay meadow vegetation. The main recommendations include:

- Survey and define the types of vegetation that are currently poorly understood
- Broaden the UKBAP definition of the Upland Hay Meadow habitat to include all types of species-rich grassland that occur in upland hay meadows and that include northern-montane species.
- Compare these data to similar data from older surveys, to assess changes in the vegetation.
- Compare these data to similar data from recent surveys in other parts of the range of the habitat in Britain, to assess if the changes are consistent through the range of the habitat.
- Analyse the ecological traits of species that appear to have become more frequent in species-rich MG3 vegetation.

1 Introduction, survey methodology and how to read the floristic tables.

The Hay Time project

The Hay Time project in the North Pennines is run by the North Pennines AONB Partnership. It began in 2006. The main focus of the project is on restoration and enhancement of species-rich upland hay meadows by harvesting green hay from species-rich meadows to spread on other meadows that are being restored. A similar type and size of project runs concurrently in the Yorkshire Dales, which is run by the Yorkshire Dales Millennium Trust. The project also provides conservation management advice to landowners and managers. The target for the amount of hay spreading in the first 3 years of the project was 120 hectares. Almost 600 meadows were surveyed in the North Pennines AONB in 2006, 2007 & 2008.

The rationale for the project was largely due to concerns over continuing declines in extent and quality of the upland hay meadow resource. An overall decline in quality of upland hay meadow vegetation has been well documented (Pacha 2004, Hewins *et al*. 2005, Critchley *et al*. 2004, Bradshaw 2009). Pacha (2004) has documented in detail the decline in populations of wood crane's-bill *Geranium sylvaticum* and the fragmentation of the upland hay meadow habitat in the Yorkshire Dales National Park in the last two decades of the twentieth century. Some of the more important changes in farming practices over the past 50 years are summarised in Bradshaw (2009). Hewins *et al*. (2005) found that about 25% of non-statutory upland hay meadows that were included on the Grassland Inventory, had deteriorated in quality so much that they were now closest to MG6, MG7 or MG9. Some of the factors behind the changes in upland hay meadow vegetation are examined in some detail in Critchley *et al*. (2004).

Time constraints for surveying upland hay meadows

The optimum survey season for hay meadows is shorter than most other habitats. There is a short period in early summer when the vegetation is allowed to grow and most species are visible. The sward is normally kept short at other times of year. In winter, about 35% of meadow species are invisible as they overwinter below ground as seeds, rhizomes, tubers, bulbs, etc. (R. Jefferson pers. comm.). Most meadows in the area are in some kind of agri-environment agreement. The rules of these agreements normally allow spring grazing up to mid-May and cutting by early to mid July. In the first week after the stock have been removed in the spring, plants are only just starting to grow. This leaves a maximum period in many meadows of about 7 weeks during which reasonably comprehensive surveys can be accomplished. The optimum period for surveying is the 3 week period between about 15 June and 7 July and all of the project's more detailed monitoring surveys from 2007 on, were carried out in this period. It is easier to assess the full range of grass species in this period as late-flowering species such as common bent *Agrostis capillaris*, creeping bent *Agrostis stolonifera*, yellow oat-grass *Trisetum flavescens*, Timothy *Phleum pratense* and downy oat-grass *Avenula pubescens* are more obvious. After 7 July it becomes difficult to find *Poa* species and low-growing species that have finished flowering are less obvious on walk-over surveys.

Survey method

The main purpose of these surveys was to collect enough information in order to judge whether or not a field was suitable for restoration or as a seed donor site. Due to the time constraints outlined above and the large number of meadows to survey, usually only about 40 minutes was spent in each field. A species list for the whole field was compiled during a walk-over survey. Most areas of the field were accessed following a W-shaped walk. At the end of the survey each species was given a score for frequency within the field on a regular 5-point scale with 1 being the least frequent category. If a species was found only in atypical parts of the field such as on a bank or at the edge, this information was noted. If more than one type of vegetation was found in the field, the boundaries between the vegetation types were marked on a field map.

Survey data used in this phytosociological analysis

All the species that were only found in atypical parts of the field were deleted from the data before the floristic analysis was carried out. Species lists from fields with more than 1 type of vegetation within the main mown part of the field were also not included in the data analysis. Thus the data for each field included in the analysis includes only species growing within the main mown part of the field and only from one vegetation community per field. This resulted in data from 429 stands being available for the analysis.

Limitations of the survey method
The survey method was not designed with a detailed phytosociological analysis in mind. If the original aim had been to carry out a detailed phytosociological analysis of hay meadow vegetation this type of survey method would not have been chosen. Instead quantitative data (%cover or DOMIN scores) from representative 2m x 2m quadrats would have been recorded. These different methods of field recording have implications for the phytosociological analysis. Two particular aspects are worth noting.

- In our surveys, the total number of species per stand will be higher than the total number of species for a 2m x 2m quadrat.
- In our surveys there was no measure of abundance (or % cover) within stands recorded, instead frequency within stands was recorded. In most phytosociological studies, the floristic tables (including the tables published in Rodwell, 1992) are based on both frequency between stands and average (or range of) cover or abundance within stands.

These differences in our surveys make the vegetation types look richer than they would appear in tables derived from quantitative data collected from quadrats. It also means that our vegetation types appear at first glance to be more similar than they would appear in tables derived from quantitative data collected from quadrats. Where these impacts are most pronounced and/or potentially confusing in the floristic tables that follow, they are discussed in order to aid interpretation of the data.

There is also likely to be some bias in our survey data. In particular, bryophytes and late-flowering grasses are likely to be relatively under-recorded from our walk-over surveys compared to how they would have been recorded from quadrats surveys. Further specific issues with the data are discussed in the main MG6 and MG3 sections later on.

Overall, the survey data is unsatisfactory for a phytosociological analysis, but the volume of the data from the recent Hay Time surveys presented an opportunity that was too good to miss, as long as the limitations of the data are borne in mind.

Construction of the floristic tables
All of the data was entered in a single Excel spreadsheet, with a separate row for each species and a separate column for each meadow. The whole dataset was too large to combine into a single analysis, so the data was first broken manually into main communities (MG3, MG6, MG7 or MG8). Data from the 2007 and 2008 surveys had provisionally been allotted to a main community in the field, based on presence/absence and frequency of key indicator species, for separating the main communities involved. This provisional allocation (and all of the unallocated 2006 data) was checked by comparing the data to the tables and descriptions in BPC and the appropriate main community for each meadow dataset was then finalised. Separate floristic tables for each of these main communities were then extracted from the original dataset. Floristic tables of each of these smaller datasets were then analysed in more detail using the manual ordination method as described in chapter 9 of Mueller-Dombois & Ellenberg (1925). This process involves manual sorting and resorting of the data until a satisfactory classification results. Finally, the final floristic tables as presented here were constructed so as to highlight the differences between the sub-communities.

How to read the floristic tables
The tables in themselves, without the text that follows them, give a comprehensive description of the vegetation types. The presentation of the tables is similar to how the NVC tables are presented in Rodwell (1992), with some additional features to aid interpretation. All of the species found in each type of vegetation are listed with figures summarising their frequency between stands and their frequency within stands. The order of the species in the tables is organised in order to aid comparison between the different types of meadow vegetation.

Frequency data in the columns
Three sets of figures are presented for each species in each vegetation type.

- **bF** – means ‘between-stand frequency’, or how frequent was the species in all of the different stands of this vegetation type. These data are presented as a Roman numeral from I to V based on 5 frequency classes. If a species occurred in up to 20% of the stands, it is assigned to frequency class I. If it occurred in more than 20% and up to 40%, it is assigned to frequency class II, and so on.

- **wF** – means 'within-stand frequency range', or how frequent was the species within each stand on the regular 5-point scale for frequency that was recorded in the field. This figure often varies from stand to stand so the data is presented as a range from the minimum to the maximum frequency recorded.
- **av wF** – means 'average within-stand frequency'. This is the average number for frequency on the 5-point scale in all of the stands that the species was recorded in, in this type of vegetation. This figure is often more informative than the within-stand frequency (wF) range.

Data in the top six rows of the tables

- The NVC code for the vegetation community or sub-community appears in the shaded boxes on the top row.
- The **No. of stands** row has the total number of stands for that vegetation type, that were included in the analysis.
- The **Altitude range** row lists the minimum and maximum altitude for all stands of that vegetation type, that were included in the analysis.
- The **Average altitude** row gives the average altitude for all stands of that vegetation type, that were included in the analysis.
- The **No. of species range** row lists minimum and maximum number of species recorded in all stands of that vegetation type, that were included in the analysis.
- The **Average no. of species** row gives the average number of species recorded in all stands of that vegetation type, that were included in the analysis.

Presentation of the species data

The species are presented in labelled blocks to aid interpretation and comparison between vegetation types. Some of these species blocks list species that are **differential** or **preferential** for some types of vegetation over others. **Differential** species are those that occur in the data only in one type of vegetation and not in the others in the table. **Preferential** species are those that in our data occur significantly more frequently in one type of vegetation compared to the other types in the table. There are 5 different types of species blocks that appear in the tables in the following order:

- **Constants** are those species that appear at a 'between-stand frequency' of IV or V overall in **all** of the vegetation types in the table and which are not significantly more frequent in one vegetation type over the others. These are often common species in the vegetation, but are not of much use for deciding which of the vegetation types in the table you have.
- **all except type X** (e.g. all except MG7) lists the species that are differential or preferential for all types of vegetation in the table except for vegetation type X. I.e. this species is infrequent or absent in vegetation type X, but it is significantly more frequent or common in all the other vegetation types in the table. Vegetation type X could therefore be recognised by the lack of these indicator species.
- **type X & type Y** (e.g. MG7 & MG6) lists the species that are differential or preferential for both vegetation types X & Y compared to the other types of vegetation in the table. The presence of these indicator species tells you that you probably have either vegetation type X or Y and not any other type of vegetation, but you don't know which of type X or Y you have.
- **type X** (e.g. MG7) lists the differential and preferential species for vegetation type X over all other types of vegetation in the table. These are the indicator species that strongly indicate one vegetation type over all of the others.
- **Noise** includes those species that appear at a 'between-stand frequency' of I, II or III in **all** of the vegetation types in the table, without showing a significant difference in between-stand frequency in the different vegetation types. These species are less common in the vegetation types that the **constant** species are, but like the constants they are not of much use for deciding which of the vegetation types in the table you have.

There is one exception to these rules in the tables that follow. In the table that lists the sub-communities of MG6 in section 4, in addition to the figures for between-stand frequency, the figures for average within-stand frequency are also used for determining which species are differential or preferential for the different sub-communities of MG6. This is discussed further in the MG6 section.

Species highlighted in **bold** text in the tables are either 'northern' species or else species whose 'normal' habitat is in woodland rather than grassland. These are the species that make upland hay meadows distinct from other types of grassland.

Species that occur in less than 5% of the stands of the vegetation types in the tables are not listed in the main table with figures for frequency, but are listed immediately after the table without any frequency figures

Soil data
Data for soil pH and soil phosphate (P) are included in the tables where they are available. These data are based on soil samples taken from a subset of the meadows that were surveyed. Soil data are available for roughly one quarter of all of the surveyed meadows. Samples are based on 25 cores per field which were bulked together and analysed as one sample following standard soil sampling procedures for ecological studies (Allen 1989). Soil results are discussed in more detail in section 7.

Transitions between vegetation types and transitional vegetation types
The types of vegetation presented here are often distinct in the field. However, sometimes two vegetation types grade into each other gradually and sometimes stands are encountered that are difficult to pigeonhole, appearing to have characteristics of more than one vegetation type. In this report, the different types of vegetation are discussed as if they are clearly distinct.

To avoid repetition all future references to Rodwell (1992) are referred to as '**BPC**' (British Plant Communities).

Species nomenclature follows Stace (2010) for vascular plants and Hill et al. (2008) for bryophytes. When vascular plants are mentioned in the text, both the common name and scientific name are used the first time that the species is mentioned and only the scientific name is used for all subsequent mentions. The floristic tables include the scientific names only.

2 The 4 main upland hay meadow communities in the North Pennines

Comparative table of the main vegetation types in upland hay meadows in the North Pennines

	MG7			MG6			MG3			MG8			All		
No. of stands	52			265			56			56			429		
Altitude range	160-410			145-480			155-440			240-510			145-510		
Average altitude	285			292			274			400			303		
No. of soil samples	13			79			18			0			110		
Soil pH range	5.0-6.4			4.9-7.1			5.4-6.8			na			4.9-7.1		
Average soil pH	5.6			5.7			5.9			na			5.8		
Soil P (mg/l) range	10-48			4-40			2-26			na			2-48		
Average soil P (mg/l)	19.5			12.8			7.9			na			12.8		
No. of species range	15-36			15-61			16-69			15-59			15-69		
Average no. of species	25.1			31.7			40.1			32.0			32.1		
Taxon	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF
Constants															
Holcus lanatus	V	2-5	4.3	V	1-5	4.2	V	1-5	4.3	V	3-5	4.7	V	1-5	4.3
Lolium perenne	V	2-5	4.3	V	1-5	4.0	IV	1-5	3.4	IV	1-5	3.8	V	1-5	3.9
Ranunculus acris	V	1-5	3.3	V	1-5	3.8	V	2-5	4.2	V	1-5	3.2	V	1-5	3.7
Rumex acetosa	V	1-5	3.3	V	1-5	3.5	V	1-5	3.5	V	1-5	3.8	V	1-5	3.5
Trifolium repens	V	1-5	3.2	V	1-5	3.4	V	1-5	3.3	V	1-5	3.2	V	1-5	3.4
Alopecurus pratensis	V	1-5	3.5	V	1-5	3.2	IV	1-5	2.7	V	1-5	3.2	V	1-5	3.2
Ranunculus repens	V	1-5	3.2	V	1-5	2.6	IV	1-5	2.1	V	2-5	4.3	V	1-5	2.9
Trifolium pratense	V	1-3	1.4	V	1-5	2.6	V	1-5	3.4	V	1-5	2.3	V	1-5	2.5
Cerastium fontanum	V	1-5	2.3	V	1-5	2.4	V	1-5	2.4	V	1-5	2.2	V	1-5	2.3
Agrostis capillaris	III	2-5	3.9	IV	1-5	4.1	IV	2-5	4.4	IV	2-5	4.1	IV	1-5	4.1
Poa trivialis	V	2-5	4.4	IV	1-5	3.6	IV	1-5	3.5	V	1-5	3.4	IV	1-5	3.7
Bromus hordaceus hordaceus	V	1-5	3.7	IV	1-5	2.9	III	1-5	2.3	III	1-4	2.0	IV	1-5	2.9
Bellis perennis	IV	1-5	2.1	IV	1-5	2.8	IV	1-5	2.6	IV	1-5	2.6	IV	1-5	2.6
Conopodium majus	III	1-5	2.2	IV	1-5	2.6	V	1-5	3.0	III	1-4	2.2	IV	1-5	2.6
Dactylis glomerata	IV	1-5	3.2	IV	1-5	2.3	IV	1-5	2.5	III	1-5	2.2	IV	1-5	2.4
Veronica chamaedrys	IV	1-2	1.3	IV	1-5	1.5	IV	1-5	2.0	IV	1-4	1.7	IV	1-5	1.6
Rumex obtusifolius	IV	1-3	1.4	IV	1-4	1.3	III	1-2	1.3	III	1-3	1.3	IV	1-4	1.3
all except MG7															
Cynosurus cristatus	I	1-3	1.7	V	1-5	3.9	V	1-5	4.5	IV	1-5	4.2	IV	1-5	4.0
Festuca rubra	II	1-5	3.1	IV	1-5	4.0	V	1-5	4.3	IV	1-5	3.7	IV	1-5	4.0
Anthoxanthum odoratum	III	1-5	2.7	V	1-5	4.0	V	2-5	4.2	V	1-5	3.9	V	1-5	3.9
Plantago lanceolata	II	1-3	1.7	IV	1-5	3.2	V	1-5	4.1	IV	1-5	2.8	IV	1-5	3.2
Rhinanthus minor minor	II	1-3	1.3	IV	1-5	3.0	V	1-5	3.5	IV	1-5	2.6	IV	1-5	2.9
***Euphrasia arctica* s.l.**				II	1-5	2.2	III	1-5	2.5	III	1-5	2.5	II	1-5	2.4
Phleum pratense	I	1-5	2.4	II	1-5	2.1	II	1-4	1.7	II	1-3	1.5	II	1-5	2.0
Trollius europaeus				I	1-2	1.5	I	1	1.0	I	1-4	2.3	I	1-4	1.7
Dactylorhiza species				I	1-2	1.4	I	1-3	2.0	I	1	1.0	I	1-3	1.5
Anemone nemorosa				I	1-2	1.1	I	1-3	1.7	I	1-3	2.0	I	1-3	1.4
Carex flacca				I	1-2	1.1	I	1-5	1.7	I	1-4	2.0	I	1-5	1.4
Carex panicea				I	1	1.0	I	1	1.0	I	1-4	1.7	I	1-4	1.3
Dactylorhiza fuchsii				I	1	1.0	I	1-3	1.7	I	1	1.0	I	1	1.3
Succisa pratensis				I	1	1.0	I	1-2	1.3	I	1-3	1.5	I	1-3	1.3
Dactylorhiza purpurella				I	1	1.0	I	1	1.0	I	1-2	1.3	I	1-2	1.2
Poa pratensis				I	1-2	1.1	I	1-2	1.3	I	1-2	1.3	I	1-2	1.2
Achillea ptarmica				I	1	1.0	I	1	1.0	I	1-2	1.2	I	1-2	1.1
Briza media				I	1	1.0	I	1-2	1.1	I	1	1.0	I	1-2	1.1
Lathyrus linifolius				I	1-2	1.3	I	1	1.0	I	1	1.0	I	1-2	1.1
Trifolium medium				I	1	1.0	I	1	1.0	I	2	2.0	I	1-2	1.1

Viola lutea				I	1	1.0	I	1-2	1.2	I	1	1.0	I	1-2	1.1
Alchemilla filicaulis vestita				I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Angelica sylvestris				I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Cirsium palustre				I	1	1.0	I	1-2	1.2	I	1	1.0	I	1-2	1.0
Juncus conglomeratus				I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Stellaria alsine				I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
all except MG8															
Anthriscus sylvestris	II	1-5	2.0	II	1-5	1.8	II	1-2	1.1	I	1-2	1.1	II	1-5	1.7
Cirsium arvense	II	1-2	1.1	II	1-4	1.3	II	1-2	1.2	I	1-2	1.4	II	1-4	1.2
Achillea millefolium	II	1	1.0	II	1-4	1.3	II	1-2	1.4	I	1-2	1.3	I	1-4	1.3
Hyacinthoides non-scripta	I	2	2.0	I	1-4	1.4	I	1-2	1.2				I	1-4	1.4
Myosotis arvensis	I	1	1.0	I	1-2	1.2	I	1-2	1.5				I	1-2	1.2
Primula veris	I	1	1.0	I	1-2	1.3	I	1-2	1.3				I	1-2	1.2
Galium aparine	I	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
Galium verum	I	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
Geranium pratense	I	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
MG6 & MG3															
Heracleum sphondylium	II	1-2	1.1	III	1-5	1.2	III	1-4	1.5	I	1-2	1.2	III	1-5	1.2
Vicia sepium	II	1-3	1.3	III	1-3	1.2	III	1-2	1.3	II	1-2	1.2	III	1-3	1.2
Ranunculus bulbosus	I	1-3	1.9	II	1-5	2.6	II	1-5	2.2	I	1	1.0	II	1-5	2.5
Senecio jacobea	I	1	1.0	II	1-3	1.1	II	1	1.0	I	1-3	1.3	I	1-3	1.1
Alchemilla acutiloba				I	1-4	2.2	I	1-4	2.0				I	1-4	2.2
Betonica officinalis				I	1	1.0	I	1-4	2.3				I	1-4	1.7
Cirsium heterophyllum				I	1-2	1.2	I	1-2	1.2				I	1-2	1.2
Saxifraga granulata				I	1-4	1.7	I	1	1.0				I	1-4	1.0
MG7															
Cerastium glomeratum	IV	1-5	1.5	III	1-5	1.6	I	1-4	1.6	II	1-3	1.4	III	1-5	1.5
Urtica dioica	IV	1-3	1.1	III	1-2	1.1	II	1-2	1.1	II	1-2	1.1	III	1-3	1.1
Stellaria media	III	1-5	1.6	I	1-2	1.1	I	1	1.0	I	1-3	1.3	I	1-5	1.3
Rumex crispus	II	1-2	1.1	I	1-2	1.1	I	1	1.0	I	1-3	1.5	I	1-3	1.1
MG6															
Taraxacum agg.	III	1-4	1.4	IV	1-5	1.6	III	1-5	1.8	II	1-3	1.6	III	1-5	1.6
MG3															
Geranium sylvaticum	I	1-2	1.2	II	1-4	1.3	V	1-5	2.1	I	1-2	1.1	II	1-5	1.6
Filipendula ulmaria	I	1	1.0	II	1-4	1.5	IV	1-5	1.9	II	1-5	1.8	II	1-5	1.6
Alchemilla glabra	I	1	1.0	II	1-3	1.2	IV	1-5	2.0	I	1-4	1.6	II	1-5	1.5
Lathyrus pratensis	I	1	1.0	II	1-3	1.4	IV	1-3	1.7	I	1-5	2.1	II	1-5	1.5
Trisetum flavescens	II	1-4	1.5	II	1-5	2.1	III	1-5	2.2	I	1-3	1.4	II	1-5	2.0
Trifolium dubium	I	1-2	1.3	II	1-5	2.1	III	1-5	2.8	I	1-2	1.6	II	1-5	2.2
Prunella vulgaris	I	1	1.0	II	1-5	1.5	III	1-4	1.8	II	1-3	1.4	II	1-5	1.6
Centaurea nigra	I	1	1.0	II	1-3	1.3	III	1-4	1.6	I	1-2	1.2	II	1-4	1.4
Sanguisorba officinalis	I	1	1.0	I	1-4	1.3	III	1-5	2.9	I	1-2	1.3	I	1-5	1.9
Hypochaeris radicata	I	1	1.0	I	1-4	1.4	III	1-4	2.1	I	1-2	1.1	I	1-4	1.6
Leontodon hispidus	I	1	1.0	I	1-3	1.3	III	1-5	1.9	I	1-2	1.3	I	1-5	1.5
Alchemilla xanthochlora	I	1	1.0	I	1-5	1.2	III	1-4	1.6	I	1	1.0	I	1-5	1.3
Avenula pubescens	I	2	2.0	I	1-5	1.4	III	1-4	1.6	I	1-2	1.2	I	1-5	1.5
Luzula campestris	I	1	1.0	I	1-4	1.3	II	1-5	2.0	I	1-3	1.5	I	1-5	1.4
Stellaria graminea	I	1	1.0	I	1-2	1.2	II	1-3	1.5	I	1-2	1.3	I	1-3	1.3
Equisetum arvense	I	1	1.0	I	1	1.0	II	1-3	1.1	I	1	1.0	I	1-3	1.0
Ajuga reptans				I	1-2	1.1	II	1-3	1.5	I	1-3	1.2	I	1-3	1.3
Lotus corniculatus				I	1-2	1.1	II	1-4	1.5	I	1	1.0	I	1-4	1.3
Potentilla erecta erecta				I	1	1.0	II	1-4	1.6	I	1	1.0	I	1-4	1.3
Leucanthemum vulgare	I	1	1.0	I	1-2	1.3	II	1-3	1.3				I	1-3	1.3
Vicia cracca	I	1	1.0	I	1-3	1.2	II	1-2	1.3				I	1-3	1.2

Equisetum sylvaticum	I	1	1.0	I	1	1.0	II	1	1.0	I	1-2	1.3	I	1-2	1.1
MG8															
Caltha palustris	I	1-2	1.2	II	1-3	1.3	II	1-2	1.6	V	1-5	3.4	II	1-5	2.2
Juncus acutiflorus	I	1	1.0	I	1-4	1.4	II	1-3	1.7	III	1-5	2.4	II	1-5	1.7
Scorzoneroides autumnalis	I	1	1.0	II	1-2	1.3	II	1-3	1.7	III	1-5	2.3	II	1-5	1.6
Juncus effusus	I	1	1.0	II	1-2	1.1	II	1-2	1.3	III	1-4	1.3	II	1-4	1.2
Alopecurus geniculatus	II	1-2	1.1	I	1-2	1.1	I	1-2	1.3	III	1-3	1.3	I	1-3	1.2
Montia fontana	I	1	1.0	I	1-4	1.2	I	1-2	1.3	II	1-5	2.5	I	1-5	1.5
Myosotis scorpioides	I	1	1.0	I	1-4	1.6				II	1-5	2.9	I	1-5	2.2
Carex nigra				I	1-2	1.3	I	1-2	1.3	II	1-5	2.8	I	1-5	1.9
Silene flos-cuculi				I	1	1.0	I	1	1.0	II	1-4	1.9	I	1-4	1.4
Myosotis secunda	I	1	1.0	I	1-2	1.2	I	1	1.0	I	2-4	3.3	I	1-4	1.4
Noise															
Myosotis discolor	III	1-2	1.2	III	1-4	1.4	III	1-3	1.6	III	1-4	1.5	III	1-4	1.4
Cardamine pratensis	III	1-2	1.2	III	1-2	1.1	III	1-3	1.3	III	1-3	1.6	III	1-3	1.2
Agrostis stolonifera	II	1-5	2.9	I	1-4	2.4	II	1-5	2.1	II	1-5	2.8	II	1-5	2.5
Cirsium vulgare	II	1	1.0	II	1	1.0	I	1	1.0	II	1	1.0	II	1	1.0
Poa humilis	I	1-2	1.5	I	2-5	2.7	I	2-3	2.5	I	1	1.0	I	1-5	2.3
Brachythecium rutabulum	I	1-2	1.5	I	1-4	1.9	I	1-5	3.2	I	1-2	1.2	I	1-5	2.0
Schedonorus pratensis	I	1	1.0	I	1-4	1.4	I	1-2	1.5	I	1-5	3.1	I	1-5	1.9
Holcus mollis	I	2-4	2.8	I	1-5	1.4	I	1-2	1.4	I	1	1.0	I	1-5	1.6
Rhytidiadelphus squarrosus	I	2	2.0	I	1-2	1.3	I	1-5	1.9	I	1-2	1.3	I	1-5	1.5
Arrhenatherum elatius	I	1-2	1.5	I	1-3	1.4	I	1-2	1.5	I	1-2	1.7	I	1-3	1.4
Cruciata laevipes	I	1	1.0	I	1-2	1.2	I	1-4	2.1	I	1	1.0	I	1-4	1.4
Geum rivale	I	1	1.0	I	1	1.0	I	1-3	1.3	I	1-4	1.8	I	1-4	1.3
Glyceria fluitans	I	1	1.0	I	1	1.0	I	1	1.0	I	1-4	1.6	I	1-4	1.3
Persicaria bistorta	I	1	1.0	I	1-2	1.1	I	1-3	1.3	I	2	2.0	I	1-3	1.3
Poa annua	I	1	1.0	I	1-5	1.4	I	1	1.0	I	1-3	1.7	I	1-5	1.3
Deschampsia cespitosa	I	1	1.0	I	1-4	1.2	II	1-2	1.3	II	1-3	1.4	I	1-4	1.2
Cardamine flexuosa	I	1	1.0	I	1-2	1.2	I	1-3	1.5	I	1	1.0	I	1-3	1.2
Lotus pedunculatus	I	1	1.0	I	1	1.0	I	1-2	1.3	I	1	1.0	I	1-2	1.1
Ficaria verna	I	1	1.0	I	1	1.0	I	1-2	1.3	I	1	1.0	I	1-2	1.1
Rumex longifolius	I	1	1.0	I	1-3	1.1	I	1	1.0	I	1	1.0	I	1-3	1.1
Carex leporina	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Plantago major	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Potentilla anserina	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Veronica arvensis	I	1	1.0	I	1-2	1.1	I	1	1.0	I	1	1.0	I	1-2	1.0
Veronica serpyllifolia	I	1-3	1.3	I	1	1.0	I	1	1.0	I	1	1.0	I	1-3	1.0

General comments on upland hay meadow vegetation in the North Pennines

17 species appear at a frequency of IV or V in the table overall, and are similarly frequent in all four of the main vegetation types. This illustrates a large degree of overlap between the four main vegetation types. These 17 species were the most characteristic species of upland hay meadows in the North Pennines between 2006 and 2008.

The majority of species in the table are perennials, but 6 annual species appear at an overall frequency of II or more: soft brome *Bromus hordaceus* (IV); yellow rattle *Rhinanthus minor* (IV); changing forget-me-not *Myosotis discolor* (III); sticky mouse-ear *Cerastium glomeratum* (III); eyebright *Euphrasia arctica* s.l. (II); and lesser trefoil *Trifolium dubium* (II). The significance of annuals in upland hay meadow vegetation is discussed in the main MG3 section (section 5) later on.

Looking at the floristic tables in BPC, both pignut *Conopodium majus* and *Euphrasia arctica* s.l. appear to be useful indicator species for MG3. However in our data, they appear at similar frequencies in most of the upland hay meadow vegetation types (although *Conopodium majus* is a bit more frequent in MG3: V in MG3 compared to IV in MG6 and III in MG7 and MG8). *Conopodium majus* and eyebrights *Euphrasia* species (although usually different eyebright taxa) also are

relatively frequently found in pastures in the North Pennines. These species may not be very useful indicators for MG3 within the North Pennines. The reason that they appear to be useful in BPC may largely be due to their limited geographical range rather than a genuine preference for one vegetation type over another. The geographical range of MG3 coincides with the main upland range of these species. The sampling for MG6 and MG7 in BPC occurred throughout the geographical ranges of these communities in Britain, in both lowland and upland situations. It is not surprising therefore, that these species appear at much lower frequencies in the tables for MG6 and MG7 in BPC than they do in our tables for MG6 and MG7 from the North Pennines.

MG7

MG7 is the most agriculturally improved and least species-rich type of upland hay meadow vegetation in the North Pennines. This is usually a grass-dominated type of meadow vegetation. The most common grasses are often Yorkshire-fog *Holcus lanatus*, perennial rye-grass *Lolium perenne*, rough meadow-grass *Poa trivialis*, meadow foxtail *Alopecurus pratensis*, *Bromus hordaceus* and cock's-foot *Dactylis glomerata*. Finer-leaved species like *Agrostis capillaris*, red fescue *Festuca rubra*, sweet vernal-grass *Anthoxanthum odoratum* and *Trisetum flavescens* are less common. Flowers are normally sparse and are mainly comprised of common species tolerant of some agricultural improvement like meadow buttercup *Ranunculus acris*, creeping buttercup *Ranunculus repens*, common sorrel *Rumex acetosa* and white clover *Trifolium repens*. Other species are usually much sparser, including common mouse-ear *Cerastium fontanum*, common nettle *Urtica dioica*, red clover *Trifolium pratense*, daisy *Bellis perennis*, *Conopodium majus*, germander speedwell *Veronica chamaedrys and* broad-leaved dock *Rumex obtusifolius*.

MG7 is characterised mainly by a group of 'missing' species (the 'all except MG7' block in the table) that are present in most of the other types. i.e. MG7 does not have strong differential/preferential species, but it can be recognised as MG7 due to the lack of the prefential/differential species from the other communities. The main species 'missing' from MG7 include crested dog's-tail *Cynosurus cristatus*, *Festuca rubra*, *Anthoxanthum odoratum*, ribwort plantain *Plantago lanceolata* and *Rhinanthus minor*. These species are not entirely missing from MG7 but are present at a much lower frequency overall in MG7 than in the other types, where they are consistently present at a high frequency. *Euphrasia arctica* s.l. is also present at a frequency of II or III in the other types but missing entirely from MG7 here. Perhaps surprisingly, *Phleum pratense* seems slightly more frequent in the other types compared to MG7 here. *Phleum pratense* was (at least in the past) a common constituent of grass seed mixes for sown agricultural leys, so it would be expected to be more common in MG7. However, the predominant type of MG7 here is MG7d (see main MG7 section below), which is not characterised by a high frequency of *Phleum pratense*.

Some weedy and nutrient-loving species were more frequent in MG7 compared to the other types. These included *Cerastium glomeratum*, *Urtica dioica*, common chickweed *Stellaria media* and curled dock *Rumex crispus*. The first two were also relatively frequent in MG6.

MG6

This is quite a broad type of vegetation ranging from quite agriculturally improved and species-poor grassland to much more flowery semi-improved grassland with a high cover of herbs. The species-poor types of MG6 differ from MG7 in normally having *Cynosurus cristatus* mixed with the other grasses and in often having more of a mixture of coarse and fine-leaved grasses than is found in MG7, with species like *Anthoxanthum odoratum*, *Festuca rubra* and *Agrostis capillaris*, all more common in MG6. Most examples of MG6 are at least a little more flowery than typical MG7 and the richer examples can have well over 50% cover of broad-leaved herbs. The herb species are mostly common species like those mentioned for MG7 above, plus some extra species including *Plantago lanceolata*, *Rhinanthus minor*, *Conopodium majus*, dandelion *Taraxacum* agg., hogweed *Heracleum sphondylium* and bush vetch *Vicia sepium*. *Rhinanthus minor* can be present in abundance in some examples. *Taraxacum* agg. appears to be a little more frequent in MG6 hay meadow vegetation here compared to the other types.

Examples of MG6 with a high cover of colourful herbs can be distinguished from MG3 and MG8 meadows because MG6 lacks many of the distinctive preferential species of those communities, which are mentioned below. Some of the MG3 herbs can be present occasionally, but they are usually sparse in MG6.

MG3
This is a distinctive type of hay meadow vegetation, which has quite a long list of preferential species in the table above compared to the other types. Stands range from very species-rich examples with a high cover of the northern montane species amongst an overall high cover of herbs and a low cover of grasses, to less species-rich stands (some of which can be quite grassy) with some of the preferential MG3 species mentioned below. Some of these less species-rich stands may be unimproved, but were never as species-rich as the best examples, but others have probably undergone a moderate amount of agricultural improvement at some point in the past, but still retain characteristics of MG3.

The grass component is mixed and usually includes a relatively high proportion of the finer-leaved species, although *Holcus lanatus* can often have a high cover. The grass component is similar to MG6, but *Trisetum flavescens* and *Avenula pubescens* are a bit more frequent in MG3. *Trisetum flavescens* has a frequency of III in MG3, compared to II in MG6. *Avenula pubescens* has a frequency of II in MG3, compared to I in MG6.

The distinctive herbs that distinguish MG3 from other communities include the northern montane species *Geranium sylvaticum*, smooth Lady's-mantle *Alchemilla glabra* and pale Lady's-mantle *Alchemilla xanthochlora*. The best examples have a high cover of these species. Other herbs that are normally found mainly in species-rich grasslands are also common here, including meadow vetchling *Lathyrus pratensis*, selfheal *Prunella vulgaris*, common knapweed *Centaurea nigra*, great burnet *Sanguisorba officinalis*, cat's-ear *Hypochaeris radicata* and rough hawkbit *Leontodon hispidus*.

Interestingly, meadowsweet *Filipendula ulmaria* occurred at a frequency of IV in MG3 here, which is higher than expected, and considerably higher than in the tables in BPC. It is also surprising that it is considerably less frequent in MG8 here. *Filipendula ulmaria* is a species of moderately damp, weakly to moderately acid soils of, intermediate fertility (Hill *et. al.*, 2004), so it could have been expected to be as frequent or more frequent in the generally damper MG8 community compared to MG3. The frequency of *Filipendula ulmaria* in our data for MG3 meadows is discussed further in section 5.

Some types of MG8 also contain populations of the northern montane species but differ in the ways described below.

MG8
This is a very easy type of meadow vegetation to identify in the northern uplands as it is more-or-less always characterised by a high cover of marsh marigold *Caltha palustris*, which is absent or only sparse in the other meadow types. This is the type of upland hay meadow vegetation characteristic of the wettest and highest altitude meadows in the North Pennines. The average altitude for MG8 is 400m, whereas all of the other types have an average altitude of well below 300m. Fig 1 shows the distribution of the four main meadow communities in the North Pennines. Most meadows above 360m in all of the valleys in the North Pennines support MG8 unless they have been very agriculturally improved. Presumably the wetter climate at these high altitudes is enough to maintain this damp type of vegetation. These highest sections of the valleys are coloured deep yellow for field after field in the early part of the growing season. It appears that these extensive areas with whole fields of MG8 may be a particular feature of the North Pennines and much less common in other areas with upland hay meadow vegetation such as the Yorkshire Dales (Pippa Rayner pers. com.) and the Lake District and Orton fells in Cumbria (Claire Cornish pers. com.). However, survey data from Cumbria and Yorkshire from the 1980s suggest that MG8 fields were occasional in those areas at that time (O'Reilly & Shiel 2010). In addition to these whole fields, MG8 vegetation also occurs in smaller damp areas within drier types of vegetation such as MG6 and MG3 lower down the valleys.

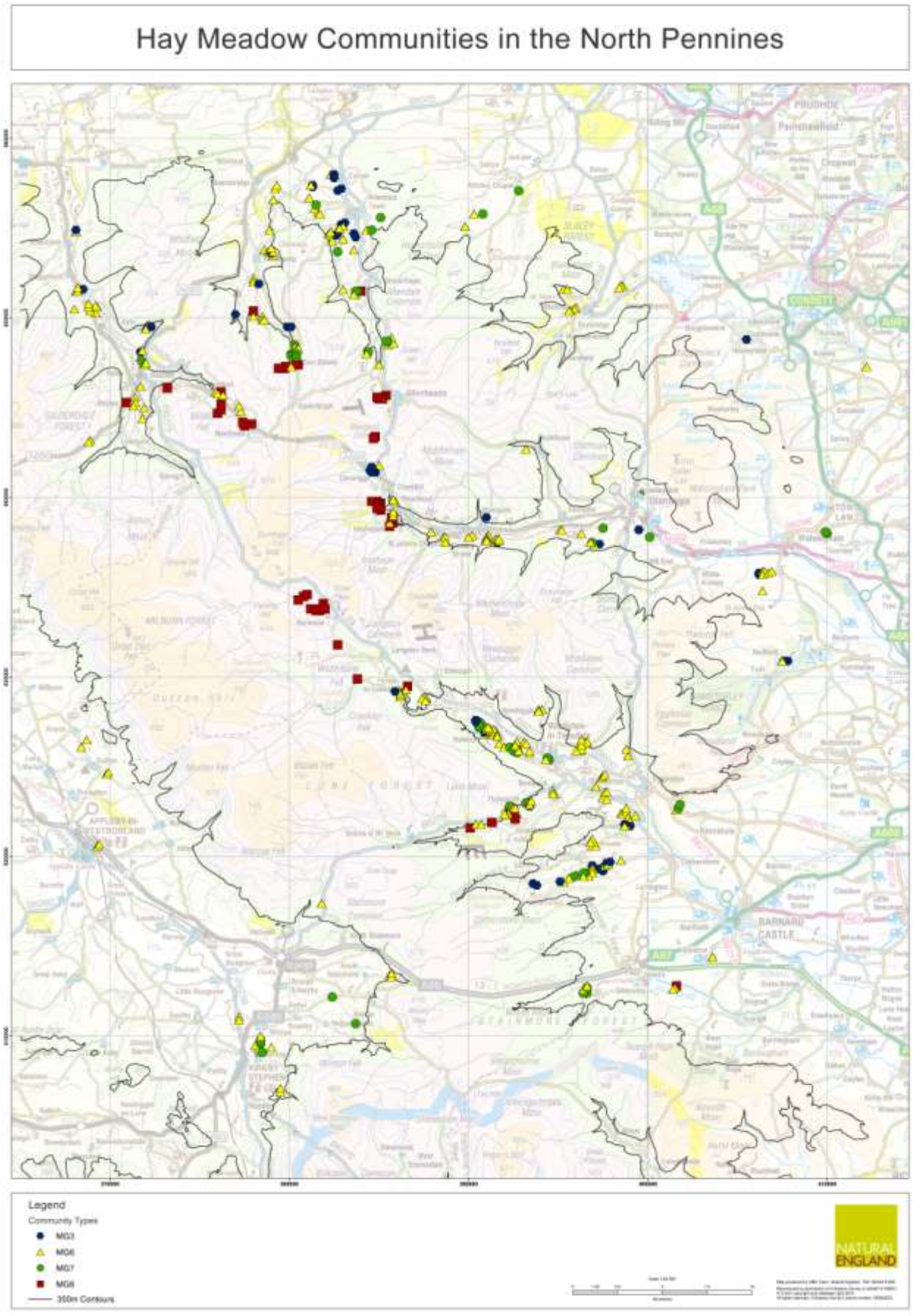

Fig 1: Distribution of the four main meadow communities in the North Pennines

Although it is easy to identify, this is the most variable type of upland hay meadow vegetation in the North Pennines in terms if its species-richness and overall quality. Some stands are very agriculturally improved and resemble species-poor versions of MG7 or MG6 but with the addition of a high cover of *Caltha palustris*. These stands could equally be regarded as a *Caltha palustris* variant of MG7 or MG6. Or species-poor stands that are quite rushy could be considered as *Caltha palustris* variants of MG10. A small number of stands are species-rich and include populations of northern montane species like globeflower *Trollius europaeus* and marsh hawk's-beard *Crepis paludosa* along with other characteristic herbs including water avens *Geum rivale* and bugle *Ajuga reptans*. There are also examples at all stages of semi-improvement in between.

Apart from the frequency of *Caltha palustris*, most examples share many species with the other types of meadow vegetation found here, especially MG6 and MG3. Marsh foxtail *Alopecurus geniculatus* is significantly more frequent in MG8 than in the other types and a few other species are a little more frequent in MG8 including autumn hawkbit *Scorzoneroides autumnalis*, sharp-flowered rush *Juncus acutiflorus* and soft-rush *Juncus effusus*. Other wetland herbs including blinks *Montia fontana*, water forget-me-not *Myosotis scorpioides*, creeping forget-me-not *Myosotis secunda* and ragged robin *Silene flos-cuculi* are occasional in MG8 meadows and normally much rarer in the drier types of meadow vegetation. Common sedge *Carex nigra* is also occasional in MG8 and can occur in abundance in some examples.

3 MG7 *Lolium perenne* (perennial rye-grass) leys and related grasslands

	MG7b			MG7d			all MG7		
No of stands	5			47			52		
Altitude range	180-270			160-410			160-410		
Average altitude	221			292			285		
No. of soil samples	1			12			13		
Soil pH range				5.0-6.4			5.0-6.4		
Average soil pH	6.4			5.5			5.6		
Soil P (mg/l) range				5-40			10-48		
Average soil P (mg/l)	48			17.1			19.5		
No. of species range	25-31			15-36			15-36		
Average no of species	27.4			24.8			25.1		
Taxon	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF
Constants									
Poa trivialis	V	4-5	4.6	V	2-5	4.4	V	2-5	4.4
Lolium perenne	IV	5	5.0	V	2-5	4.2	V	2-5	4.3
Ranunculus acris	IV	1-4	2.5	V	1-5	3.4	V	1-5	3.3
Ranunculus repens	V	1-4	2.6	V	1-5	3.3	V	1-5	3.2
Trifolium repens	V	1-5	2.6	IV	1-5	3.3	IV	1-5	3.2
Cerastium fontanum	IV	1-4	1.8	V	1-5	2.3	V	1-5	2.3
Dactylis glomerata	III	2-4	3.0	IV	1-5	3.2	IV	1-5	3.2
Bellis perennis	V	1-3	1.6	IV	1-5	2.2	IV	1-5	2.1
Rumex obtusifolius	V	1-2	1.2	IV	1-3	1.4	IV	1-3	1.4
Cerastium glomeratum	IV	1-3	1.5	IV	1-5	1.5	IV	1-5	1.5
Urtica dioica	IV	1-3	1.5	IV	1-2	1.1	IV	1-3	1.1
Veronica chamaedrys	III	1-2	1.3	IV	1-2	1.3	IV	1-2	1.3
MG7b									
Phleum pratense	IV	2-5	3.5	I	1-3	1.6	I	1-5	2.4
Festuca rubra	IV	1-4	2.3	II	2-5	3.3	III	1-5	3.1
Cynosurus cristatus	II	2	2.0	I	1-3	1.6	I	1-3	1.7
Veronica serpyllifolia	II	1-3	2.0	I	1	1.0	I	1-3	1.3
Alchemilla xanthochlora	II	1	1.0	I	1	1.0	I	1	1.0
Deschampsia cespitosa	II	1	1.0	I	1	1.0	I	1	1.0
MG7d									
Holcus lanatus	III	2-5	3.0	V	2-5	4.4	V	2-5	4.3
Alopecurus pratensis	III	1-3	1.7	V	2-5	3.6	V	1-5	3.5
Rumex acetosa	III	1-5	2.3	V	1-5	3.4	V	1-5	3.3
Trifolium pratense	III	1	1.0	V	1-3	1.4	IV	1-3	1.4
Bromus hordaceus	II	2-4	3.0	V	1-5	3.7	V	1-5	3.7
Agrostis capillaris				IV	2-5	3.9	III	2-5	3.9
Conopodium majus				IV	1-5	2.2	III	1-5	2.2
Stellaria media	I	2	2.0	III	1-5	1.5	III	1-5	1.6
Anthriscus sylvestris	I	1	1.0	III	1-5	2.0	III	1-5	2.0
Heracleum sphondylium	I	1	1.0	III	1-2	1.1	II	1-2	1.1
Agrostis stolonifera	I	4	4.0	II	1-5	2.9	II	1-5	2.9
Plantago lanceolata	I	1	1.0	II	1-3	1.7	II	1-3	1.7
Rhinanthus minor	I	1	1.0	II	1-3	1.3	II	1-3	1.3
Cardamine pratensis	I	1	1.0	II	1-2	1.2	II	1-2	1.2
Trisetum flavescens	I	1	1.0	II	1-4	1.5	II	1-4	1.5
Vicia sepium	I	1	1.0	II	1-3	1.3	II	1-3	1.3
Achillea millefolium	I	1	1.0	II	1	1.0	II	1	1.0
Ranunculus bulbosus				I	1-3	1.9	I	1-3	1.9
Caltha palustris				I	1-2	1.2	I	1-2	1.2

Veronica arvensis				I	1	1.0	I	1	1.0
Lathyrus pratensis				I	1	1.0	I	1	1.0
Poa annua				I	1	1.0	I	1	1.0
Montia fontana				I	1	1.0	I	1	1.0
Juncus effusus				I	1	1.0	I	1	1.0
Rumex longifolius				I	1	1.0	I	1	1.0
Cruciata laevipes				I	1	1.0	I	1	1.0
Noise									
Taraxacum agg.	III	1	1.0	III	1-4	1.5	III	1-4	1.4
Anthoxanthum odoratum	II	1	1.0	III	1-5	2.8	III	1-5	2.7
Myosotis discolor	II	1-2	1.5	III	1-2	1.2	III	1-2	1.2
Cirsium arvense	III	1	1.0	II	1-2	1.1	II	1-2	1.1
Rumex crispus	III	1	1.0	II	1-2	1.1	II	1-2	1.1
Cirsium vulgare	III	1	1.0	II	1	1.0	II	1	1.0
Alopecurus geniculatus	II	1-2	1.5	II	1-2	1.1	II	1-2	1.1
Holcus mollis	I	4	4.0	I	2-4	2.6	I	2-4	2.8
Poa humilis	I	1	1.0	I	1-2	1.6	I	1-2	1.5
Arrhenatherum elatius	I	2	2.0	I	1-2	1.4	I	1-2	1.5
Filipendula ulmaria	I	1	1.0	I	1	1.0	I	1	1.0
Geranium sylvaticum	I	1	1.0	I	1-2	1.2	I	1-2	1.2
Trifolium dubium	I	1	1.0	I	1-2	1.3	I	1-2	1.3
Cardamine flexuosa	I	1	1.0	I	1	1.0	I	1	1.0
Luzula campestris	I	1	1.0	I	1	1.0	I	1	1.0

Extra species occurring in fewer than 5% of MG8 fields: *Acer pseudoplatanus, **Alchemilla glabra**, Arctium minus* agg*., Avenula pubescens, Brachythecium rutabulum, Calliergonella cuspidata, Carex leporina, Centaurea nigra, Epilobium hirsutum, Equisetum arvense, **Equisetum sylvaticum**, Ficaria verna, Fraxinus excelsior, Galeopsis tetrahit, Galium aparine, Galium palustre, Galium verum, Geranium pratense, **Geum rivale**, Glyceria fluitans, **Hyacinthoides non-scripta**, Hypochaeris radicata, Juncus acutiflorus, Leontodon hispidus, Leucanthemum vulgare, Lolium multiflorum, Lotus pedunculatus, Myosotis arvensis, Myosotis scorpioides, **Myosotis secunda**, **Persicaria bistorta**, Pilosella aurantiaca, Plantago major, Potentilla anserina, Primula veris, Prunella vulgaris, Rhytidiadelphus squarrosus, Sanguisorba officinalis, Schedonorus pratensis, Scorzoneroides autumnalis, Senecio jacobaea, Stachys palustris, Stellaria graminea, Vicia cracca.*

General comments on MG7 sub-communities

Most (47) of the 52 stands were MG7d and the remaining 5 stands were MG7b. This small number of stands of MG7b may not be representative of this vegetation in North Pennines meadows and so the value of splitting the sub-communities in the table above is questionable. However, these sub-communities do often appear distinctive in the field. On the other hand, two stands with roughly equal amounts of *Phleum pratense* and *Alopecurus pratensis* were difficult to assign to either sub-community. These two stands are included in the data for MG7d in the table.

MG7b

This is a common type of improved grassland, typical of agricultural leys especially in the north of Britain (BPC). In some cases it may represent a stage in the natural diversification of an improved grassland, several years after an agricultural grass-seed mixture has been sown (MG7a) and a few more species have naturally regenerated in the sward. However, it can probably also develop from more species-rich vegetation through repeated fertiliser applications, without ever being re-sown.

Overall it is a very grassy type of vegetation, with *Phleum pratense* and *Poa trivialis* often being co-dominant with *Lolium perenne* (BPC). In our vegetation, the grasses *Festuca rubra*, *Alopecurus pratensis*, *Cynosurus cristatus* and tufted hair-grass *Deschampsia cespitosa* all appear more frequently than in the published tables in BPC.

MG7d

This is the more common type of MG7 meadow in the North Pennines, often characterised by a high frequency of *Alopecurus pratensis*, with a low frequency, or no *Phleum pratense*. This is normally a slightly less grassy and overall, slightly richer type of vegetation than MG7b, although the figures for average number of species per stand in the table above do not reflect this. It is also slightly less

agriculturally improved than MG7b. The still quite grassy sward of MG7d is often dotted with a few common flowers. *Poa trivialis* appears as a differential species for MG7b over MG7d in the tables in BPC, but in these vegetation data, it is almost equally frequent in both sub-communities.

There is quite a long list of species in the table above that appear to be differential or preferential for MG7d over MG7b in North Pennines meadows, but the length of this list is at least partly due to many more stands of MG7d compared to MG7b being included in the analysis. *Agrostis capillaris* and *Conopodium majus* appear to be among the most useful differential species for MG7d in our vegetation. Other species from this lists that may be genuine preferential species for MG7d in our vegetation include *Holcus lanatus*, *Rumex acetosa*, *Trifolium pratense*, *Bromus hordaceus*, *Stellaria media*, cow parsley *Anthriscus sylvestris* and *Heracleum sphondylium*.

4 MG6 *Lolium perenne-Cynosurus cristatus* (perennial rye-grass/crested dog's-tail) grassland

	MG6b-i			MG6b-ii			MG6b-iii			All MG6b		
No. of stands	92			84			91			265		
Altitude range	160-460			180-440			145-480			145-480		
Average altitude	300			281			294			292		
No. of soil samples	17			43			19			79		
Soil pH range	5.3-7.1			4.9-6.6			5.2-6.3			4.9-7.1		
Average soil pH	5.8			5.8			5.7			5.7		
Soil P (mg/l) range	5-40			4-34			4-25			4-40		
Average soil P (mg/l)	15.5			11.7			12.6			12.8		
No. of species range	17-53			15-48			18-61			15-61		
Average no. of species	29.2			32.3			33.6			31.7		
Taxon	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF
Constants												
Holcus lanatus	V	2-5	4.3	V	2-5	4.3	V	1-5	4.1	V	1-5	4.2
Cynosurus cristatus	V	1-5	3.6	V	1-5	4.0	V	2-5	4.2	V	1-5	3.9
Lolium perenne	V	2-5	3.9	V	1-5	4.1	V	1-5	3.9	V	1-5	4.0
Rumex acetosa	V	1-5	3.3	V	1-5	3.4	V	1-5	3.8	V	1-5	3.5
Trifolium repens	V	1-5	3.2	V	1-5	3.5	V	1-5	3.6	V	1-5	3.4
Alopecurus pratensis	V	1-5	3.2	V	1-5	3.2	V	1-5	3.3	V	1-5	3.2
Cerastium fontanum	V	1-5	2.2	V	1-5	2.3	V	1-5	2.5	V	1-5	2.4
Agrostis capillaris	IV	2-5	4.0	IV	1-5	4.2	IV	1-5	4.1	IV	1-5	4.1
Poa trivialis	IV	1-5	3.6	IV	2-5	3.7	IV	1-5	3.5	IV	1-5	3.6
Bromus hordaceus hordaceus	IV	1-5	2.9	IV	1-5	2.9	IV	1-5	2.8	IV	1-5	2.9
Dactylis glomerata	IV	1-5	2.6	IV	1-5	2.2	IV	1-5	2.1	IV	1-5	2.3
Veronica chamaedrys	IV	1-3	1.4	IV	1-5	1.7	IV	1-4	1.5	IV	1-5	1.5
MG6b-i & MG6b-ii												
Cardamine pratensis	III	1-2	1.1	III	1-2	1.1	II	1-2	1.2	III	1-2	1.1
Urtica dioica	III	1-2	1.0	III	1-2	1.1	II	1-2	1.0	III	1-2	1.1
Cerastium glomeratum	III	1-4	1.6	III	1-5	1.5	II	1-4	1.5	III	1-5	1.6
Caltha palustris	II	1-3	1.4	II	1-2	1.4	I	1-2	1.2	II	1-3	1.3
Veronica serpyllifolia	II	1-2	1.1	II	1	1.0	I	1	1.0	I	1	1.0
MG6b-i & MG6b-iii												
Rumex obtusifolius	IV	1-4	1.5	III	1-2	1.3	IV	1-3	1.2	IV	1-4	1.3
Phleum pratense	II	1-5	2.2	I	1-5	2.1	II	1-5	2.0	II	1-5	2.1
MG6bii & MG6b-iii												
Ranunculus acris	V	1-5	3.0	V	1-5	4.0	V	2-5	4.4	V	1-5	3.8
Anthoxanthum odoratum	IV	1-5	3.2	V	1-5	4.0	V	2-5	4.5	V	1-5	4.0
Festuca rubra	IV	1-5	3.6	V	1-5	4.1	V	1-5	4.3	IV	1-5	4.0
Bellis perennis	IV	1-5	2.3	IV	1-5	3.1	IV	1-5	2.9	IV	1-5	2.8
Vicia sepium	II	1-3	1.3	III	1-3	1.2	III	1-2	1.2	III	1-3	1.2
Prunella vulgaris	I	1-2	1.3	II	1-3	1.4	II	1-5	1.6	II	1-5	1.5
Achillea millefolium	I	1-2	1.1	II	1-4	1.6	II	1-2	1.1	II	1-4	1.3
Centaurea nigra	I	1-2	1.1	II	1-3	1.3	II	1-3	1.4	II	1-3	1.3
Geranium sylvaticum	I	1	1.0	II	1-4	1.5	II	1-3	1.2	II	1-4	1.3
Lathyrus pratensis	I	1-2	1.2	II	1-3	1.3	II	1-3	1.5	II	1-3	1.4
Senecio jacobea	I	1-2	1.1	II	1	1.0	II	1-3	1.1	II	1-3	1.1
Scorzoneroides autumnalis	I	1-2	1.1	II	1-2	1.2	II	1-2	1.2	II	1-2	1.2
Luzula campestris	I	1	1.0	II	1-2	1.2	I	1-4	1.5	I	1-4	1.3
MG6b-i												
Ranunculus repens	V	1-5	3.1	V	1-5	2.4	V	1-5	2.3	V	1-5	2.6
Rumex crispus	II	1-2	1.2	I	1-2	1.2	I	1	1.0	I	1-2	1.1
Stellaria media	II	1-2	1.1	I	1-2	1.1	I	1	1.0	I	1-2	1.1

Poa annua	I	1-5	1.6	I	1-3	1.3	I	1-2	1.1	I	1-5	1.4
Holcus mollis	I	1-4	1.8	I	1	1.0	I	1	1.0	I	1-4	1.4
Myosotis arvensis	I	1-2	1.4	I	1	1.0	I	1-2	1.1	I	1-2	1.2
MG6b-ii												
Cruciata laevipes	I	1	1.0	I	1-2	1.4	I	1	1.0	I	1-2	1.2
MG6b-iii												
Trifolium pratense	V	1-5	1.7	V	1-5	2.3	V	1-5	3.5	V	1-5	2.6
Rhinanthus minor minor	IV	1-5	2.2	IV	1-5	2.2	V	2-5	4.2	V	1-5	3.0
Plantago lanceolata	IV	1-5	2.3	IV	1-5	2.9	V	1-5	4.1	IV	1-5	3.2
Conopodium majus	IV	1-4	1.8	IV	1-5	2.9	V	1-5	3.0	IV	1-5	2.6
Taraxacum agg.	III	1-5	1.7	III	1-3	1.5	IV	1-5	1.7	IV	1-5	1.6
Myosotis discolor	III	1-3	1.3	III	1-3	1.4	III	1-4	1.4	III	1-4	1.4
***Euphrasia arctica* s.l.**	I	1-2	1.3	I	1-5	2.2	III	1-5	2.5	II	1-5	2.2
Trifolium dubium	I	1-5	1.6	II	1-4	1.7	III	1-5	2.5	II	1-5	2.1
Trisetum flavescens	II	1-4	1.7	II	1-3	1.8	II	1-5	2.6	II	1-5	2.1
Alchemilla glabra	I	1-2	1.1	I	1-2	1.1	II	1-3	1.3	II	1-3	1.2
Hypochaeris radicata	I	1-2	1.2	I	1-2	1.2	II	1-4	1.5	I	1-4	1.4
Sanguisorba officinalis	I	1-2	1.0	I	1-4	1.5	II	1-3	1.3	I	1-4	1.3
Alchemilla xanthochlora	I	1-2	1.2	I	1-2	1.1	II	1-5	1.3	I	1-5	1.2
Vicia cracca	I	1-2	1.2	I	1-3	1.3	II	1-2	1.2	I	1-3	1.2
Myosotis scorpioides	I	1-2	1.3	I	1-2	1.5	I	1-4	2.0	I	1-4	1.6
Arrhenatherum elatius	I	1-2	1.2	I	1-2	1.3	I	1-3	1.8	I	1-3	1.4
Avenula pubescens	I	1-2	1.2	I	1-2	1.2	I	1-5	1.7	I	1-5	1.4
Hyacinthoides non-scripta	I	1-2	1.2	I	1-2	1.3	I	1-4	1.7	I	1-4	1.4
Leontodon hispidus	I	1-2	1.1	I	1	1.0	I	1-3	1.5	I	1-3	1.3
Leucanthemum vulgare	I	1	1.0	I	1	1.0	I	1-2	1.4	I	1-2	1.3
Noise												
Heracleum sphondylium	II	1-2	1.2	III	1-2	1.2	III	1-5	1.2	III	1-5	1.2
Ranunculus bulbosus	II	1-5	2.3	II	1-5	2.6	II	1-5	2.8	II	1-5	2.6
Anthriscus sylvestris	II	1-4	1.7	II	1-5	2.0	II	1-5	1.7	II	1-5	1.8
Filipendula ulmaria	II	1-3	1.3	II	1-4	1.5	II	1-3	1.5	II	1-4	1.5
Cirsium arvense	II	1-4	1.3	II	1-3	1.3	II	1-3	1.2	II	1-4	1.3
Juncus effusus	II	1-2	1.1	II	1	1.0	II	1-2	1.2	II	1-2	1.1
Cirsium vulgare	II	1-2	1.1	II	1	1.0	II	1	1.0	II	1	1.0
Agrostis stolonifera	I	1-4	2.5	I	1-4	2.5	I	1-4	2.1	I	1-4	2.4
Schedonorus pratensis	I	1	1.4	I	1-4	1.6	I	1-3	1.5	I	1-4	1.5
Juncus acutiflorus	I	1-4	1.4	I	1-2	1.2	I	1-3	1.5	I	1-4	1.4
Carex nigra	I	1	1.0	I	1-2	1.2	I	1-2	1.3	I	1-2	1.3
Deschampsia cespitosa	I	1-2	1.1	I	1-2	1.1	I	1-4	1.4	I	1-4	1.2
Montia fontana	I	1-3	1.3	I	1-4	1.2	I	1-2	1.1	I	1-4	1.2
Rumex longifolius	I	1-2	1.1	I	1-2	1.2	I	1-3	1.2	I	1-3	1.1
Stellaria graminea	I	1-2	1.2	I	1-2	1.2	I	1-2	1.2	I	1-2	1.2
Ajuga reptans	I	1	1.0	I	1-2	1.1	I	1-2	1.2	I	1-2	1.1
Alopecurus geniculatus	I	1-2	1.1	I	1	1.0	I	1-2	1.3	I	1-2	1.1
Lotus corniculatus	I	1	1.0	I	1-2	1.1	I	1-2	1.2	I	1-2	1.1
Veronica arvensis	I	1-2	1.1	I	1-2	1.1	I	1	1.0	I	1-2	1.1
Equisetum arvense	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0
Ficaria verna	I	1	1.0	I	1	1.0	I	1	1.0	I	1	1.0

Extra species occurring in fewer than 5% of MG6 fields: *Acer pseudoplatanus, Achillea ptarmica, Agrostis canina,* ***Alchemilla acutiloba****,* ***Alchemilla filicaulis vestita****,* ***Alchemilla monticola****,* ***Alchemilla subcrenata****, Alnus glutinosa,* ***Anemone nemorosa****, Angelica sylvestris, Arctium minus* agg.*,* ***Atrichum undulatum****, Avenula pratensis, Betonica officinalis, Betula pubescens, Brachythecium rutabulum, Briza media, Calliergonella cuspidata, Campanula rotundifolia, Capsella bursa-pastoris, Cardamine flexuosa, Carex acutiformis, Carex caryophyllea, Carex flacca, Carex hirta, Carex leporina, Carex pallescens, Carex panicea, Centaurea cyanus, Chenopodium bonus-henricus,* ***Cirsium heterophyllum****, Cirsium palustre,* ***Cochlearia pyrenaica****, Comarum palustre, Crataegus monogyna,* ***Crepis mollis****,* ***Crepis paludosa****, Cytisus scoparius, Dactylorhiza fuchsii, Dactylorhiza maculata,* ***Dactylorhiza purpurella****, Dactylorhiza* species,

Dactylorhiza* x *venusta, *Deschampsia flexuosa,* ***Dryopteris filix-mas****, Eleocharis palustris, Epilobium hirsutum, Epilobium obscurum, Epilobium palustre, Equisetum fluviatile, Equisetum palustre,* ***Equisetum sylvaticum****, Eriophorum vaginatum, Fraxinus excelsior, Galium aparine,* ***Galium boreale****, Galium palustre, Galium saxatile, Galium uliginosum, Galium verum, Geranium pratense,* ***Geum rivale****, Glyceria fluitans, Homalothecium lutescens, Hylocomium splendens,* ***Hypericum pulchrum****, Juncus articulatus, Juncus conglomeratus, Kindbergia praelonga, Knautia arvensis, Lathyrus linifolius, Linum catharticum, Lotus pedunculatus, Luzula multiflora, Mentha* species*, Myosotis laxa, Myosotis secunda, Myosotis* species*, Myosotis sylvatica, Myrrhis odorata, Neottia ovata, Ophioglossum vulgatum, Papaver dubium,* ***Persicaria bistorta****, Petasites hybridus, Pilosella officinarum, Pinus species,* ***Plagiomnium undulatum****, Plantago major, Poa humilis, Poa pratensis, Polygonum aviculare, Potentilla anserina, Potentilla erecta,* ***Potentilla sterilis****, Poterium sanguisorba, Primula veris,* ***Primula vulgaris****, Prunus padus, Quercus petraea, Ranunculus flammula, Rhytidiadelphus squarrosus, Rosa canina* agg.*, Rumex sanguineus, Salix caprea, Salix pentandra, Salix* species*, Saxifraga granulata, Senecio aquaticus, Senecio vulgaris, Silene flos-cuculi, Sorbus aucuparia,* ***Stellaria holostea****, Stellaria uliginosa, Succisa pratensis, Symphytum* x *uplandicum, Trifolium medium,* ***Trollius europaeus****, Tussilago farfara, Ulex europaeus, Veronica beccabunga, Veronica filiformis, Vicia sativa segetalis,* ***Viola lutea****,* ***Viola riviniana***.

General comments on the MG6 table

At first glance, the three types (variants) of MG6b as presented in the table here do not appear very different to each other. However, they are normally recognisable in the field. There is a lot of overlap in species composition between the three types. The main differences between three types are in the grass to herb ratio and the relative abundance of certain indicator species. In this table, it is useful to compare the figures for 'average within-stand frequency' as well as the figures for 'between-stand frequency' in order to appreciate the differences between the variants. If these vegetation types had been sampled using quadrats rather than whole stands as the sampling unit, the differences between the variants would probably be considerably more obvious in the resulting table.

The three types presented here represent three points along a continuum of vegetation quality and herb-richness, with MG6b-i being the most herb-poor, MG6b-iii the most herb-rich and MG6-ii in between.

Rationale for separating these vegetation types and relationship to the published NVC sub-communities

In BPC, three sub-communities of MG6 are identified, which correspond to points along a continuum of pH. MG6b represents samples towards the acidic end of the continuum, MG6c represents samples towards the calcareous end of the continuum and MG6a represents mesotrophic samples. There is no distinction made in BPC between samples from meadows and pastures unlike in the treatment of MG7 where two 'meadow' sub-communities 'MG7c and MG7d' are separated from the other sub-communities from pastures or amenity situations.

Our data are all from meadows, so it is unsurprising that species that do best in meadows rather than pastures, such as *Alopecurus pratensis*, *Bromus hordaceus* and *Trisetum flavescens* are over-represented in our data compared to the published tables for MG6 in BPC. Soil tests were carried out on 88 of these MG6 meadows and the pH ranged from 5.1 to 6.5 with a mean of 5.9. Our MG6 vegetation, fits in to the mesotrophic to slightly acidic end of the continuum (which would correspond to BPC's MG6a and MG6b), but is biased towards true meadow species rather than pasture species. It is also not surprising therefore, that the published sub-communities in BPC do not fit our vegetation types precisely. Our data does not seem to include any samples that fit well into BPC's MG6c.

Many of our samples fit best into MG6b with some affinities to MG6a at times. Our three types are probably best regarded as three northern meadow variants of MG6b

MG6b-i (*Rumex obtusifolium-Ranunculus repens* variant)

The overall appearance of MG6b-i is similar to MG7d. Their species composition is very similar. They are both quite grassy types of vegetation with usually only scattered flowers in the sward or else only one or two herb species that are co-dominant with the grasses. The main difference between these is that MG6b-i normally has frequent *Cynosurus cristatus*, which is absent from, or rare in MG7d.

MG6b-i differs from MG6b-ii mainly in being more grassy and less herb-rich. MG6b-ii often has more variety of herbs and/or more of the herb species present are frequent in the vegetation. Once several

examples of both types have been seen, they are often instantly separable in the field without even looking at the species composition.

There are two main differences in species composition between MG6bi and MG6b-ii. MG6b-i has several weedy species that are more frequent than in MG6b-ii, including *Rumex obtusifolius*, , *Ranunculus repens, Rumex crispus* and *Stellaria media*. Also, in MG6b-ii there is a long list of species that are common to MG6b-ii and MG6b-iii but less frequent in MG6b-i. These species are listed in the table above in the 'MG6b-ii & MG6b-iii' block. These species could all be considered as 'axiophytes' (see http://www.bsbi.org.uk/axiophytes.html) or species indicating vegetation of moderate to high quality. Some of these axiophyte species are also used as positive indicator species in Common Standards Monitoring (Robertson & Jefferson 2000).

MG6b-ii (*Festuca rubra-Veronica chamaedrys* variant)
MG6b-ii lies in the mid range in terms of quality among MG6 samples in our classification. The differences from MG6b-i are outlined above. MG6b-ii is a semi-improved type of grassland that is usually moderately flowery, although the herb element is still usually comprised of a relatively small number of common species.

There is a strong overlap in species composition between MG6b-ii and MG6b-iii. There are two main differences between these two types. MG6b-ii usually has a lower %cover of herbs overall, often in the range of 20% to 35% cover, whereas in MG6b-iii the %cover of herbs is often over 50%. Floristically, there is a long list of axiophytes indicating higher quality grassland that are more frequent in MG6b-iii than in MG6b-ii. These species are listed in the MG6b-iii block in the table above. In particular five species on this list, *Trifolium pratense*, *Rhinanthus minor*, *Plantago lanceolata*, *Conopodium majus* and *Euphrasia arctica* s.l. can be abundant in MG6b-iii but are usually less frequent and significantly less abundant in examples of MG6b-ii.

MG6b-iii (*Trifolium pratense-Rhinanthus minor* variant)
This is a type of grassland that does not fit in easily to anything described in BPC. In many cases it appears intermediate in terms of species composition between MG6b and MG3. It is clearly of conservation significance. It often has quite a high cover of herbs and the grass element of the flora usually has a significant proportion of fine-leaved grasses. It can very often have big populations of *Rhinanthus minor* and/or *Euphrasia arctica* s.l. There are a number of genuine upland hay meadow indicator species (highlighted in bold text in the table) that appear in this type of vegetation, but most of these apart from *Conopodium majus* and *Euphrasia arctica* s.l. are normally quite sparse in the vegetation. None of the examples are rich enough in these upland hay meadow indicator species, to include them in MG3.

Undoubtedly, some surveyors would include this type of herb-rich grassland within MG5. However, despite the high cover of herbs here, it is not regarded as species-rich enough to be included in MG5. Also, to qualify as MG5, at least two of the following would be expected to be frequent in the sward: common bird's-foot-trefoil *Lotus corniculatus*; *Centaurea nigra*; oxeye daisy *Leucanthemum vulgare*; *Prunella vulgaris*; and *Lathyrus pratensis*. In many fields of this rich MG6 vegetation, several MG3b indicator species (such as *Geranium sylvaticum*, *Sanguisorba officinalis*, Lady's-mantles *Alchemilla vulgaris* agg. or melancholy thistle *Cirsium heterophyllum*), survive around the field edges, suggesting that the flowery vegetation currently occupying the main sward is an impoverished version of the MG3b that probably occurred in the field in the past.

If genuine restoration of MG3 upland hay meadows is ever to take place on a significant scale, it is in these fields that it will most likely happen. These fields also provide a very useful seed source for starting off the restoration process on other fields that have been more improved. However, as these samples usually lack the distinctive preferential species of more species-rich grassland types like MG3 and MG5, it is still best considered as being a relatively impoverished, semi-improved type of grassland overall. It is however, at the very high end of semi-improved grasslands in terms of quality.

There were a relatively large (91) number of examples of this sub-community from our surveys. This type of grassland appears to have survived better in the North Pennines compared to other parts of northern England with upland hay meadows, where it is much rarer (Pippa Rayner & Claire Cornish pers. com.).

5 MG3 *Anthoxanthum odoratum-Geranium sylvaticum* (sweet vernal-grass/wood crane's-bill) grassland

	MG3a			MG3b			MG3c			all MG3		
No. of stands	38			12			4			54		
Altitude range	155-430			170-440			190-310			155-440		
Average altitude	292			238			235			276		
No. of soil samples	14			3			1			18		
Soil pH range	5.4-6.8			5.6-6.5						5.4-6.8		
Average soil pH	6.0			5.9			5.6			5.9		
Soil P (mg/l) range	2-26			2-9						2-26		
Average soil P (mg/l)	8.3			6.3			8.0			7.9		
No. of species range	16-69			35-62			23-61			16-69		
Average no. of species	39.8			46.2			40.0			41.2		
Taxon	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF
Constants												
Festuca rubra	V	1-5	4.39	V	2-5	4.09	IV	3-5	3.67	V	1-5	4.27
Holcus lanatus	V	1-5	4.15	V	1-5	4.36	V	3-5	4.00	V	1-5	4.26
Ranunculus acris	V	2-5	4.36	V	2-5	4.17	V	2-3	2.50	V	2-5	4.17
Anthoxanthum odoratum	V	2-5	4.26	V	3-5	4.64	IV	2-4	2.67	V	2-5	4.24
Rumex acetosa	V	1-5	3.49	V	1-5	3.50	V	1-4	3.00	V	1-5	3.45
Trifolium pratense	V	1-5	3.40	V	2-5	4.00	V	1-2	1.75	V	1-5	3.41
Conopodium majus	V	1-5	2.75	V	2-5	3.42	V	3-5	3.75	V	1-5	3.00
Cerastium fontanum	V	1-4	2.24	V	1-5	3.40	IV	1-2	1.33	V	1-5	2.43
Geranium sylvaticum	V	1-4	1.74	V	1-5	3.18	V	1-3	2.00	V	1-5	2.11
Agrostis capillaris	IV	2-5	4.31	V	3-5	4.82	III	2-3	2.50	IV	2-5	4.36
Poa trivialis	IV	1-5	3.46	IV	1-5	3.75	III	3	3.00	IV	1-5	3.50
Lolium perenne	IV	1-5	3.74	III	1-4	2.57	III	1-2	1.50	IV	1-5	3.39
Alopecurus pratensis	IV	1-5	2.96	V	1-5	2.17	III	2-4	3.00	IV	1-5	2.73
Dactylis glomerata	V	1-5	2.39	IV	1-5	2.75	IV	2-4	3.33	IV	1-5	2.52
Ranunculus repens	IV	1-4	2.32	IV	1-3	1.67	IV	1-3	1.67	IV	1-5	2.13
Veronica chamaedrys	IV	1-5	1.73	IV	1-5	2.25	V	2-4	3.25	IV	1-5	2.00
Alchemilla glabra	IV	1-5	1.80	V	1-4	2.27	III	1-3	2.00	IV	1-5	1.95
Filipendula ulmaria	IV	1.3	1.58	IV	1-5	2.13	V	1-5	3.00	IV	1-5	1.86
Lathyrus pratensis	IV	1-3	1.60	V	1-3	1.64	IV	1-3	2.00	IV	1-3	1.64
MG3a & MG3b												
Plantago lanceolata	V	1-5	3.97	V	3-5	4.58	III	2-3	2.50	V	1-5	4.06
Trifolium repens	V	1-5	3.44	V	1-5	3.09	III	1-2	1.50	V	1-5	3.28
Cynosurus cristatus	V	1-5	4.41	V	3-5	4.80	II	3	3.00	V	1-5	4.47
Rhinanthus minor minor	V	1-5	3.38	V	2-5	3.91				V	1-5	3.51
Bellis perennis	IV	1-5	2.68	III	1-4	2.00				IV	1-5	2.56
Trisetum flavescens	III	1-4	1.90	IV	1-5	2.88				III	1-5	2.17
Hypochaeris radicata	III	1-4	1.94	IV	1-4	2.50				III	1-4	2.12
Leontodon hispidus	III	1-3	1.47	IV	1-5	2.75				III	1-5	1.88
Prunella vulgaris	III	1-4	1.75	IV	1-4	2.00				III	1-4	1.82
Taraxacum agg.	III	1-5	1.76	IV	1-4	1.75				III	1-5	1.76
Trifolium dubium	III	1-5	2.38	III	2-5	4.14				III	1-5	2.82
***Euphrasia arctica* s.l.**	IV	1-5	2.29	III	1-5	3.29				III	1-5	2.52
Bromus hordaceus hordaceus	III	1-5	2.48	III	1-4	1.67				III	1-5	2.30
Myosotis discolor	III	1-2	1.41	III	1-3	2.00				III	1-3	1.56
Scorzoneroides autumnalis	III	1-3	1.56	III	1-3	2.00				II	1-3	1.67
Phleum pratense	II	1-4	1.54	III	1-4	1.80				II	1-4	1.63
Ranunculus bulbosus	II	1-5	2.21	II	1-4	2.33				II	1-5	2.24
Agrostis stolonifera	II	1-5	2.33	II	1-2	1.50				II	1-5	2.13

Anthriscus sylvestris	II	1-2	1.08	II	1-2	1.33				II	1-2	1.13
Kindbergia praelonga	I	2-3	2.50	I	5	5.00				I	2-5	3.33
Brachythecium rutabulum	I	2-5	3.00	I	5	5.00				I	1-5	3.17
Anemone nemorosa	I	1-3	1.60	I	1-3	2.00				I	1-3	1.71
Holcus mollis	I	1-2	1.50	I	1	1.00				I	1-2	1.40
Poa pratensis	I	1-2	1.50	I	1	1.00				I	1-2	1.33
Alopecurus geniculatus	I	1-2	1.33	I	1	1.00				I	1-2	1.25
Viola lutea	I	1-2	1.25	I	1	1.00				I	1-2	1.20
Achillea ptarmica	I	1	1.00	I	1	1.00				I	1	1.00
Alchemilla subcrenata	I	1	1.00	I	1	1.00				I	1	1.00
Carex leporina	I	1	1.00	I	1	1.00				I	1	1.00
Juncus conglomeratus	I	1	1.00	I	1	1.00				I	1	1.00
Silene flos-cuculi	I	1	1.00	I	1	1.00				I	1	1.00
Poa annua	I	1	1.00	I	1	1.00				I	1	1.00
Rumex longifolius	I	1	1.00	I	1	1.00				I	1	1.00
Trollius europaeus	I	1	1.00	I	1	1.00				I	1	1.00
Veronica serpyllifolia	I	1	1.00	I	1	1.00				I	1	1.00
MG3b & MG3c												
Centaurea nigra	II	1-2	1.27	IV	1-3	2.00	V	1-4	2.00	III	1-4	1.59
Potentilla erecta erecta	I	1-3	1.43	III	1-4	1.60	IV	1-3	2.00	II	1-4	1.60
Equisetum arvense	II	1	1.00	III	1-3	1.40	III	1	1.00	II	1-3	1.13
MG3a & MG3c												
Cardamine pratensis	III	1-2	1.22	I	1-2	1.50	IV	1-3	1.67	III	1-3	1.30
Hyacinthoides non-scripta	I	1-2	1.25				II	1	1.00	I	1-2	1.20
MG3a												
Heracleum sphondylium	IV	1-3	1.32	III	1-4	2.00	II	2	2.00	IV	1-4	1.48
Rumex obtusifolius	IV	1-2	1.25	II	1.2	1.50	II	1	1.00	III	1-2	1.28
Caltha palustris	II	1-2	1.64	I	1	1.00				II	1-2	1.56
Cerastium glomeratum	II	1-4	1.50	I	1-3	2.00				I	1-4	1.60
Carex nigra	II	1-2	1.25	I	1-2	1.50				I	1-2	1.30
Rumex crispus	II	1-2	1.00							I	1	1.00
Alchemilla acutiloba	I	1-4	2.00							I	1-4	2.00
Dactylorhiza species	I	1-3	2.00							I	1-3	2.00
Schedonorus pratensis	I	1-2	1.50							I	1-2	1.50
Lotus pedunculatus	I	1-2	1.33							I	1-2	1.33
Montia fontana	I	1.2	1.25							I	1-2	1.25
Succisa pratensis	I	1.2	1.25							I	1-2	1.25
Juncus articulatus	I	1	1.00							I	1	1.00
Myosotis secunda	I	1	1.00							I	1	1.00
Stellaria media	I	1	1.00							I	1	1.00
MG3b												
Vicia cracca	II	1-2	1.30	IV	1-2	1.25				II	1-2	1.28
Stellaria graminea	I	1-2	1.20	III	1-3	1.71	II	2	2.00	II	1-3	1.54
Leucanthemum vulgare	I	1	1.00	III	1-3	1.67	II	1	1.00	II	1-3	1.31
Senecio jacobea	II	1	1.00	III	1	1.00	II	1	1.00	II	1	1.00
Primula veris	I	1-2	1.50	III	1-2	1.20	II	1	1.00	I	1-2	1.25
Dactylorhiza fuchsii	I	1	1.00	III	1-3	1.71				I	1-3	1.56
Persicaria bistorta	I	1-3	1.50	II	1	1.00				I	1-3	1.25
Platanthera chlorantha				II	1-2	1.25				I	1-2	1.25
MG3c												
Cirsium arvense	II	1-2	1.15	II	1	1.00	V	1-2	1.25	II	1-2	1.15
Ajuga reptans	I	1-3	1.57	II	1	1.00	III	2-3	2.50	II	1-3	1.54
Deschampsia cespitosa	I	1-2	1.40	II	1-2	1.25	III	1	1.00	II	1-2	1.27
Cruciata laevipes	I	1-2	1.33	I	2	2.00	IV	2-4	3.00	I	1-4	2.14

Rhytidiadelphus squarrosus	I	1-3	1.40	I	1	1.00	III	2-5	3.50	I	1-5	1.88
Lathyrus linifolius	I	1	1.00	II	1	1.00	III	1	1.00	I	1	1.00
Cirsium heterophyllum	I	1	1.00	I	2	2.00	III	1	1.00	I	1-2	1.17
Briza media	I	1	1.00	I	1-2	1.50	III	1	1.00	I	1-2	1.14
Alchemilla filicaulis vestita	I	1	1.00	I	1	1.00	III	1	1.00	I	1	1.00
Cirsium vulgare	I	1	1.00	I	1	1.00	III	1	1.00	I	1	1.00
Trifolium medium	I	1	1.00	I	1	1.00	III	1	1.00	I	1	1.00
Crepis mollis				I	1	1.00	III	1-3	2.00	I	1-3	1.50
Cardamine flexuosa	I	1	1.00	I	1	1.00	II	3	3.00	I	1-3	1.50
Geum rivale	I	1-3	1.67	I	1	1.00	II	1	1.00	I	1-3	1.33
Potentilla sterilis	I	1	1.00	I	1	1.00	II	2	2.00	I	1-2	1.20
Cirsium palustre	I	1.2	1.25	I	1	1.00	II	1	1.00	I	1-2	1.17
Galium aparine	I	1	1.00	I	1	1.00	II	1	1.00	I	1	1.00
Galium verum	I	1	1.00	I	1	1.00	II	1	1.00	I	1	1.00
Pilosella officinarum	I	1	1.00	I	1	1.00	II	1	1.00	I	1	1.00
Orchis mascula				1	1-2	1.50	II	1	1.00	I	1-2	1.33
Primula vulgaris							III	1	1.00	I	1	1.00
Arrhenatherum elatius	I	1	1.00				II	2	2.00	I	1-2	1.50
Stellaria holostea	I	1	1.00				II	2	2.00	I	1-2	1.50
Campanula rotundifolia				I	1	1.00	II	1	1.00	I	1	1.00
Atrichum undulatum							II	2	2.00	I	2	2.00
Crataegus monogyna							II	2	2.00	I	2	2.00
Acer pseudoplatanus seedling							II	1	1.00	I	1	1.00
Alnus glutinosa seedling							II	1	1.00	I	1	1.00
Athyrium filix-femina							II	1	1.00	I	1	1.00
Digitalis purpurea							II	1	1.00	I	1	1.00
Dryopteris filix-mas							II	1	1.00	I	1	1.00
Hypericum pulchrum							II	1	1.00	I	1	1.00
Petasites hybridus							II	1	1.00	I	1	1.00
Pimpinella saxifraga							II	1	1.00	I	1	1.00
Pteridium aquilinum							II	1	1.00	I	1	1.00
Rosa species							II	1	1.00	I	1	1.00
Noise												
Sanguisorba officinalis	III	1-5	2.37	IV	2-5	4.11	IV	2-3	2.67	III	1-5	2.90
Alchemilla xanthochlora	III	1-4	1.60	IV	1-4	1.44	IV	1-2	1.67	III	1-4	1.56
Vicia sepium	IV	1-2	1.13	III	1-2	1.50	III	1-2	1.50	III	1-2	1.23
Avenula pubescens	II	1-3	1.33	III	1-4	2.60	III	1-2	1.50	III	1-4	1.64
Luzula campestris	II	1-5	1.91	III	1-4	2.33	III	1-2	1.50	II	1-5	2.00
Juncus acutiflorus	II	1-3	1.64	I	2	2.00	II	2	2.00	II	1-3	1.71
Lotus corniculatus	II	1-2	1.25	III	1-4	1.86	III	2	2.00	II	1-4	1.52
Achillea millefolium	II	1-2	1.22	II	1-2	1.50	II	2	2.00	II	1-2	1.36
Juncus effusus	II	1-2	1.25	II	1	1.00	II	2	2.00	II	1-2	1.25
Urtica dioica	II	1-2	1.08	II	1	1.00	II	1	1.00	II	1-2	1.06
Equisetum sylvaticum	I	1	1.00	II	1	1.00	II	1	1.00	II	1	1.00
Betonica officinalis	I	1	1.00	II	2-4	2.75	II	2	2.00	I	1-4	2.33
Carex flacca	I	1-5	3.00	II	1	1.00	II	1	1.00	I	1-5	1.67
Ficaria verna	I	1-2	1.67	II	1	1.00	II	1	1.00	I	1-2	1.29

Extra species occurring in fewer than 5% of MG3 fields: *Alnus glutinosa*, *Angelica sylvestris*, *Arctium minus* agg., *Avenula pratensis*, *Calliergonella cuspidata*, *Carex panicea*, *Crepis biennis*, ***Dactylorhiza purpurella***, ***Dactylorhiza* x *transiens***, *Elytrigia repens*, *Epilobium hirsutum*, *Equisetum fluviatile*, *Equisetum palustre*, ***Euphrasia rostkoviana* s.l.,** *Galium saxatile*, *Geranium pratense*, ***Geum urbanum***, *Glyceria fluitans*, *Hieracium* agg., *Luzula multiflora*, ***Mnium hornum***, *Myosotis arvensis*, ***Myrrhis odorata***, *Neottia ovata*, *Pillosella aurantica*, *Plantago major*, *Plantago media*, *Poa humilis*, *Potentilla anserina*, *Ranunculus flammula*, *Rubus fruticosus* agg., *Saxifraga granulata*, *Schedonorus arundinaceus*, *Sonchus asper*, *Stellaria alsine*, *Torilis japonica*, *Tussilago farfara*, *Veronica arvensis*, *Vulpia bromoides*.

General discussion on the data for the whole MG3 community

The first impression from this data is how similar it looks overall to the published tables for MG3 in BPC. All of the constant species from the BPC tables appear in our data at a high frequency also. The only slight exception to this is that *Sanguisorba officinalis* was present in 55.4% of our stands and therefore just fails to qualify at a frequency of IV. Our data overall differs from the BPC tables in including more species at a frequency of IV or V. These extra species include *Trifolium pratense*, *Lolium perenne*, *Alopecurus pratensis*, *Ranunculus repens*, *Filipendula ulmaria*, *Cynosurus cristatus*, *Rhinanthus minor* and *Veronica chamaedrys*. Our data also includes a list of species at a frequency of II or III which are rare or absent entirely from the BPC tables. These include *Prunella vulgaris*, *Trifolium dubium*, *Euphrasia arctica* s.l., *Rumex obtusifolius*, *Vicia sepium*, *Agrostis stolonifera*, tufted vetch *Vicia cracca*, lesser stitchwort *Stellaria graminea*, creeping thistle *Cirsium arvense*, *Juncus effusus*, *Urtica dioica*, *Juncus acutiflorus* and *Myosotis discolor*. The comments below on the differences between our data and the BPC tables are based on the assumption that the data in the BPC tables are reasonably representative of the composition of MG3 in Britain at the time when the data were collected.

This large number of extra species that are more frequent in our data may be partly due to differences in sampling methods. Our data comprises near complete species list (from more or less homogenous vegetation, avoiding atypical areas like banks, edges or mires) for whole fields, whereas the BPC tables were based on sampling from 2m x 2m quadrats. It is inevitable that in our data there are more species per sample and therefore more species at a higher frequency overall. Species that occur only sparsely in fields are likely to be over-represented in our data compared to the data in BPC. Our data for MG3 therefore, has more species at a relatively high frequency than does the data for MG3 in BPC. However, it is unlikely that our MG3 fields are more species rich than the fields where MG3 was sampled for BPC. Some of the species that occurred at high frequency in the BPC data may have declined in frequency in MG3 since then, but this decline would not be apparent in our data due to the different sampling methods.

Despite these issues, it is postulated that it is still valid to say that these extra species do give the North Pennines vegetation a distinctive flavour, as compared to the overall floristic composition of MG3 throughout it British range when the surveying for the NVC was carried out. Comparing the tables from our data with the MG3 table in BPC, these extra species are more frequent in our data relative to the other species in the tables. These other species appear to occur at a similar or slightly lower frequency in our data compared to in BPC. It does appear therefore, that these extra species are genuinely more frequent in upland hay meadows in the North Pennines in recent years compared to the older data from throughout Northern England in BPC. Whether these changes are real could easily be tested by surveying a series of 2m x 2m quadrats in these fields using the same methodology as used for BPC and then comparing the resulting tables to see how many of these ‘extra’ species are present at higher frequencies on that scale.

There are four distinct elements of these extra species in the data that are all worth commenting on: weedy species, annuals, damp-loving species and other perennial herbs.

Weedy species and species associated with agricultural improvement

Several of the species that are more frequent in our data are weedy species, or species indicating agricultural improvement or agricultural mismanagement. This broad group includes *Lolium perenne*, *Alopecurus pratensis*, *Rumex obtusifolius*, *Cirsium arvense* and *Urtica dioica*. It could be inferred from this that either the North Pennines upland hay meadows were never as high in quality as the national average, which seems unlikely, or that since the surveying for BPC, there has been a deterioration in the quality of the vegetation here, which seems more likely. Remember that these data only include MG3 fields and not the more agriculturally-improved fields. This change may indicate an overall deterioration in quality even in the best remaining fields.

Some of the significant changes in farming practices that have occurred in Teesdale since the early 1950s are listed in Bradshaw (2009). These include: changes in type (heavy continental-cross suckler cows replacing traditional breed dairy cows) and numbers (particularly sheep)of livestock; changes in timing of grazing, with large numbers of sheep being wintered on the meadows in recent decades; change from farmyard manure to artificial manure; change in type of farmyard manure from the traditional type to a semi-raw, ammonia-laden type of manure; decrease in the use of lime and/or basic slag; switch from hay-making to silage or haylage. More recently, some species-rich fields

have been ploughed and reseeded following the relaxation of the Environmental Impact Assessment (Agriculture) regulations in 2006. Any one or more of these changes could cause shifts in the vegetation either directly or indirectly.

Annual herbs
It is striking that a group of annual herbs, *Rhinanthus minor*, *Trifolium dubium*, *Euphrasia arctica* s.l. and *Myosotis discolor*, are much more frequent in our vegetation than in the BPC tables representing the 'national average' of MG3 at the time when the surveying was done for the NVC. Annual species in hay meadows can be dramatically influenced by changes in management. In particular, their populations can be quickly reduced or eliminated by grazing a field for a year or two before going back to meadow management, or by having little or no management for a number of years, or possibly by shutting the meadow up later in spring than normal. The higher frequency of annual species in our data either means that the management of MG3 meadows in the North Pennines is different to the national average or that the management of meadows in the North Pennines has changed since the sampling for BPC.

It is quite likely that there has been a significant change in management in the North Pennines in recent years. Most of the farms with hay meadows in the North Pennines have been included in the Pennines Dales Environmentally Sensitive Areas agri-environment scheme for the past 10 to 15 years or more. This was an early and simple agri-environment scheme which has been criticised for being too rigid in its management prescriptions. One of the overall impacts of the scheme on the meadows of the North Pennines may have been to encourage a standardisation of management, throughout the area and in individual fields from year to year. This standardised management would have suited the life strategy of these annual species ideally and allowed them to build up and maintain large populations over the years. The cutting time is after the species have set viable seed. Cutting operations opens up the sward to allow germination niches. Grazing then keeps competition down until the time of year when the annuals start growing. If the management (grazing times and cutting times varied more, the populations would be reduced occasionally, but having the same timings every year suits the life cycle of the annual species. This type of management also unfortunately suits the troublesome, weedy, annual grass *Bromus hordaceus*, which occurs at a slightly higher frequency overall in our data than in the published tables and is one of the most significant limiting factors preventing attempts at species-rich meadow restoration using green hay.

There is a good deal of anecdotal evidence that in the past, management of meadows was not so standardised. In some areas it was relatively common practise to manage fields as pasture for a few years before going back to normal meadow management. Modern, larger and more efficient machinery, coupled with a declining agricultural workforce has also encouraged a streamlining of meadow management. Whereas 50 years ago it may have taken up to 8 weeks to cut and save all of the hay from a farm, it can normally be done in one week now if the weather is reasonably favourable. The days are long gone when fields were cut following a long established pattern of rotation, with early fields always cut early and late fields always cut late, resulting in subtle differences in their floras. These more changeable management regimes from past decades would have been less suitable for annual species as there would have been significant disruption to their life cycle in some years, knocking their populations back to very low levels.

Damp-loving species
A group of wet-loving species are significantly more frequent in the data than in the BPC tables. These are *Ranunculus repens*, *Filipendula ulmaria*, *Agrostis stolonifera*, *Juncus effusus* and *Juncus acutiflorus*. It is assumed for now that these species have become more common in upland hay meadows in recent years, rather than always having been more common in meadows in the North Pennines. It is interesting that in 15 quadrats recorded around *Alchemilla* species by Dr M.E. Bradshaw in the 1950s, *Juncus effusus* was recorded in only 1 quadrat and *Ranunculus repens* and *Juncus acutiflorus* were not recorded in a single quadrat (Bradshaw 1962). It would now appear to be very difficult to place a quadrat anywhere in a meadow in the North Pennines without including some *Ranunculus repens*.

There are several possible explanations for this increase in wet-loving species; changes in climate (wetter winters, wetter springs, wetter summers, milder winters); nitrogen deposition, general trend of agricultural improvement and associated soil compaction from higher stocking rates and/or heavier breeds and more frequent field operation using larger machinery; lack of maintenance of field drains.

Soil compaction and lack of maintenance of field drains are probably significant factors. Almost all upland hay meadow fields apart from field on the steepest slopes had stone field drains that were regularly maintained in the past as part of the regular farm management. This practise has largely stopped now. It is labour-intensive to maintain the old stone field drains and labour and skill are in relatively short supply on upland farms now. The early agri-environment schemes had a presumption against new drainage or major repairs to drainage. Even in more recent years, the language used in the prescriptions and the general awareness of the issues among agri-environment staff, often do not encourage maintenance of field drains. Natural England are aware of this issue and are trying to address it through new guidance and training.

Other perennial herbs

The fourth element of the extra species in our data are the 'non-weedy' perennial herbs and grasses. These include *Cynosurus cristatus*, *Trifolium pratense*, *Veronica chamaedrys*, *Prunella vulgaris*, *Vicia sepium*, *Vicia cracca* and *Stellaria graminea*. These are all species that might be regarded as 'axiophytes', i.e. indicators of reasonably good quality habitat, although none of them are of major conservation interest. Whether these extra species comprise a genuine element of local distinctiveness to the North Pennines meadows that has always been there, or whether they have increased in recent years due to management changes is difficult to judge. It may be possible to infer which is more likely by comparing our data to recent survey data from a set of upland hay meadows in another part of the country, or by comparing our data to older survey data from the North Pennines meadows such as the NCC surveys from the mid 1980s (Loring 1983; Prosser 1988a, 1988b, 1990a, 1990b; Wigginton 1988).

MG3 sub-communities

There are several issues with the data presented for MG3 in BPC that need highlighting before discussing how our data compare to it:

- In the years before BPC was published, the draft NVC was in fairly widespread use. For at least part of this time, the species-rich sub-community of MG3 was known as 'MG3a' and the less species-rich sub-community was known as 'MG3b'. When BPC was published however, these two sub-communities were labeled the other way round. It appears likely that the frequency and abundance figures for several or all of the 'constant' species in the published table are listed the wrong way around. Species such as *Geranium sylvaticum*, *Alchemilla glabra*, *Sanguisorba officinalis*, that would be expected to be more abundant in the species-rich sub-community, are listed as being significantly more abundant and/or frequent in MG3a in the published version.
- The list of bryophytes at the end of the table is listed only against sub-community a and not even in the right hand column against the community as a whole. If anything, bryophytes should be more frequent in sub-community b. This is more than likely due to another data entry error.
- There are no data presented at all for sub-community c.

MG3a

MG3a is less species-rich than MG3b, often because it has undergone some agricultural improvement at some point in the past. Some stands of MG3a may be unimproved, but naturally less species-rich than MG3b. It is similar in many ways to the richest forms of MG6 but with the addition of some of the MG3 differentials and preferentials such as *Geranium sylvaticum*, *Alchemilla* species and *Sanguisorba officinalis*. These species usually do not contribute a high cover to the vegetation as they do in MG3b. *Heracleum sphondylium* and *Rumex obtusifolius* appear to be the best preferential species for MG3a over other types of MG3 in our data. In BPC the strongest MG3a preferentials are *Bromus hordaceus* and *Lolium perenne*. These species are not as strongly preferential for MG3a in our data – see discussion re 'extra' species above. Compared to the other two sub-communities, MG3a usually has less *Centaurea nigra*, tormentil *Potentilla erecta* and field horsetail *Equisetum arvense*.

MG3b

This is the richest type of dry upland hay meadow vegetation. Normally there is a high cover of herbs and there are usually large populations of some of the northern-montane species. Two of the 12 fields lacked any northern-montane species, but were herb-rich and included large populations of species like *Sanguisorba officinalis*, *Leontodon hispidus* and *Filipendula ulmaria*. These fields are an almost perfect match floristically to MG4 but are in the wrong topographical and geographical

situation and are probably best thought of as 'MG3b with a few species lacking' (Richard Jefferson pers. com.). Species that were preferential for MG3b in our data included *Vicia cracca*, *Stellaria graminea*, *Leucanthemum vulgare*, common ragwort *Senecio jacobaea*, cowslip *Primula veris*, common spotted-orchid *Dactylorhiza fuchsii*, common bistort *Persicaria bistorta* and greater butterfly-orchid *Platanthera chlorantha*. All of these apart from *Senecio jacobaea* are axiophytes.

MG3c

Note that this type of vegetation is not labelled as 'MG3c' in BPC, as there are no data from it included in the MG3 floristic tables. It is briefly described on p50 of BPC Vol 3.

Sub-communities a and b normally occur in regularly mown meadows whereas sub-community c occurs in unmanaged areas such as steep banks in meadows, road verges and ungrazed riverbanks. Although the best stands of MG3c are probably derived from MG3b through management neglect, the habitat is quite different to MG3a and MG3b ecologically. It may be better to think of MG3c as a northern-montane sub-community of MG1, as it shares many characteristics and species with rich forms of this type of rank grassland. It is similar to MG1e with the addition of the northern-montane species and *Sanguisorba officinalis*.

The differences between MG3c and the other 2 sub-communities is illustrated in the table by the long list of species common to sub-communities a and b that are missing from or less frequent in MG3c and by the long list of preferential and differential species for MG3c. However, the length of the 'missing' species list is likely to be partly due to the small (4) number of samples of MG3c in our data.

This small sample of data on MG3c is unlikely to be truly representative. In particular, species like false oat-grass *Arrhenatherum elatius*, *Heracleum sphondylium*, *Anthriscus sylvestris*, sweet Cicely *Myrrhis odorata* and meadow crane's-bill *Geranium pratense* are all likely to be more frequent in MG3c than our data suggests.

This is an important habitat in conservation terms, particularly as an important reservoir of tall herb MG3 species across the range of the community in northern England. In some parts of the North Pennines it is the only type of species-rich upland hay meadow vegetation that survives. MG3c is more likely to support interesting communities of invertebrates compared to species-rich MG3b that is still regularly cut. The habitat has not been described in detail in BPC or elsewhere and perhaps partly because of this it has a low profile in nature conservation circles. Most stands receive no or minimal management and are probably slowly declining in quality.

6 MG8 *Cynosurus cristatus-Caltha palustris* (crested dog's-tail/marsh marigold) grassland

	MG8-			MG8o			MG8+			MG8n			All MG8		
No. of stands	14			26			12			4			56		
Altitude range	300-460			240-510			320-460			370-460			240-510		
Average altitude	381			414			387			413			400		
No. of species range	15-34			19-56			19-55			33-59			15-59		
Average no. of species	25.6			33.3			32.4			44.8			32.0		
Taxon	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF	bF	wF	av wF
Constants															
Holcus lanatus	V	3-5	4.5	V	3-5	4.7	V	3-5	4.6	IV	5	5.0	V	3-5	4.7
Ranunculus repens	V	3-5	4.6	V	2-5	4.3	V	2-5	4.2	V	2-5	3.5	V	2-5	4.3
Anthoxanthum odoratum	IV	1-5	2.8	V	1-5	4.1	V	2-5	4.0	V	5	5.0	V	1-5	3.9
Rumex acetosa	V	2-5	4.0	V	1-5	3.9	V	2-5	3.2	V	2-5	4.0	V	1-5	3.8
Caltha palustris	V	1-5	2.6	V	2-5	3.7	V	2-5	3.2	V	3-5	4.3	V	1-5	3.4
Poa trivialis	V	2-5	3.9	V	1-5	3.3	V	2-5	3.0	IV	3-5	4.0	V	1-5	3.4
Trifolium repens	V	1-5	3.1	V	1-5	3.4	V	1-5	2.9	IV	2-4	3.3	V	1-5	3.2
Ranunculus acris	V	1-5	2.7	IV	1-5	3.1	V	2-5	3.5	V	4-5	4.5	V	1-5	3.2
Alopecurus pratensis	V	2-5	3.5	IV	1-5	3.1	V	1-5	2.9	IV	3-5	3.7	V	1-5	3.2
Trifolium pratense	IV	1-3	1.9	V	1-3	2.0	V	2-5	3.2	V	2-4	2.5	V	1-5	2.3
Cerastium fontanum	V	1-4	2.2	V	1-5	2.3	V	1-3	2.4	V	1-3	1.8	V	1-5	2.2
Lolium perenne	IV	1-5	3.8	III	1-5	3.7	IV	2-5	4.3	IV	2-5	3.3	IV	1-5	3.8
Plantago lanceolata	IV	1-3	2.0	III	1-4	2.6	V	2-5	3.3	V	3-4	3.3	IV	1-5	2.8
Veronica chamaedrys	IV	1-2	1.6	IV	1-4	1.8	IV	1-3	1.6	IV	1-3	2.3	IV	1-4	1.7
All except MG8-															
Cynosurus cristatus	III	3-5	4.5	V	1-5	4.0	V	2-5	4.3	IV	5	5.0	IV	1-5	4.2
Festuca rubra	III	1-5	2.9	IV	1-5	3.9	V	1-5	3.5	IV	4-5	4.7	IV	1-5	3.7
Rhinanthus minor minor	III	1-4	1.7	V	1-5	1.9	V	2-5	4.0	IV	3-5	3.7	IV	1-5	2.6
Bellis perennis	III	1-2	1.6	IV	1-5	2.6	IV	1-5	3.0	V	1-5	3.5	IV	1-5	2.6
***Euphrasia arctica* s.l.**	I	1-3	2.0	IV	1-5	2.7	IV	1-4	2.3	IV	1-5	2.7	III	1-5	2.5
Juncus acutiflorus	I	1	1.0	IV	1-5	2.6	III	1-2	1.6	IV	2-5	3.3	III	1-5	2.4
Carex nigra	I	1	1.0	II	1-5	3.2	III	1-5	2.6	III	3-4	3.5	II	1-5	2.8
Filipendula ulmaria	I	1	1.0	II	1-5	2.3	III	1-2	1.2	IV	1-2	1.3	II	1-5	1.8
All except MG8n															
Agrostis capillaris	IV	3-5	4.3	IV	2-5	3.9	V	3-5	4.2				IV	2-5	4.1
Rumex obtusifolius	IV	1-3	1.3	III	1-3	1.5	III	1-2	1.1				III	1-3	1.3
MG8o & MG8+															
Prunella vulgaris	I	1	1.0	III	1-3	1.5	III	1-3	1.4				II	1-3	1.4
MG8+ & MG8n															
Cardamine pratensis	III	1-2	1.7	III	1-2	1.5	V	1-3	1.6	V	1-2	1.3	III	1-3	1.6
Avenula pubescens				I	1-2	1.3	III	1	1.0	III	1-2	1.5	I	1-2	1.2
Anemone nemorosa							I	3	3.0	II	2	2.0	I	1-3	2.0
Alchemilla filicaulis vestita							I	1	1.0	II	1	1.0	I	1	1.0
MG8o															
Juncus effusus	II	1	1.0	V	1-3	1.2	II	1-4	1.8	IV	1-2	1.3	III	1-4	1.3
Agrostis stolonifera	II	1-5	2.3	III	1-5	2.8	I	3	3.0	II	4	4.0	II	1-5	2.8
MG8n															
Trollius europaeus										V	1-4	2.3	I	1-4	2.3
Alchemilla glabra	I	1	1.0	I	1	1.0	I	1	1.0	IV	2-4	3.0	I	1-4	1.6
Taraxacum agg.				II	1-2	1.4	I	1-3	2.0	IV	2	2.0	II	1-3	1.6
Montia fontana	II	1-3	2.0	II	1-5	3.1	I	1-2	1.5	IV	1-3	1.7	II	1-5	2.5
Leontodon hispidus				I	1-2	1.2	II	1-2	1.3	IV	1-2	1.3	I	1-2	1.3
Carex panicea				I	1-4	2.5	I	1	1.0	IV	1-2	1.3	I	1-4	1.7

Ajuga reptans				I	1-3	1.7	II	1	1.0	IV	1	1.0	I	1-3	1.2
Geum rivale				I	1-2	1.5	I	1	1.0	III	1-4	2.5	I	1-4	1.8
Potentilla erecta erecta				I	1	1.0	I	1	1.0	III	1	1.0	I	1	1.0
Succisa pratensis				I	1	1.0	I	1	1.0	III	1-3	2.0	I	1-3	1.5
Crepis paludosa				I	1-2	1.5				III	1-2	1.5	I	1-2	1.5
Carex flacca							I	4	4.0	III	1	1.0	I	1-4	2.0
Valeriana dioica										III	1-2	1.5	I	1-2	1.5
Primula vulgaris										II	2	2.0	I	2	2.0
Trifolium medium										II	2	2.0	I	2	2.0
Lathyrus linifolius										II	1	1.0	I	1	1.0
Molinea caerulea										II	1	1.0	I	1	1.0
Palustriella commutata										II	1	1.0	I	1	1.0
Pinguicula vulgaris										II	1	1.0	I	1	1.0
Potentilla anserina										II	1	1.0	I	1	1.0
Senecio aquaticus										II	1	1.0	I	1	1.0
Noise															
Scorzoneroides autumnalis	III	1-4	2.0	III	1-5	2.5	III	1-5	2.6	IV	1-3	1.7	III	1-5	2.3
Conopodium majus	II	1-2	1.3	III	1-3	1.9	III	1-4	2.7	III	3-4	3.5	III	1-4	2.2
Dactylis glomerata	III	1-3	2.2	III	1-5	2.2	II	1-2	1.8	III	2-3	2.5	III	1-5	2.2
Bromus hordaceus hordaceus	III	1-2	1.4	II	1-4	2.3	III	1-4	2.8	IV	1	1.0	III	1-4	2.0
Myosotis discolor	IV	1-2	1.1	III	1-4	1.9	III	1-2	1.3	III	1-2	1.5	III	1-4	1.5
Myosotis scorpioides	I	1	1.0	II	1-5	3.3	I	4	4.0	III	1-4	2.5	II	1-5	2.9
Silene flos-cuculi	I	1	1.0	II	1-4	2.0	I	1	1.0	II	4	4.0	II	1-4	1.9
Phleum pratense	I	2	2.0	I	1-2	1.2	II	1-3	2.0	III	1	1.0	II	1-3	1.5
Deschampsia cespitosa	I	1	1.0	II	1-3	1.3	II	1-3	2.0	III	1	1.0	II	1-3	1.4
Cerastium glomeratum	II	1-3	1.5	II	1-3	1.5	I	1-2	1.5	III	1	1.0	II	1-3	1.4
Alopecurus geniculatus	III	1-3	1.4	III	1-3	1.4	II	1-2	1.3	II	1	1.0	III	1-3	1.3
Vicia sepium	III	1-2	1.3	I	I	I	I	1	1.0	II	1	1.0	II	1-2	1.2
Urtica dioica	III	1	1.0	II	1-2	1.1				III	1	1.0	II	1-2	1.1
Cirsium vulgare	II	1	1.0	II	1	1.0	I	1	1.0				II	1	1.0
Myosotis secunda				I	4	4.0	I	2	2.0				I	2-4	3.3
Schedonorus pratensis	I	2-5	3.5	I	1-5	2.8	I	2	2.0	II	5	5.0	I	1-5	3.1
Lathyrus pratensis				I	1-2	1.6	II	1-5	2.7	II	3	3.0	I	1-5	2.1
Arrhenatherum elatius	I	2	2.0	I	1-2	1.5							I	1-2	1.7
Poa annua				I	3	3.0	I	1	1.0				I	1-3	1.7
Glyceria fluitans	II	1-4	1.8	I	1-3	1.4							I	1-4	1.6
Trifolium dubium				I	1-2	1.3	II	1-2	1.7	II	2	2.0	I	1-2	1.6
Galium palustre	I	1	1.0	I	1-3	1.7							I	1-3	1.5
Luzula campestris				I	1-2	1.4	II	1-3	1.5	II	2	2.0	I	1-3	1.5
Rumex crispus	I	1-3	2.0	I	1	1.0	1	1	1.0	II	2	2.0	I	1-3	1.5
Cirsium arvense	I	1-2	1.5	I	1-2	1.4	I	1	1.0				I	1-2	1.4
Trisetum flavescens	I	1	1.0	I	1-3	1.6	II	1-2	1.3	II	1	1.0	I	1-3	1.4
Achillea millefolium	I	1	1.0	I	1-2	1.5							I	1-2	1.3
Stellaria graminea				II	1-2	1.2	I	1	1.0	II	2	2.0	I	1-2	1.3
Dactylorhiza purpurella				I	1-2	1.3	I	1	1.0	II	2	2.0	I	1-2	1.3
Senecio jacobea	I	1	1.0	I	1	1.0	I	1	1.0	II	3	3.0	I	1-3	1.3
Equisetum sylvaticum	I	1	1.0	I	1	1.0	I	1-2	1.5				I	1-2	1.3
Poa pratensis				I	1	1.0	I	1	1.0	II	2	2.0	I	1-2	1.3
Sanguisorba officinalis				I	1	1.0	I	2	2.0	II	1	1.0	I	1-2	1.3
Stellaria media	II	1-3	1.5	I	1	1.0							I	1-3	1.3
Brachythecium rutabulum				I	1-2	1.3	I	1	1.0	II	1	1.0	I	1-2	1.2
Centaurea nigra				I	1-2	1.2	II	1-2	1.3				I	1-2	1.2
Equisetum palustre				I	1-2	1.3				II	1	1.0	I	1-2	1.2
Achillea ptarmica				I	1	1.0	II	1	1.0	II	2	2.0	I	1-2	1.2

Heracleum sphondylium	II	1-2	1.3	II	1-2	1.2	I	1	1.0				I	1-2	1.2
Anthriscus sylvestris	II	1	1.0	I	1-2	1.5	I	1	1.0	II	1	1.0	I	1-2	1.1
Hypochaeris radicata	II	1	1.0	I	1	1.0	II	1-2	1.3				I	1-2	1.1
Geranium sylvaticum	I	1	1.0	I	1	1.0	I	1-2	1.5	II	1	1.0	I	1-2	1.1
Cirsium palustre				II	1	1.0				II	1	1.0	I	1	1.0
Carex leporina				II	1	1.0				II	1	1.0	I	1	1.0
Lotus corniculatus				I	1	1.0	I	1	1.0				I	1	1.0
Stellaria alsine				II	1	1.0				II	1	1.0	I	1	1.0
Rumex longifolius	II	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
Equisetum arvense				I	1	1.0	I	1	1.0	II	1	1.0	I	1	1.0
Veronica serpyllifolia				I	1	1.0	I	1	1.0	II	1	1.0	I	1	1.0
Cruciata laevipes	I	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
Alchemilla xanthochlora				I	1	1.0	I	1	1.0	II	1	1.0	I	1	1.0
Cochlearia pyrenaica	I	1	1.0							II	1	1.0	I	1	1.0
Juncus conglomeratus	I	1	1.0	I	1	1.0	I	1	1.0				I	1	1.0
Holcus mollis				I	1	1.0							I	1	1.0
Angelica sylvestris				I	1	1.0							I	1	1.0
Sagina procumbens				I	1	1.0				II	1	1.0	I	1	1.0

Extra species occuring in fewer than 5% of MG8 fields: *Agrostis canina, Brachythecium rivulare, Briza media, Calliergonella cuspidata, Cardamine flexuosa, Carex caryophyllea, Carex hirta, Climacium dendroides, Crataegus monogyna, Dactylorhiza fuchsii, Dactylorhiza* species*, Epilobium* species*, Ficaria verna, Juncus articulatus, Juncus squarrosus, Lotus pedunculatus, Mentha* species*, Mimulus* species*, Nardus stricta,* ***Persicaria bistorta****, Petasites hybridus, Plantago major, Poa humilis, Ranunculus bulbosus, Ranunculus flammula,* ***Teucrium scorodonia****, Veronica filiformis,* ***Viola lutea****, Veronica arvensis.*

General discussion on the data for the whole MG8 community

The description on MG8 in BPC is based on a small (15) number of samples from a limited geographical area. The floristic table does include data from some upland stands but the verbal description describes the community only as occurring in seasonally-flooded meadows and pastures in the lowlands. The upland version of this community is briefly described in Rodwell *et al*. (2000) and Averis *et al*. (2004).

Considering that MG8 is one of the least well described grassland communities in BPC (John Rodwell pers. comm.) and that most of the stands sampled in BPC are from lowland situations, our MG8 data is remarkably close overall to the published tables in BPC. All of the constant species from BPC also appear at a frequency of 4 or 5 overall in our vegetation with the exception of *Scorzoneroides autumnalis*, which appears at a frequency of 3. Similar to our MG3 tables discussed above, there are several extra species that appear at frequencies of 5, 4, or 3 in our data that are less frequent or absent from the published community. These include *Alopecurus pratensis*, *Rumex obtusifolius*, *Conopodium majus*, *Bromus hordaceus*, *Myosotis discolor*, *Ranunculus repens*, *Agrostis capillaris*, *Lolium perenne*, *Veronica chamaedrys* and *Rhinanthus minor*. It is difficult to know for certain how significant these extra species are in our data since the data in BPC is unlikely to be fully representative of the community throughout Britain.

MG8 sub-communities

No sub-communities are described in BPC. As the quality of the vegetation in MG8 fields in the North Pennines varied considerably, it was found useful to split MG8 into 4 groups which are labelled ‘MG8-‘, ‘MG8o’, ‘MG8+’ and ‘MG8n’. These can be thought of as the damp meadow equivalents respectively of MG7/MG6b-i, MG6b-ii, MG6b-iii/MG3a and MG3b. Only 4 samples of the highest quality group, MG8n were available for the analysis, so these data are unlikely to be fully representative of this species-rich and rare grassland type.

MG8-

This was the least species-rich type of MG8 and differed from the other types in lacking or having less of *Cynosurus cristatus*, *Festuca rubra*, *Rhinanthus minor*, *Bellis perennis*, *Euphrasia arctica* s.l., *Juncus acutiflorus*, *Carex nigra* and *Filipendula ulmaria*. MG8- had no preferential or differential species itself. This is a grassy and agriculturally-improved type of grassland which in overall floristics and appearance resembles MG7 or MG6b-i but with the addition of *Caltha palustris*. Even in this species-poor vegetation, the cover of *Caltha palustris* can be quite high, often over 40%. It would be

equally valid to consider this type of grassland to be a *Caltha palustris* variant of MG7 or MG6, or to regard particularly rushy examples as a *Caltha palustris* variant of MG10.

MG8o
This is a relatively species-poor type of grassland which has probably been subject to some agricultural improvement. It is intermediate in species-richness and quality between MG8- and MG8+. It usually contains several of the species that are listed above as being normally missing from MG8-, but lacks the distinctive preferentials and differentials of MG8n which are listed below. There were two species, *Juncus effusus* and *Agrostis stolonifera* that were preferential for MG8o over the other 3 types of MG8 in our data. Floristically MG8o it is quite similar to MG8+. It usually has a lower overall cover of herbs and in particular has a significantly lower average cover of *Trifolium pratense*, *Rhinanthus minor* and *Conopodium majus* than MG8+. MG8+ and MG8n also have cuckooflower *Cardamine pratensis* and *Avenula pubescens* at a higher between-stand frequency. Overall MG8o resembles a damp version of MG6b-ii (or MG10a) with the addition of *Caltha palustris and* more rushes *Juncus* species.

MG8+
This type of MG8 represents the next step upwards in terms of quality from MG8o. It is often a drier type of vegetation than MG8o with fewer *Juncus* species. The most distinctive aspect of the flora is the usually high frequency of *Rhinanthus minor*. It has a higher cover of herbs overall. Some stands may have originally been MG8n or M26b, but have undergone some agricultural improvement. These stands are however, still at the very high end of semi-improved grasslands in terms of quality. Other stands may be unimproved. It resembles MG6b-iii and shares most of the same species, but with the addition of *Caltha palustris* and sometimes a few other damp-loving herbs.

MG8n
This is the most species-rich type of MG8 vegetation. It is equivalent in terms of quality to MG3b and has populations of northern montane species like *Trollius europaeus* and *Crepis paludosa*. Compared to the other 3 types of MG8 this has by far the longest list of preferential and differential species which also include *Alchemilla glabra*, *Taraxacum* agg., *Montia fontana*, *Leontodon hispidus*, carnation sedge *Carex panicea*, *Ajuga reptans*, *Geum rivale*, *Potentilla erecta,* Devil's-bit scabious *Succisa pratensis*, glaucous sedge *Carex flacca* and marsh valerian *Valeriana dioica*. As mentioned above, our data is based only on 4 samples so it may not be fully representative.

This rare type (MG8n) of vegetation is clearly of high conservation interest. It is not described in BPC and is relatively neglected in conservation terms due to the upland hay meadow BAP officially excluding all communities except MG3. From a practical delivery standpoint, Natural England treat upland MG8 within the upland hay meadows category, e.g. it is counted as upland hay meadow for the purpose of the BAP grassland inventories. However, the BAP definition is influential and other conservation practitioners do not generally have access to Natural England's internal guidance on such matters. Further surveying of MG8n fields and examination of old survey data should be a high priority.

7 Soil data

Soil samples were collected and analysed from 115 meadows, distributed between the vegetation types as shown in the table below. Unfortunately, no samples were collected from MG8 meadows. In the charts below (Figs 1 & 2) only vegetation types with 3 or more samples are included in the analysis.

Meadow vegetation type	Number of soil samples	Number of soil samples for each of the main vegetation types
MG7b	1	
MG7d	12	
All MG7		13
MG6b-i	17	
MG6b-ii	43	
MG6b-iii	19	
All MG6b		79
MG3a	14	
MG3b	3	
MG3c	1	
All MG3		18
All MG8		0
Other minor vegetation types		5
Total		**115**

In both Figs 1 and 2, the order in which the vegetation types appear in the chart is significant. The vegetation type on the left (MG3b) is of the highest quality in nature conservation terms. Each subsequent vegetation type to the right, represents a step downwards in terms of quality, with the vegetation type on the right (MG7d), representing species-poor meadows that have been very 'improved' agriculturally.

The data in Fig 1 shows relatively small, but consistent differences between the average soil pH in these six meadow vegetation types. The overall range in average soil pH varies between 5.96 (MG3a) and 5.54 (MG7d). The overall trend is in the direction that would be expected.

The more agriculturally improved fields are likely to have received larger and more frequent, annual dressings of farmyard manure and/or regular dressings of artificial fertiliser. Regular applications of fertilisers containing nitrogen, in the absence of liming, has been shown to lower soil pH significantly (Shiel, 2002). It is interesting that the best meadows have a higher average soil pH. This may be due to these meadows having received less nitrogen in the form of fertiliser in the past and/or due to these meadows having a higher soil pH naturally.

There is a good deal of anecdotal evidence that liming and/or the application of basic slag were more regular practises in the past, in upland hay meadows. From the author's observations over 4 years, it is quite unusual now for a North Pennines farmer to lime the meadows. It is possible therefore, that the average pH of all of the meadows is slowly dropping, due largely to the natural influence of the climate in terms of leaching, not being balanced by frequent enough applications of lime. The recent increased rate of atmospheric deposition of nitrogen, is likely to speed up this trend.

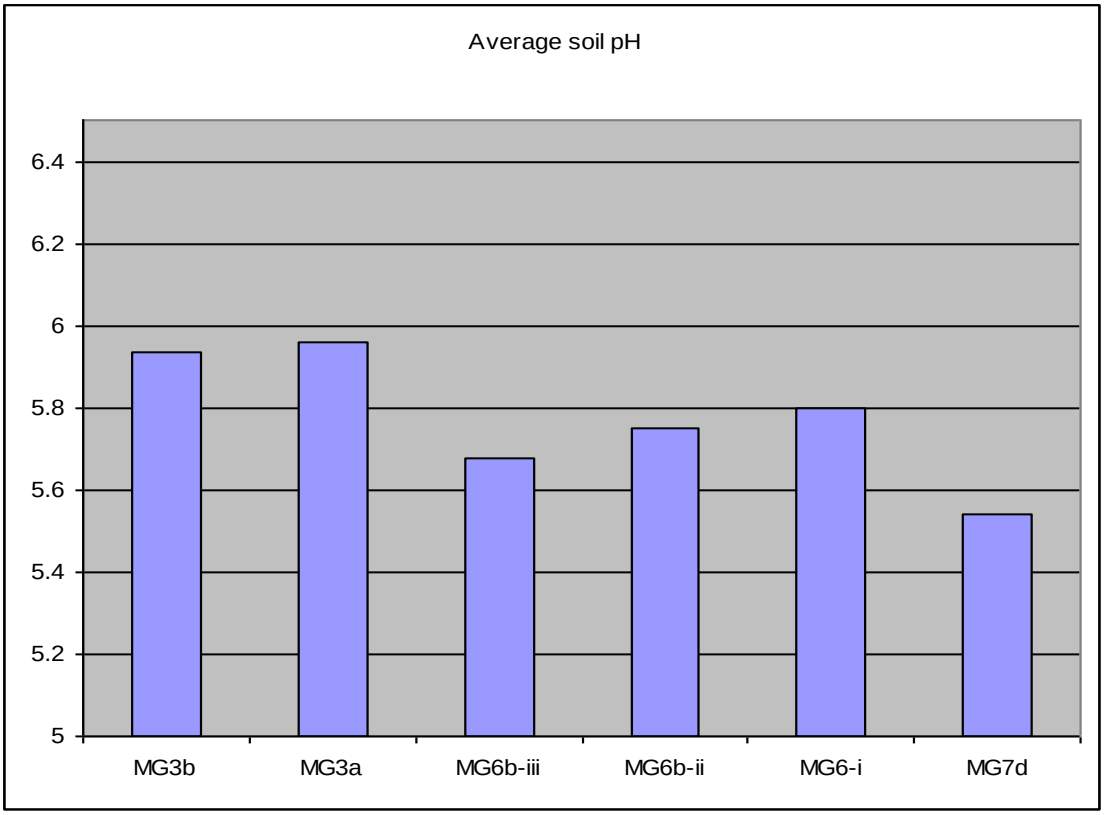

Fig 1: Average soil pH values for some of the main upland hay meadow vegetation types

The differences between the average soil phosphorous levels in these six vegetation types (Fig 2) are more striking. Again the trend is in the direction that would be expected with the vegetation types of higher nature conservation interest (MG3a & MG3b) having lower (8.3 and 6.3mg/l respectively) soil P levels and the most agriculturally improved meadows (MG7d & MG6b-i) having quite high (17.1 and 15.5mg/l respectively) soil P levels.

In terms of vegetation quality from a nature conservation perspective, MG6b-iii lies roughly mid-way between MG3a and MG6b-ii. It is surprising therefore that the average soil P level for MG6b-iii does not reflect this. The assignment of meadows to either MG6b-iii or MG6b-ii based on the botanical data collected through the Hay Time project was not always straightforward. The differences between these two variants of MG6b are quite obvious in the field, but less obvious in at least some examples, using data collected from whole stands of vegetation rather than from smaller standard-sized quadrats. The limitations of this survey method have been discussed already in section 1. Furthermore, there is often some variation in quality over a whole stand, but in our analysis this variation is not taken into account and each meadow that was used in the analysis was assigned to only one vegetation type. It is quite possible that some of the meadows assigned to MG6b-iii would fit better in MG6b-ii and vice versa, or that in some cases the soil sampling represents an average over both variants. If a survey of these vegetation types were done using standard 2m x 2m quadrats as the basic survey unit, it is postulated that MG6b-iii would have a lower soil P level than would MG6b-ii.

For a more detailed analysis of soil properties in different semi-natural grassland communities see Critchley *et al*. (2002).

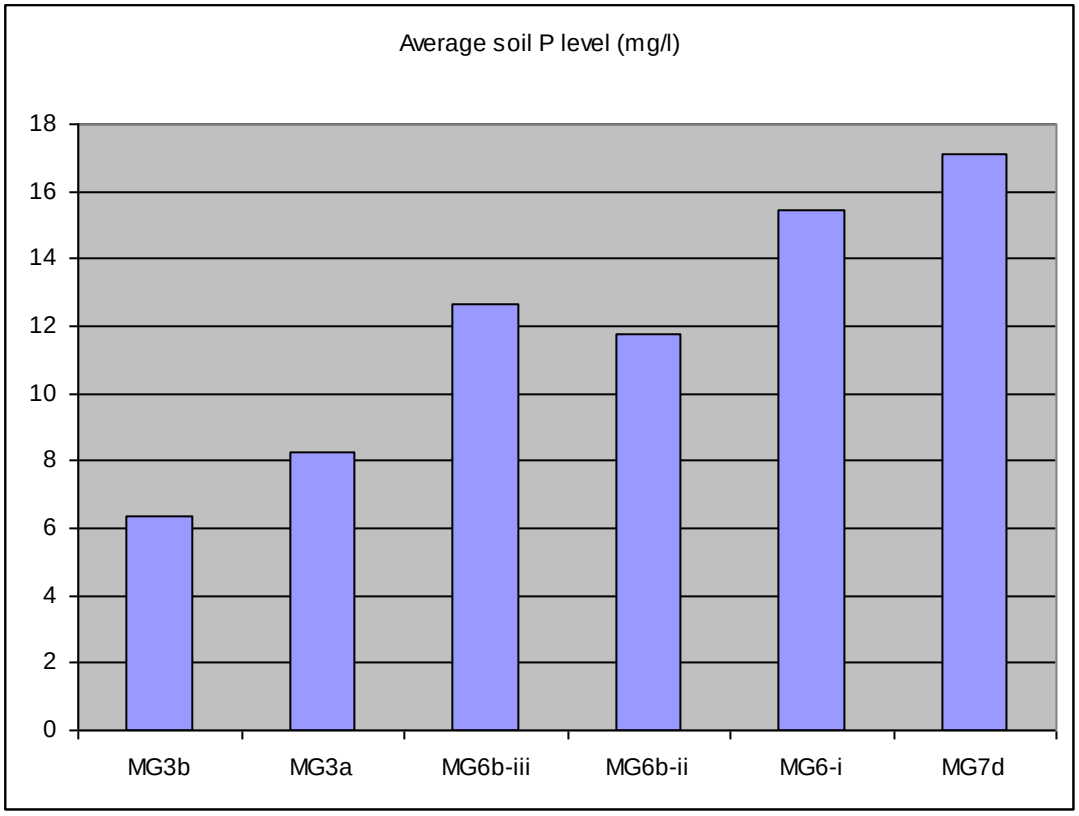

Fig 2: Average soil phosphorous (P) values for some of the main upland hay meadow vegetation types

8 Other types of vegetation in North Pennines meadows

Fig 1 below summarises the main types of grassland that occur in upland hay meadows in the North Pennines. The main type of grassland in a mown meadow is usually one of MG3, MG6, MG7 or MG8. These have been discussed already. Other species-rich types of grassland (MG1e, MG3c, U4c, MG5c, M26b) occur within upland hay meadows in the North Pennines, but are normally confined to banks, flushed areas or other mires. None of these vegetation types (apart from the 4 relevées from MG3c) appear in our data, but they are described briefly below. In the hay time surveys, we did not record separate species lists for these areas.

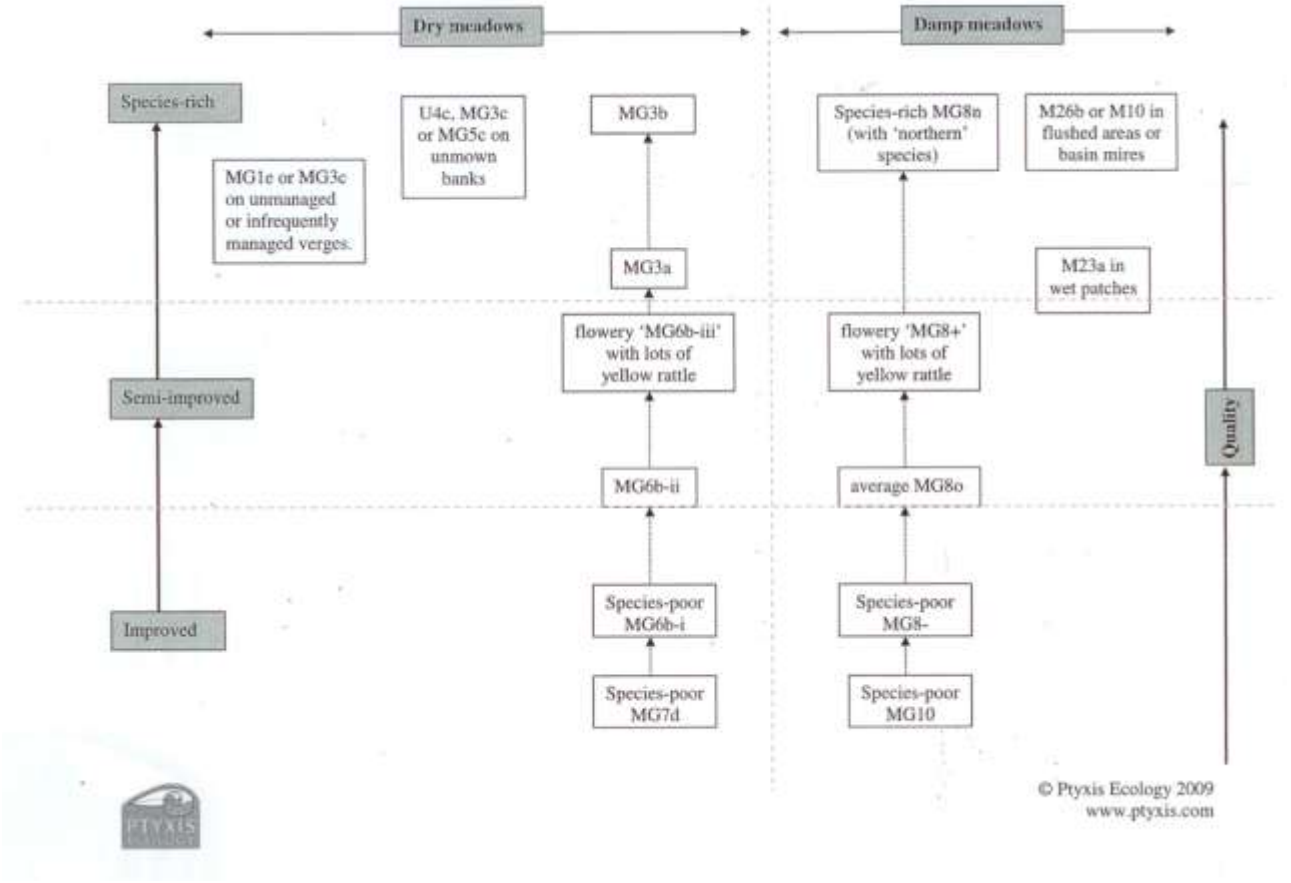

Fig 1: Some of the main types of vegetation in upland hay meadows in the North Pennines

MG1e
This is a herb-rich rank grassland resembling MG3c and differing only in lacking populations of any northern-montane species. *Arrhenatherum elatius* and/or *Dactylis glomerata* are usually prominent amongst the grasses and *Avenula pubescens* is more frequent here than in most of the mown meadow communities. The more common herbs include *Centaurea nigra*, *Heracleum sphondylium*, *Veronica chamaedrys*, crosswort *Cruciata laevipes*, *Geranium pratensis* and *Lathyrus pratensis*. It occurs mainly along road verges and uncut banks

MG5c
In the North Pennines a type of MG5c grassland was found a few times on uncut and infrequently grazed banks in meadows in Teesdale. Elsewhere MG5c is a relatively widespread (though rare) community of lowland hay meadows and lightly grazed pastures. The herb element of the MG5c flora has much overlap with that of U4c with the following species frequent in both: betony *Betonica officinalis*, bitter-vetch *Lathyrus linifolius*, *Succisa pratensis*, *Potentilla erecta* and zig-zag clover *Trifolium medium*. Heath grass *Danthonia decumbens* is occasionally present in both communities, but rare or absent from other types of vegetation in upland hay meadows.

One of the main differences between the two communities is the grass component. *Agrostis capillaris* and *Festuca rubra* are common to both, but MG5c has much more of several broad-leaved

or more mesotrophic species including *Holcus lanatus*, *Cynosurus cristatus*, *Dactylis glomerata* and *Lolium perenne*. In several of the examples on banks in Teesdale, bluebell *Hyacinthoides non-scripta* was abundant. A small population of the rare northern-montane species small white-orchid *Pseudorchis albida* was found on one MG5c bank.

Another type of MG5 that is occasional in meadows occurs as a narrow band alongside rivers in a zone that gets regular flooding. This regular flooding seems to keep the vegetation relatively short and open and prevent any one species from dominating. The herb and grass element of the flora corresponds closely with MG5. Some of the more commonly occurring herbs in these situations include typical MG5 species like *Centaurea nigra*, *Lotus corniculatus* and *Prunella vulgaris*. The vegetation often has a high cover of bryophytes comprised of common grassland species as well as species normally associated with sandy or silty soils in the flood zone of upland rivers including the mosses *Plagiothecium rostratum*, *Climacium dendroides* and *Dichodontium pellucidum* and the liverwort *Chiloscyphus polyanthus*. This is one of the main habitats in northern England for flat sedge *Blysmus compressus*.

U4c

This is a very interesting type of species-rich grassland which is poorly understood. The data from which the sub-community is described in BPC comes from a small number of samples, all from Derbyshire. U4c is in fact widespread (though rare) more or less throughout the British uplands. It also occurs sporadically in the lowlands e.g. Corfe Castle Common in Dorset (R Jefferson pers. comm.). Some of the differences between U4c and MG5c are discussed above. Grasses typical of acid grassland are usually the main grass species here, including especially *Agrostis capillaris* and *Festuca rubra*. Other acid grassland grasses and rushes, like mat-grass *Nardus stricta,* sheep's fescue *Festuca ovina*, heath rush *Juncus squarrosus* and purple moor-grass *Molinia caerulea* are occasional to frequent. The sward is often short and small sedges *Carex* species and wood-rushes *Luzula* species are more frequent here than in other types of upland hay meadow vegetation including spring sedge *Carex caryophyllea*, pill sedge *Carex pilulifera*, *Carex flacca*, *Carex panicea* and field wood-rush *Luzula campestris*.

The herb element is very distinctive. Usually one of more of *Betonica officinalis*, *Lathyrus linifolius*, *Succisa pratensis* or *Trifolium medium* is abundant. Other common herbs here include *Potentilla erecta*, heath bedstraw *Galium saxatile*, harebell *Campanula rotundifolia*, mountain pansy *Viola lutea*, *Euphrasia* agg., *Conopodium majus*, *Leontodon hispidus*, *Trifolium pratense*, *Lotus corniculatus*, common dog-violet *Viola riviniana* and heath milkwort *Polygala serpyllifolia*. Occasionally there are uncommon or rare species like heath fragrant-orchid *Gymnadenia borealis*, *Platanthera chlorantha* or alpine bistort *Persicaria vivipara*. It is one of the main habitats for *Pseudorchis albida*.

Unlike most other types of vegetation in upland hay meadows, moss cover is normally quite high and includes several of the following species *Rhytidiadelphus squarrosus, Pseudoscleropodium purum, Thuidium tamariscinum, Kindbergia praelonga* and *Brachythecium rutabulum*.

U4c is not confined to banks in meadows. It also occurs occasionally in unimproved pastures. In one 2m x 2m quadrat from a fairly typical looking example 34 species were recorded and the soil pH was 4.6. There must be something unusual about the soils of U4c that allows such an acid grassland to become so species-rich.

M26b

This is perhaps the rarest and least well understood of all of the grassland types discussed here. The original data and description of M26b are based largely on surveys in Upper Teesdale (Jones 1984) and includes only 13 relevées. Data from four 2m x 2m relevées recorded by the author are presented below. The first 3 came from upper Teesdale and the fourth from Gowk Bank NNR by the River Irthing in Cumbria. Compared to the data in BPC, these M26b data has less marsh horsetail *Equisetum palustre*, *Carex nigra*, *Lathyrus pratensis*, *Deschampsia cespitosa* and *Geum rivale*. On the other hand, the data has more *Trifolium pratense*, *Lotus corniculatus*, *Trifolium repens*, *Scorzoneroides autumnalis*, tawny sedge *Carex hostiana*, sneezewort *Achillea ptarmica* and *Nardus stricta*. With such a small original sample in BPC it is difficult to know what, if any significance these differences have.

In the author's experience of the habitat, the vegetation is always species-rich, herby and mossy. There is usually some *Trollius europaeus*, *Crepis paludosa* or *Geum rivale*. *Valeriana dioica* appears to be a strong differential for this community over most other types of vegetation in upland hay meadows. *Juncus acutiflorus* is abundant in some stands and absent in others. This can make these stands appear very different physiognomically.

M26b occurs mostly as small stands on banks in meadows, but can more or less occupy whole banks or even whole fields. Similar vegetation in small basin mires in upland hay meadows was encountered at least twice but these stands were not sampled.

4 samples of M26b from northern England				
altitude	425	360	455	240
aspect	SW	S	SW	E
Slope (degrees)	15	30	17	3
Shade (1-7 scale)	2	2	1	1
herb height (cm)	5	9	20	14
herb cover (%)	99	95	95	90
bryo height (cm)	1.5	2.5	1.5	3
bryo cover (%)	30	35	15	95
soil pH	6.75	7.36	7.32	6.96
soil texture	OZCL	PL	ZCL	PL
bare ground	1	1	0	0
litter	2	3	20	80
Number of species	46	37	34	36
Succisa pratensis	15	3	25	30
Carex panicea	8	5	5	30
Calliergonella cuspidata	15	3	5	15
Molinia caerulea	15	3	7	3
Rhytidiadelphus squarrosus	2	3	3	20
Potentilla erecta erecta	3	7	7	3
Festuca rubra	3	3	2	5
Trifolium pratense	3	2	5	3
Lotus corniculatus	2	3	5	2
Valeriana dioica	2	5	2	3
Trifolium repens	2	3	3	3
Prunella vulgaris	5	2	2	1
Carex hostiana	1	2	2	3
Juncus acutiflorus		25	20	15
Nardus stricta	2		3	7
Briza media	3	7	1	
Ranunculus acris	3		3	5
Anthoxanthum odoratum	3	3	2	
Carex pulicaris	2		3	3
Scorzoneroides autumnalis	3		3	2
Achillea ptarmica	1		1	3
Crepis paludosa		10		3
Centaurea nigra	5			2
Campylium protensum	3		3	
Euphrasia c.f. *arctica*	3		3	
Filipendula ulmaria		3		3
Carex flacca	2	3		
Luzula campestris	3	2		
Trollius europaeus	3		2	
Vicia cracca		3		2
Leontodon hispidus	2		2	
Cynosurus cristatus	2	1		
Dactylorhiza purpurella	1			2
Holcus lanatus	2			1
Hylocomium splendens		2		1
Cerastium fontanum	1	1		
Rhinanthus minor minor	1			1

Climacium dendroides				70
Rhytidiadelphus triquetrus		25		
Thuidium delicatulum	10			
Ctenidium molluscum molluscum			7	
Festuca ovina			5	
Pseudoscleropodium purum		5		
Bellis perennis	3			
Carex nigra			3	
Equisetum arvense		3		
Avenula pratensis		3		
Kindbergia praelonga			3	
Plagiomnium undulatum				3
Salix repens				3
Ajuga reptans	2			
Alchemilla glabra	2			
Brachythecium rutabulum	2			
Euphrasia c.f. *rostkoviana montana*				2
Euphrasia c.f. *scottica*	2			
Galium uliginosum				2
Geum rivale	2			
Gymnadenia conopsea s.s.		2		
Juncus squarrosus	2			
Lathyrus pratensis		2		
Palustriella commutata			2	
Primula farinosa			2	
Sanguisorba officinalis		2		
Thuidium tamariscinum		2		
Trifolium medium		2		
Aneura pinguis	1			
Angelica sylvestris				1
Atrichum undulatum	1			
Cardamine pratensis		1		
Carex pilulifera	1			
Chiloscyphus pallescens	1			
Cirsium palustre				1
Dactylorhiza maculata				1
Danthonia decumbens				1
Linum catharticum		1		
Neottia ovata		1		
Lophocolea heterophylla			1	
Luzula multiflora	1			
Phleum pratense	1			
Plantago lanceolata			1	
Platanthera bifolia			1	
Polygala serpyllifolia		1		

Has M26b been recorded in error on SSSIs in the past?

In 2009 the author was commissioned through the North Pennines AONB Partnership to undertake CSM surveys of 10 farms in the Harwood Valley in Upper Teesdale. M26b was recorded as an 'interest feature' five times in the Natural England documentation for these farms. However, in all cases the vegetation in 2009 was very much less species rich than the M26b described above and bore little resemblance to it apart from containing both *Molinea caerulea* and *Crepis paludosa*. It was difficult to know if these habitats had been misidentified as M26b originally, or if they had been species-rich M26b in the past but had now declined significantly in quality due to mismanagement.

Conversely, the author found three excellent examples of M26b elsewhere on these farms that had not been identified as such in the SSSI documentation before. This may suggest that the surveyors who were active when the habitats were originally surveyed were not familiar with the habitat and consistently overlooked or misidentified it. However, these habitat surveys in Upper Teesdale were far from comprehensive and it is also possible that these three stands were on farms that never had been surveyed thoroughly before.

In summary, in the author's experience M26b is always a species-rich type of vegetation. Species-poor grassland with *Molinea caerulea* and *Crepis paludosa*, the species that give the M26 community its name, should be regarded as M25.

M10
Stands of M10 flush occasionally occur within upland hay meadows in the North Pennines, especially in Upper Teesdale, sometimes on banks but also sometimes in flushed areas with the same degree of sloping as the main mown meadow. Sometimes these M10 stands are distinct and other times there is a gradual transition over space or time to grassland communities including M23a, M26b or U5c (in pastures).

M23a
Juncus acutiflorus is occasionally found in upland hay meadows in the North Pennines. Where it occurs, it is often abundant. Some of these stands are close matches to M23a as described in BPC.

Others are more like one of various types of mesotrophic grassland with the addition of abundant *Juncus acutiflorus*. These latter stands lack any of the typical fen species of M23a such as marsh bedstraw *Galium palustre*, greater bird's-foot-trefoil *Lotus pedunculatus*, *Achillea ptarmica*, marsh thistle *Cirsium palustre*, lesser spearwort *Ranunculus flammula*, water mint *Mentha aquatica* or fen bedstraw *Galium uliginosum*.

These stands do not seen to fit in to M23a as described in BPC but neither do they fit easily in any other community. These types of vegetation are common in the North Pennines. It seems that they were not sampled for BPC. Is it possible that sharp-flowered rush has become more frequent since the sampling for BPC and has invaded other communities resulting in new variants of communities or new communities that did not exist or were uncommon several decades ago? There is some evidence from Countryside Survey that soft rush has increased over the period 1998-2007 and that there has been an increase in plant species with higher Ellenberg moisture values over this period (R Jefferson pers. com.). Some or many of the records of *Juncus acutiflorus* may be referable to the hybrid between it and jointed rush *Juncus articulatus*. Is it possible that the hybrid has become much more frequent and invasive due to hybrid vigour in recent decades and is invading types of grassland where the species does not normally grow?

MG2?
One woodland glade that was surveyed within Derwent Gorge NNR was close to MG2 in species composition. Several of the distinctive MG2 preferential and differential species were present but at low cover, including dog's-mercury *Mercurialis perennis*, *Geum rivale*, male fern *Dryopteris filix-mas* and red campion *Silene dioica*. The more widespread of the two sub-communities (MG2a) in BPC is described from only 12 samples. The habitat of MG2a is described in BPC as being confined to steep, north-facing slopes in the sub-montane zone, often associated with fragmentary woodland. The glade in Derwent Gorge was relatively flat so does not conform exactly to the BPC habitat, but the vegetation nevertheless had obvious affinities to MG2.

However rank grassland with prominent *Mercurialis perennis*, *Silene dioica* and various large ferns including *Dryopteris filix-mas*, scaly male-fern *Dryopteris affinis* agg. and Lady fern *Athyrium filix-femina* is relatively frequent in the sub-montane zone in northern England on road verges with fragmentary hedges or scattered scrub and occasionally in woodland glades. Common valerian *Valeriana officinalis* and wood stitchwort *Stellaria holostea* occur occasionally in these situations, but overall the vegetation does not appear to be nearly as rich as MG2a as described in BPC. Perhaps this type of vegetation should be recognised as a basal sub-community of MG2 or as a new sub-community of MG1. Rodwell in BPC reports that MG2 is close to the northern montane tall herb communities of the Cicerbition alpini from continental Europe which are sometimes managed as hay meadows. It would be interesting to investigate our MG2-type vegetation more, to see what relationship, if any, it has with these continental tall herb communities.

9 Recommendations for further work

Survey and define poorly described types
Several of the species-rich grassland types described above are of conservation interest but are poorly described or not described at all in literature that is easily accessible by conservation practitioners. Due to several recent or current upland hay meadow projects and road verge surveys in the north of England, there is now information on the location of many stands of most of these interesting grassland types. It would now be relatively straightforward therefore to target these vegetation types for detailed surveying and phytosociological analysis. The types of vegetation that could be covered in order to fill these gaps in our knowledge include MG3c, U4c, M26b, MG8n and the MG2-related vegetation. A single standard grassland relevée should be recorded from each stand including some basic environmental data such as altitude, soil type and pH, management, etc. The survey should take place over as a wide a geographical area as possible within the sub-montane zone in England (or preferably Britain).

Broaden the UKBAP definition of upland hay meadows
The official UKBAP description of the upland hay meadows priority habitat includes only MG3 (Maddock, 2008). In the author's opinion, this definition should be modified to include all types of species-rich grassland that occur in upland hay meadows which include populations of northern-montane species. There are two main arguments to justify this broadening of the definition.

1. The non-MG3 grassland types have been relatively neglected in nature conservation and are mostly not even described in easily accessible literature. A self-fulfilling prophesy – if it is defined as only including MG3, then MG3 is what people see and MG3 is regarded as being more important than any other type of species-rich upland hay meadow grassland.
2. The MG3-only approach is unhelpful and must be puzzling for inexperienced people working in nature conservation, when they find species-rich grasslands in upland hay meadows that do not fit into MG3. For example, MG8 is officially supposed to be dealt with under the 'lowland meadows and pastures' HAP, but in the North Pennines it typically occurs at a much higher altitude on average than MG3 and can include a similar suite of northern-montane species to MG3.

Compare these data to data from older surveys
Our data suggests that the even the richest types of upland hay meadows have undergone significant floristic change in recent decades. In order to test whether or not these perceived changes are real it would be worthwhile to compare survey data from meadows that still conform to MG3b or one of the other species-rich types which had a survey 2 or 3 decades ago (e.g. Prosser, Wiggington, Loring) and a recent survey from the Hay Time project and assess what changes have taken place.

Compare these data to other recent upland hay meadow survey data
Compiling floristic tables from recent surveys of upland hay meadows outside of the North Pennines would also be informative. Similar recent survey information should be available from the Hay Time project in the Yorkshire Dales, from the Hay Day project in Cumbria and possibly from the Seeding Change project in Northumberland National Park. If the data from these new tables showed similar patterns of change to those noticed for MG3 in the North Pennines in this report, then that would give a greater degree of confidence that these changes are real.

Analyse the 'extra' MG3 species against ecological traits
It would be informative to look for patterns in ecological traits such as Ellenberg Indicator Values, etc amongst the species that seem to have 'joined' MG3 in recent decades. If clear patterns are apparent it might throw light on which management or environmental changes are behind the floristic changes.

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