

A step-by-step guide to upland hay meadow restoration in the North Pennines



Species-rich upland hay meadow, Weardale

NORTH PENNINES
Area of Outstanding Natural Beauty



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1. Introduction

- 1.1 The North Pennines AONB Partnership launched its Hay Time project in May 2006 with the aim of restoring and enhancing upland hay meadows within the AONB and increasing people's awareness, enjoyment and understanding of this important habitat. The first phase of the project ran from 2006 to 2008. The project was re-launched with an expanded team in 2009 and is due to run until October 2012.
- 1.2 Upland hay meadows are internationally recognised as important. Though increasingly scarce, they occur in hilly areas across central and eastern Europe. In the UK there are thought to be about 1000ha of upland hay meadows left, of which 40% (400ha) are found in the North Pennines AONB.
- 1.3 The richest hay meadows support a great variety of flowering plants, with the very best fields containing more than 30 different species per square metre. In these diverse meadows, as spring progresses through summer, different plants come into bloom in a breathtaking display of colour. Even within the same field plants that are characteristic of different latitudes mingle. Wood crane's-bill, for example, is typically a plant of northern England and Scotland, seldom occurring further south, whereas great burnet is rarely found further north than the England/Scotland border.
- 1.4 Hay meadows declined drastically during the 20th century, almost entirely due to changing agricultural practices. These include the use of inorganic fertilisers, ploughing and reseeded, a switch to silage making and heavy grazing pressure.
- 1.5 Even where a hay meadow is returned to traditional management, species that were once present are unlikely to return naturally. This is due to very slow rates of natural dispersal and the scarcity of species-rich sites. Research suggests, however, that through the phased introduction of key species, meadows can be both restored and enhanced. To achieve this, the Hay Time project carefully harvests seed from species-rich meadows and spreads it on nearby fields that have lost their special species. Using special machinery, hay from species-rich fields is cut, transported and spread un-dried ('green') on fields being restored. This provides the best opportunity for the transfer of a wide variety of species.
- 1.6 One of the outputs from the first phase of the Hay Time project was the production of this 'step-by-step' guide to hay meadow restoration in the North Pennines drawing on experience gained during the first three years of habitat restoration. It is hoped that the lessons learned and experience we have gained will benefit others working in the field of hay meadow restoration.
- 1.7 The report is presented as a series of steps detailing the approach we have taken to survey meadows, identify seed 'donor' and 'receptor' sites, manage harvesting and spreading operations, monitoring and reporting.

2. Botanical surveying – timing

- 2.1 The season during which botanical surveys of upland hay meadows can be carried out is very short. Standard hay meadow management in the North Pennines involves removing livestock from the field ('shutting up') for only 7 to 10 weeks before the vegetation is cut. In the early part of this period many plant species are difficult to spot during survey work.
- 2.2 Fields are normally 'shut up' around mid-May and have usually been grazed tightly prior to this. In our experience, surveying should not start before the last week of May though it may be possible to start a little earlier if the field has not been grazed in the spring.
- 2.3 If the survey is to be thorough enough for monitoring purposes, surveying should not begin before mid-June. Several grasses do not flower before this time, including common bent *Agrostis capillaris*, creeping bent *Agrostis stolonifera*, downy oat-grass *Helictotrichon pubescens*, Timothy *Phleum pratense* and yellow oat-grass *Trisetum flavescens*. Although, in theory, an experienced grassland surveyor can recognise all of these species vegetatively, it is difficult to estimate the relative abundance of non-flowering species in a field as a whole without taking the time to regularly stop and examine vegetative grasses throughout the field. For flowering plants, estimates of relative abundance can differ considerably in the same field from early to late June depending on how obvious individual species are i.e. how much is flowering.
- 2.4 Surveys can be carried out after the vegetation has been cut and the hay removed but some species will not be visible at this time. It is likely that records will be biased towards species predominating in the field margins or on uncut banks and these areas may not be representative of the field as a whole. Analysing what is in the cut hay can shed some light on the species present but it is not possible to assess the relative abundance of important indicator species by doing this.
- 2.5 Surveying in late autumn, winter and early spring is relatively pointless. The annual species over-winter as seeds and the more robust perennial herbs tend to over-winter underground as rhizomes, bulbs or corms. Even for surveyors with good vegetative plant identification skills, about 40% of the plants will be entirely invisible at these times of year. In winter it is usually possible to identify fields that have been significantly agriculturally improved but not usually possible to go further than this. Agriculturally improved fields are usually grass-dominated with few if any herbs apart from white clover or creeping buttercup. The cover of the latter two species can be high in agriculturally improved fields. All other fields, ranging from the low end of semi-improved to very species-rich fields, look more-or-less the same in winter. Furthermore, some important indicator species like soft brome, yellow rattle and eyebright are annual species; before they have germinated and grown up it is not possible to do a proper assessment of a field's suitability for restoration. Soft brome sometimes germinates in the autumn and so is visible in the sward over winter. However, when only short shoots are present during winter, it looks very similar to the most common grass found in meadows:

Yorkshire-fog. As a result, it is almost impossible to assess the abundance of this important negative indicator species.

- 2.6 There is no substitute for a thorough survey, including estimates of cover of each species, carried out at the right time of year. The optimum time for surveying in the North Pennines is between 15th June and 7th July and all monitoring surveys (including baselines) should ideally be carried out in these 3 weeks. Surveys to assess a field's suitability for restoration can be carried out during a slightly longer period from the last week of May to whenever the hay is cut. Surveys undertaken outside the optimum time, however, will not give useful data for a baseline to monitor against. Meadows where seed is to be harvested from or where seed is to be spread, should always have a thorough baseline survey after 15th June.

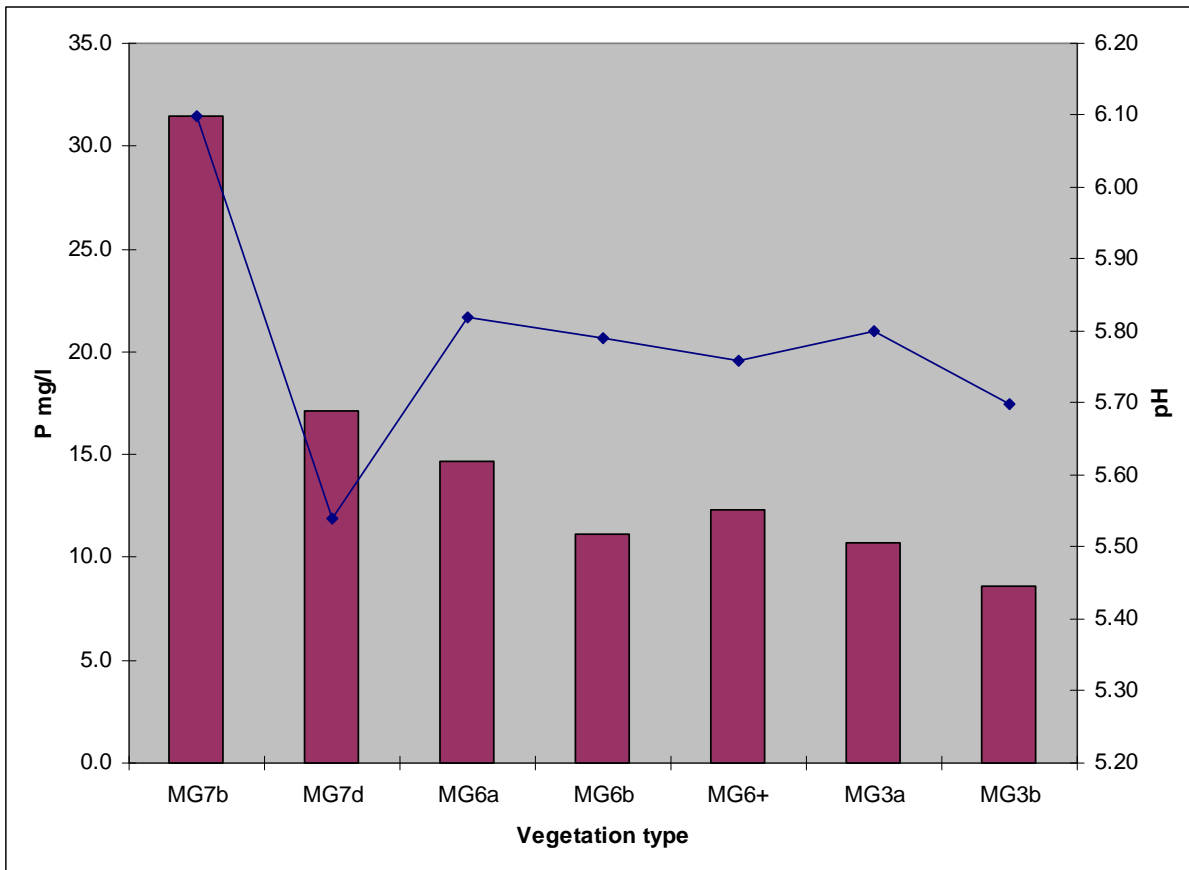


3. Soil testing

- 3.1 The soil P (phosphorous) index can give some useful information about a field's potential for restoration to traditional hay meadow vegetation. Agriculturally improved fields tend to have a high P index (3 or above) whereas most semi-natural fields have an index of 0 or 1. Some fields that appear from the vegetation to have been subject to agricultural improvement can also sometimes have a fairly low P index.
- 3.2 A high P index does not necessarily mean that the large amount of phosphate in the soil would be a limiting factor. However, as artificial fertiliser is normally applied as a mixture of NPK (nitrogen, phosphorous and potassium), a high P index usually indicates that high levels of nitrogen fertiliser have been applied in the past. This can be a problem as the application of nitrogen tends to inhibit essential aspects of the soil micro-flora and fauna on which diverse vascular plant communities depend.
- 3.3 Nitrogen and phosphorous behave very differently in the soil. Nitrogen usually disappears from the soil within a very short space of time unless it is taken up quickly by plant roots. Phosphorous on the other hand gets attached firmly to clay particles and usually remains in the soil for a very long time. In fact, most phosphorous in the soil is unavailable to plants as it forms such a close bond with the clay particles. A soil test assessing N and P levels in an agriculturally improved field, therefore, is unlikely to find an excess amount of N, but is likely to find high levels of P.

3.4 The soil P index is a useful piece of information to have when assessing a field's suitability for restoration to traditional hay meadow vegetation, especially in winter when many plants are semi-dormant below the soil surface. However, its usefulness should not be overplayed and it is no substitute for a botanical survey. If a full botanical survey has been done and it is clear from the vegetation whether or not a field is suitable for restoration, then a soil test is not essential, unless there are concerns about pH.

Fig 1. Soil pH and P index in different types of meadow vegetation



Note: Only 2 fields are included in the MG7b sample.
See Appendix 1 for an explanation of national vegetation classification codes (eg MG3)

3.5 The only other aspect of the standard soil test that we have used to assess field suitability is the soil pH. Most upland hay meadows have a soil pH between about 5.5 and 6.5. The average pH from 155 fields where we have done soil tests between 2006 & 2008 was 5.76. This seems like a relatively low pH and is probably lower than it would have been in the past. If the pH has dropped below 5.5 we normally recommend adding lime.

3.6 Regular liming has declined over the last 30 years in the North Pennines. Basic slag became less easily available after the Teesside industries stopped producing it in large quantities and the local railway lines closed down.

4. Botanical surveying – for site selection

- 4.1 It is possible to gather enough information from a relatively brief survey to determine whether a field is suitable to be a 'donor' site (have seed harvested from it) or a 'receptor' site (have seed spread on it). However, there is a minimum level of detail that should be obtained. The survey to obtain this information can be carried out in most fields in 25 - 45 mins, with a few exceptionally complex and species-rich fields taking longer.
- 4.2 In the first year of the Hay Time project in 2006, we were urged by Natural England to make our assessment method as close as possible to the SSSI Common Standards Monitoring (CSM) methodology. Initially we structured our method along the same lines as CSM by recording only certain indicator species. We have since reviewed our approach and consider it preferable to record all species seen, rather than try to filter out only the indicator species. These more comprehensive data are also more useful for monitoring purposes.

5. How to fill in the Hay Time recording form

- 5.1 Figure 2 shows the Hay Time recording form. This form has been developed following three years of trial and refinement. The top few boxes are fairly self-explanatory.
- 5.2 Use the **field name** box for the name that the farmer uses for the field. This is not essential information but can be useful to know.
- 5.3 The **field number** box is for a unique reference code. The Hay Time reference consists of three elements: a code for the dale, the number for the farm within that dale and the letter for the field on that farm. The list below details the codes used for the North Pennines dales. Each farm in each dale needs a unique number. We normally give each new farm the next available number.

Fig 2. Hay Time Survey Form

Hay Time survey form		Recorder:
Farm		Weather: wet /dry cold / warm / hot
Farmer	Date	Time spent
Field name		Field number
AE scheme or application (include start or end date, agreement number and CPH number)		
Description of field (including NVC)		
Features of interest (+ fauna)		Bank: species-rich / medium
Stream Wood/scrub Edges		
Negative features	docks cow parsley creeping buttercup soft brome	sharp-flowered rush Yorkshire-fog spear thistle creeping thistle ragwort
Practical issues (access etc.)		
Suitable as seed source? (yellow rattle / species-rich?) (ok / good?) (wet / dry?) (whole / part field?)		
Suitable for - restoration / enhancement (wet / dry?) (low / medium / high?)		
Things to look up and send to farmer		
Potential for small scale habitat work		
Sketch map		

Species	Q	freq	%cov	Species	Q	freq	%cov	Species
<i>Acer pseudoplatanus</i>				<i>Euphrasia arctica</i> s.l.				<i>Potentilla anserina</i>
<i>Achillea millefolium</i>				rostkoviana s.l.				<i>Potentilla erecta erecta</i>
<i>ptarmica</i>				<i>Eurhynchium praelongum</i>				<i>sterilis</i>
<i>Agrostis capillaris</i>								<i>Primula veris</i>
<i>stolonifera</i>				<i>ovina</i>				<i>vulgaris</i>
<i>Ajuga reptans</i>				<i>pratensis</i>				<i>Prunella vulgaris</i>
Alchemilla acutiloba				<i>rubra</i>				<i>Pteridium aquilinum</i>
<i>filicaulis vestita</i>				<i>Filipendula ulmaria</i>				<i>Ranunculus acris</i>
<i>glabra</i>				<i>Fraxinus excelsior</i>				<i>bulbosus</i>
monticola				<i>Galium aparine</i>				<i>ficaria</i>
<i>xanthochlora</i>				<i>palustre</i>				<i>flammula</i>
<i>Alopecurus geniculatus</i>				<i>saxatile</i>				<i>repens</i>
<i>pratensis</i>				<i>verum</i>				<i>Rhinanthus minor minor</i>
<i>Anemone nemorosa</i>				<i>Geranium pratense</i>				<i>Rhytiadelphus squarros</i>
<i>Angelica sylvestris</i>				<i>sylvaticum</i>				<i>Rubus fruticosus</i> agg.
<i>Anthoxanthum odoratum</i>				<i>Geum rivale</i>				<i>Rumex acetosa</i>
<i>Anthriscus sylvestris</i>				<i>Glyceria fluitans</i>				<i>crispus</i>
<i>Arrhenatherum elatius</i>				Gymnadenia cono bore				<i>longifolius</i>
<i>Athyrium filix-femina</i>				<i>Helictotrichon pratense</i>				<i>obtusifolius</i>
<i>Bellis perennis</i>				<i>pubescens</i>				<i>Sagina procumbens</i>
				<i>Heracleum sphondylium</i>				<i>Sanguisorba minor</i>
<i>Brachythecium rutabulu</i>				<i>Holcus lanatus</i>				<i>officinalis</i>
<i>Briza media</i>				<i>mollis</i>				<i>Saxifraga granulata</i>
<i>Bromus hordaceus</i> <i>horda</i>				<i>Hyacinthoides non-script</i>				<i>Scleropodium purum</i>
<i>Calliergonella cuspidata</i>				<i>Hylacomium splendens</i>				<i>Senecio jacobea</i>
<i>Caltha palustris</i>				<i>Hypochaeris radicata</i>				<i>Silene dioica</i>
<i>Campanula rotundifolia</i>				<i>Juncus acutiflorus</i>				<i>Stachys officinalis</i>
<i>Cardamine flexuosa</i>				<i>articulatus</i>				<i>sylvatica</i>
<i>pratensis</i>				<i>conglomeratus</i>				<i>Stellaria graminea</i>
				<i>effusus</i>				<i>holostea</i>
<i>Carex caryophyllea</i>				<i>squarrosus</i>				<i>media</i>
<i>flacca</i>								<i>uliginosa</i>
<i>hirta</i>				<i>Lathyrus linifolius</i>				<i>Succisa pratensis</i>
<i>nigra</i>				<i>pratensis</i>				<i>Taraxacum</i> agg
<i>ovalis</i>				<i>Leontodon autumnalis</i>				<i>Trifolium dubium</i>
<i>panicea</i>				<i>hispidus</i>				<i>medium</i>
				<i>Leucanthemum vulgare</i>				<i>pratense</i>
<i>Centaurea nigra</i>				<i>Linum catharticum</i>				<i>repens</i>
<i>Cerastium fontanum</i>				<i>Listera ovata</i>				<i>Trisetum flavescens</i>
<i>glomeratum</i>				<i>Lolium perenne</i>				Trollius europaeus
				<i>Lotus corniculatus</i>				<i>Tussilago farfara</i>
<i>Cirsium arvense</i>				<i>pedunculatus</i>				<i>Ulex europaeus</i>
heterophyllum				<i>Luzula campestris</i>				<i>Urtica dioica</i>
<i>palustre</i>				<i>multiflora</i>				<i>Valeriana dioica</i>
<i>vulgare</i>				<i>Lychnis flos-cuculi</i>				<i>Veronica arvensis</i>
				<i>Matricaria discoidea</i>				<i>beccabunga</i>
				<i>Mercurialis perennis</i>				<i>chamaedrys</i>
<i>Conopodium majus</i>				<i>Mimulus species</i>				
				<i>Molinea caerulea</i>				<i>serpyllifolia</i>
<i>Crataegus monogyna</i>				<i>Montia fontana</i>				<i>Vicia cracca</i>
Crepis paludosa				<i>Myosotis arvensis</i>				<i>sepium</i>
<i>Cruciata laevipes</i>				<i>discolor</i>				<i>Viola lutea</i>
<i>Cynosurus cristatus</i>				<i>scorpioides</i>				<i>riviana</i>
<i>Dactylis glomerata</i>				<i>secunda</i>				

<i>Dactylorhiza fuchsii</i>				<i>Myrrhis odorata</i>				
<i>maculata</i>				<i>Nardus stricta</i>				
<i>purpurella</i>				<i>Orchis mascula</i>				
species				<i>Persicaria bistorta</i>				
				<i>Phleum pratense</i>				
<i>Deschampsia cespitosa</i>				<i>Pilosella officinarum</i>				
<i>flexuosa</i>				<i>Plantago lanceolata</i>				
<i>Digitalis purpurea</i>				major				
<i>Dryopteris filix-mas</i>				<i>Platanthera chlorantha</i>				
<i>Epilobium palustre</i>				<i>Pleurozium schreberi</i>				
<i>Equisetum arvense</i>				<i>Poa annua</i>				% cover herbs
<i>fluviatile</i>				<i>humilis</i>				% cover weeds
<i>palustre</i>				<i>pratensis</i>				% bare ground
<i>sylvaticum</i>				<i>trivialis</i>				Species per m ²
Qualifiers (Q - column): e = edge, b = banks, w = wet areas, g = near gate								

Hay Time codes for the different dales and areas in the North Pennines

A = West Allendale

CN = East Fellside, North (north of Melmerby)

CS = East Fellside, South (south of Melmerby)

G = Greta Valley/Bowes area

K = Rookhope Valley

M = Geltsdale/Midgeholme area

SM = mid South Tynedale (up to Alston)

SU = upper South Tynedale (above Alston)

TM = mid Teesdale (up to Newbiggin)

TU = upper Teesdale (above Newbiggin)

WM = mid Weardale (up to St John's Chapel)

WU = upper Weardale (above St John's Chapel)

X = Brough/South Stainmore area

B = Baldersdale

E = East Allendale

L = Lunedale

H = Hamsterley area

N = Nent Valley

R = Derwent Valley

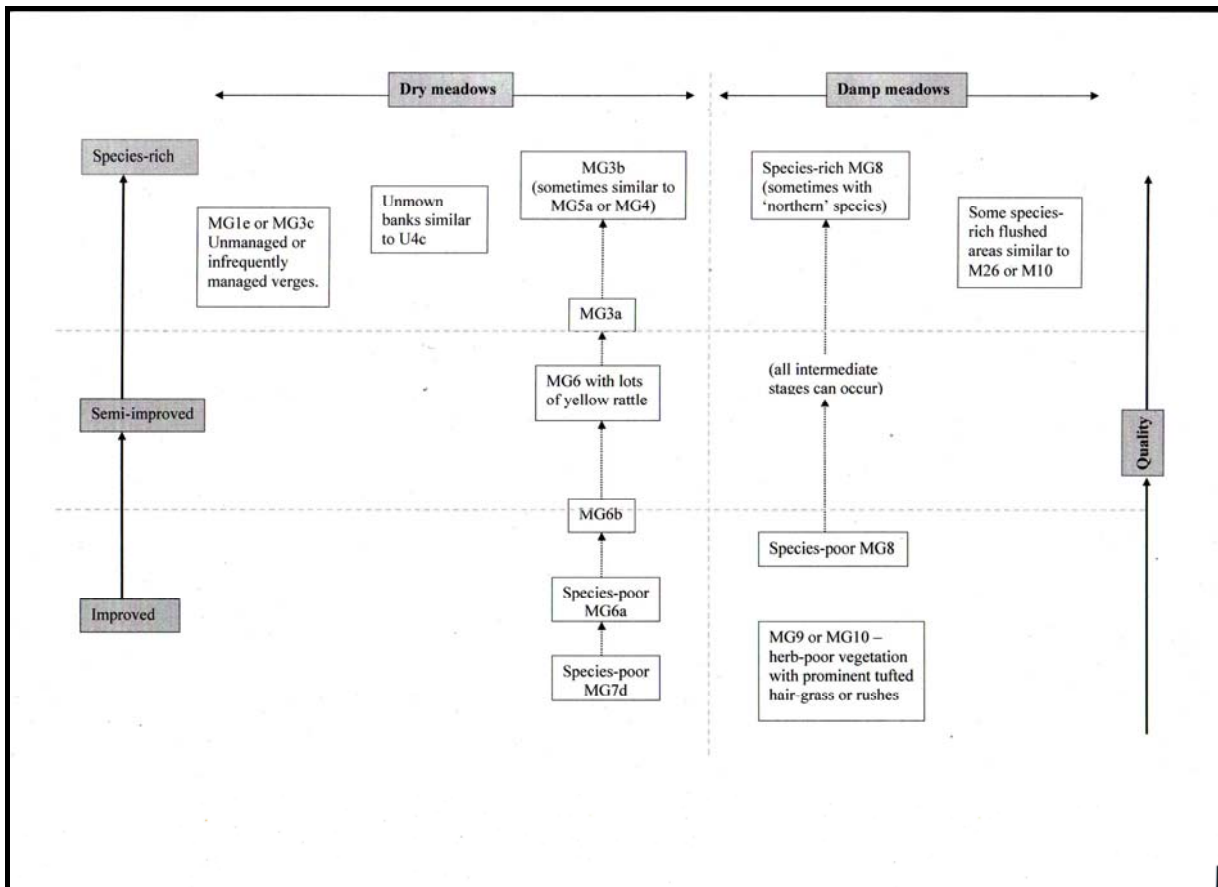
Z = Waskerley/A68 area

- 5.4 The **AE scheme or application** box is self-explanatory.
- 5.5 The **description of field** box is an important part of the form as it is used when writing the survey report and when identifying potential donor and receptor sites. Valuable information to include here includes words describing the overall impression of the field, e.g. weedy, flowery, grassy, vigorous crop, lots of annuals. Also useful are comments describing how the vegetation changes from one part of the field to another. These areas should also be mapped on a sketch map.
- 5.6 The National Vegetation Classification framework should be used when describing the vegetation where possible. The main community should be put in this box with any smaller areas mentioned in the **features of interest** box. The diagram below shows the main vegetation communities found in North

Pennines meadows and Appendix 1 contains a key to the main upland hay meadow communities in the North Pennines.

- 5.7 Apart from being a useful way of describing vegetation and assessing the quality of meadows, this information is useful for analysing large amounts of survey data to get a comprehensive overview of upland hay meadow vegetation in the North Pennines. NB: It is much easier to assign the correct NVC category to a field on-site than later on in the office.

Fig 3. The main vegetation communities found in North Pennine hay meadows



- 5.8 The **features of interest (+fauna)** box can be used for highlighting a range of interesting features in the field. Put a ring around the particular feature(s) present and write a short description if necessary. For banks and wet areas, indicate whether they are species-rich or just of moderate interest. For banks, wet areas, field edges and wood/scrub record the NVC community(ies) present. All of these data can be captured on a GIS layer so they can be used for future analysis. Only features of a reasonable size (larger than approx 5m x 5m) need to be recorded. If they are large enough they should also be marked on the sketch map. This is especially useful for putting the shape of large banks on a GIS system later. If there are any rare plant species present they can be highlighted here.

- 5.9 Birds and other fauna seen during the visit can be recorded here but in practise it is often easier for surveyors to mark them on the margins of the other side of the form while they walk across the field.
- 5.10 Banks with potential for use as a source of hand-collected seed for growing on as plug plants by volunteers should also be noted in the 'features of interest' box. Five species are gathered by hand by Hay Time volunteers (wood crane's-bill, globeflower, Lady's-mantles, melancholy thistle and great burnet). List which of these species are present in sufficient number to be collected by hand and mark the bank on the sketch map.
- 5.11 Put a ring around any of the species listed in the **negative features** box if they are present at problem levels in the field, not just if a few plants are present. Problem levels vary from species to species and surveyors will get to know when something is too abundant with experience. For example, we would want soft brome to cover no more than 5% of the field in a potential receptor and ideally a lot less, but we might rule a field out as a donor if it had 2% soft brome. We might consider creeping buttercup a problem only over 10% cover. It is also important to take note of the distribution of negative species.
- 5.12 Include any signs of negative management in the box for example signs of ring feeders, excessive poaching, fences or walls not stock-proof, etc.
- 5.13 The **practical issues** box refers specifically to practical issues related to harvesting and spreading green hay, eg. narrow gates, very bumpy or rocky ground, excessive slopes, difficult access route, somewhere with enough space for unloading the trailer.
- 5.14 In the **suitable as seed source** box the normal answer is 'no'. If it is suitable, chose one from each pair of options by putting a ring round the right one. If the answer to the final pair is 'part field', mark which part is suitable on the sketch map.
- 5.15 In the **suitable for restoration / enhancement** box, ring 'restoration' or 'enhancement' as appropriate, mark in whether the field is wet (e.g. MG8) or dry (MG6 or MG3a). The second section is for indicating high, medium or low potential for restoration. The factors outlined in the tables in the next few pages can be used to make this judgement.
- 5.16 The **things to look up and send the farmer** box is just a space to write in anything the farmer asked for e.g. more information about costs, aspects of agri-environment schemes.
- 5.17 In the **potential for small-scale habitat work** note down any meadows or parts of meadows that may be suitable for management to increase habitat diversity to benefit seed-eating birds or invertebrates, eg. areas that could be fenced off to enable changes in grazing management or suitable sites for small arable plots.

- 5.18 The **sketch map** is potentially very useful for marking any of the positive (including rare species locations) or negative features or management issues mentioned in the boxes above. All valuable species-rich banks and wet/damp areas of a reasonable size should be marked on a sketch map. Draw a rough outline of the field with north orientated to the top of the page. Try to mark the features in as accurately as possible. For many fields there is nothing in particular to map, so there is no need to sketch the outline of the field in such cases.
- 5.19 The **species list** includes the 185 most commonly encountered species from 3 years of meadow surveys. The species in bold are all quite uncommon or rare and it is worth noting an accurate grid reference for these in the 'features of interest' and for any other species of conservation interest not included on the list (ideally using a Geographic Positioning System). There are a few boxes at the end for extra species not on the list.
- 5.20 The **basic survey method** is to walk around the field in a roughly 'W' shape, aiming to reach most different parts of the field, especially any atypical-looking areas. If surveying before mid-June, it is a good idea to stop a few times and examine the sward to search for non-flowering grasses. It is worthwhile spending some time recording the species present in species-rich wet areas or on species-rich banks even though these areas have no relevance for harvesting or spreading green hay. As surveyors walk around, they should place a single gatemark (a vertical line) in the 'freq' column for each species they find. When they have finished surveying the whole field, they should fill in the 'Q' and '%cov' columns and complete the 'freq' column.
- 5.21 The **Q** (qualifiers) column is for indicating which part of the field the species was confined to if it did not grow in the main mown part of the meadow. The qualifiers are listed in the bottom row of the page. It is important to indicate the species that are confined to banks, edges, wet areas etc, as this makes data analysis of the floral composition of the main meadow community possible.
- 5.22 The '**freq**' column is for estimating the frequency of each species found, on a regular 5-point scale. NB: this is not the same as the DAFOR scale. For estimating on the 5-point scale surveyors should use the same method as for the structured walk for CSM of SSSIs, i.e. imagine they had done 20 quadrats; if a species would have been found in up to 20% (1-4 quadrats) it gets a 'I', if it would have been found in between 20 and 40% (5-8 quadrats) it gets a 'II', etc.
- 5.23 In the **%cov** column surveyors should mark in their estimate of the % cover of the species in the field as a whole to the nearest 5% if above 10%. For species with very low cover mark them as 1%. It is best to mark down the first figure that comes into the surveyors head without thinking about it too much or worrying about how accurate it is. Although it seems very approximate, in the absence of a more detailed survey, this information is potentially very useful for monitoring.

6. How to select which fields to use for seed harvesting or spreading

- 6.1 The tables below list the criteria used for selecting both hay meadow seed donor sites and receptor sites for restoration and enhancement. In practise, the surveyor will weigh up the factors (soil, botanical composition, weeds, management) in the field probably without referring to the table. The main use of the tables is to document what factors we have considered so that we can clearly explain our decisions or for training others to use a similar approach.

Fig 4. Criteria for choosing upland hay meadow restoration/enhancement sites

The first criterion is mandatory. Usually most or all of the other criteria will also apply.

Criterion	Maintain or enhance with no seed addition	Enhance with seed addition	Restore with early successional species	Site not suitable
Is the site (or will it be) in a traditional hay meadow management regime?	Yes	Yes	Yes	No
How many species per m ²	>20	15-20	10-15	< 10
%cover of herbs (excluding white clover, creeping buttercup and weeds)	>30%	20-30%	10-20%	<10%
Number of positive indicator species	At least 2 group 3 (or 4) species occasional and 6 group 2 species frequent	At least 2 group 2 (or higher) species frequent and 4 occasional	At least 5 group 1 (or higher) species present	< 5 species group 1 (or higher) present
-2 Negative indicator species NB: Distribution of these species is important	< 3% cover	< 3% cover	<10% cover (if > 3% cover, control weeds and reassess in 2 years)	>10% cover
Residual fertility	P index 0 or 1	P index 0 or 1	P index 0, 1 or 2 (if P index = 2, then apply no FYM for at least 5 years)	P index 2 or above (NB: may be suitable in some cases)
Cattle available to break up ground and trample in seed	n/a	preferably	preferably	n/a
Field is adjacent to an existing seed source	n/a	preferably	preferably	n/a

Fig 5. Criteria for choosing upland hay meadow seed ‘donor’ sites

To be suitable as a donor site both of the first 2 criteria must be satisfied

Criterion	Species-rich donor for enhancement sites	Donor for restoration sites	Not suitable as a donor
Positive indicator species	At least 5 species from groups 2, 3 or 4 frequent and another 5 species occasional. At least 5 of the 10 species should be from groups 3 or 4.	Yellow rattle, meadow buttercup, sweet vernal-grass <u>and</u> red clover or other legumes should be abundant.	Neither criterion met
Negative indicator species	Group -2 species absent or avoidable and large populations of group -1 species not present	Group -2 species absent or avoidable and large populations of group -1 species not present	Some group -2 species present or large populations of group -1 species present
Number of species per m ²	>25	Not as important as for enhancement sites	n/a

Fig 6. How to match donor sites with restoration/enhancement sites

Locality	Should be as close as possible to restoration/enhancement site and within the same dale.
Altitude	Should be at a similar altitude to restoration/enhancement site.
Soil type	Should be on the same or a similar soil type to restoration/enhancement site
Soil wetness	Soil wetness should be similar (it is usually possible to tell a damper soil from the species composition).
Species composition	Should have the right species composition for the restoration/enhancement site.

7. Positive and negative indicator species for upland hay meadows in the North Pennines AONB

- 7.1 The assignment of species to different categories is based on the opinion of botanists working on the Hay Time project and has been based on 3 years of experience. This system should not be used outside of the North Pennines as some of the species on these lists could be categorised differently in other areas. Also, in other areas, other important upland hay meadows species (e.g spignel *Meum athamanticum*) may occur which are not included on this list.
- 7.2 Only the more commonly found species from each category are included in the tables below. The only exception is the group ‘4’ species which are all listed in the table below.

Fig 7. Negative and positive indicator species for upland hay meadows in the North Pennines AONB

-2 negative indicator species – troublesome weeds

<i>Anthriscus sylvestris</i>	Cow parsley
<i>Bromus hordaceus hordaceus</i>	Soft-brome
<i>Cirsium arvense</i>	Creeping thistle
<i>Cirsium vulgare</i>	Spear thistle
<i>Pteridium aquilinum</i>	Bracken
<i>Ranunculus repens</i>	Creeping buttercup
<i>Rumex crispus</i>	Curled dock
<i>Rumex obtusifolius</i>	Broad-leaved dock
<i>Senecio jacobea</i>	Common ragwort
<i>Urtica dioica</i>	Common nettle

-1 negative indicator species – signs of agricultural improvement, poaching or neglect

<i>Alchemilla mollis</i>	Garden Lady's-mantle
<i>Arrhenatherum elatius</i>	False oat-grass
<i>Cerastium glomeratum</i>	Sticky mouse-ear
<i>Dactylis glomerata</i>	Cock's-foot
<i>Deschampsia cespitosa</i>	Tufted hair-grass
<i>Elytrigia repens</i>	Common couch
<i>Equisetum arvense</i>	Field horsetail
<i>Juncus acutiflorus</i>	Sharp-flowered rush
<i>Juncus effusus</i>	Soft-rush
<i>Lolium perenne</i>	Perennial rye-grass
<i>Matricaria discoidea</i>	Pineappleweed
<i>Phleum pratense</i>	Timothy
<i>Plantago major</i>	Greater plantain
<i>Rubus fruticosus</i> agg.	Bramble
<i>Stellaria media</i>	Common chickweed
<i>Trifolium repens</i>	White clover

Group 0 species – neither positive or negative

<i>Agrostis stolonifera</i>	Creeping bent
<i>Alopecurus pratensis</i>	Meadow foxtail
<i>Bellis perennis</i>	Daisy
<i>Cardamine flexuosa</i>	Wavy bitter-cress
<i>Cerastium fontanum</i>	Common mouse-ear
<i>Cirsium palustre</i>	Marsh thistle
<i>Heracleum sphondylium</i>	Hogweed
<i>Holcus lanatus</i>	Yorkshire-fog
<i>Holcus mollis</i>	Creeping soft-grass
<i>Poa annua</i>	Annual meadow-grass
<i>Poa pratensis</i>	Smooth meadow-grass
<i>Poa trivialis</i>	Rough meadow-grass
<i>Rumex acetosa</i>	Common sorrel
<i>Rumex longifolius</i>	Northern dock
<i>Taraxacum agg</i>	Dandelion
<i>Veronica arvensis</i>	Wall speedwell
<i>Veronica filiformis</i>	Slender speedwell
<i>Veronica serpyllifolia</i>	Thyme-leaved speedwell

+1 positive indicator species – botanically fairly ordinary

<i>Agrostis capillaris</i>	Common bent
<i>Alopecurus geniculatus</i>	Marsh foxtail
<i>Anthoxanthum odoratum</i>	Sweet vernal-grass
<i>Brachythecium rutabulum</i>	a moss
<i>Calliergonella cuspidata</i>	a moss
<i>Cardamine pratensis</i>	Cuckooflower
<i>Carex ovalis</i>	Oval sedge
<i>Cruciata laevipes</i>	Crosswort
<i>Cynosurus cristatus</i>	Crested dog's-tail
<i>Equisetum palustre</i>	Marsh horsetail
<i>Festuca pratensis</i>	Meadow fescue
<i>Festuca rubra</i>	Red fescue
<i>Hypochaeris radicata</i>	Cat's-ear
<i>Kindbergia praelonga</i>	a moss
<i>Leontodon autumnalis</i>	Autumn hawkbit
<i>Luzula campestris</i>	Field wood-rush
<i>Montia fontana</i>	Blinks
<i>Myosotis discolor</i>	Changing forget-me-not
<i>Plantago lanceolata</i>	Ribwort plantain
<i>Poa humilis</i>	Spreading meadow-grass
<i>Ranunculus acris</i>	Meadow buttercup
<i>Ranunculus ficaria</i>	Lesser celandine
<i>Rhytidiadelphus squarrosus</i>	a moss
<i>Trifolium dubium</i>	Lesser trefoil
<i>Trifolium pratense</i>	Red clover
<i>Veronica chamaedrys</i>	Germander speedwell
<i>Vicia sepium</i>	Bush vetch

+2 positive indicator species – botanically slightly more interesting

<i>Achillea millefolium</i>	Yarrow
<i>Caltha palustris</i>	Marsh marigold
<i>Carex flacca</i>	Glaucous sedge
<i>Carex nigra</i>	Common sedge
<i>Conopodium majus</i>	Pignut
<i>Euphrasia arctica sensu lato</i>	an eyebright
<i>Filipendula ulmaria</i>	Meadowsweet
<i>Galium palustre</i>	Common marsh-bedstraw
<i>Lathyrus pratensis</i>	Meadow vetchling
<i>Leucanthemum vulgare</i>	Oxeye daisy
<i>Myosotis scorpioides</i>	Water forget-me-not
<i>Myosotis secunda</i>	Creeping forget-me-not
<i>Prunella vulgaris</i>	Selfheal
<i>Pseudoscleropodium purum</i>	a moss
<i>Ranunculus bulbosus</i>	Bulbous buttercup
<i>Rhinanthus minor minor</i>	Yellow-rattle
<i>Rhytidiadelphus squarrosus</i>	a moss
<i>Stellaria graminea</i>	Lesser stitchwort
<i>Trisetum flavescens</i>	Yellow oat-grass
<i>Vicia cracca</i>	Tufted vetch

+3 positive indicator species – only found in the better meadows

<i>Achillea ptarmica</i>	Sneezewort
<i>Ajuga reptans</i>	Bugle
<i>Alchemilla filicaulis vestita</i>	a Lady's-mantle
<i>Alchemilla glabra</i>	a Lady's-mantle
<i>Alchemilla xanthochlora</i>	a Lady's-mantle
<i>Anemone nemorosa</i>	Wood anemone
<i>Briza media</i>	Quaking-grass
<i>Campanula rotundifolia</i>	Harebell
<i>Carex caryophyllea</i>	Spring sedge
<i>Carex pallescens</i>	Pale sedge
<i>Carex panicea</i>	Carnation sedge
<i>Centaurea nigra</i>	Common knapweed
<i>Cirsium heterophyllum</i>	Melancholy thistle
<i>Crepis paludosa</i>	Marsh hawk's-beard
<i>Dactylorhiza fuchsii</i>	Common spotted-orchid
<i>Dactylorhiza maculata</i>	Heath spotted-orchid
<i>Dactylorhiza purpurella</i>	Northern marsh-orchid
<i>Danthonia decumbens</i>	Heath-grass
<i>Equisetum sylvaticum</i>	Wood horsetail
<i>Galium verum</i>	Lady's bedstraw
<i>Geranium pratense</i>	Meadow crane's-bill
<i>Geranium sylvaticum</i>	Wood crane's-bill
<i>Geum rivale</i>	Water avens
<i>Gymnadenia conopsea sensu lato</i>	Fragrant orchid
<i>Helictotrichon pratense</i>	Meadow oat-grass
<i>Helictotrichon pubescens</i>	Downy oat-grass
<i>Hyacinthoides non-scripta</i>	Bluebell
<i>Hylocomium splendens</i>	a moss
<i>Lathyrus linifolius</i>	Bitter-vetch
<i>Leontodon hispidus</i>	Rough hawkbit
<i>Listera ovata</i>	Twayblade
<i>Lotus corniculatus</i>	Common bird's-foot-trefoil
<i>Lotus pedunculatus</i>	Greater bird's-foot-trefoil
<i>Lychnis flos-cuculi</i>	Ragged-Robin
<i>Ophioglossum vulgatum</i>	Adder's-tongue
<i>Orchis mascula</i>	Early purple-orchid
<i>Persicaria bistorta</i>	Common bistort
<i>Pleurozium schreberi</i>	a moss
<i>Potentilla erecta</i>	Tormentil
<i>Potentilla sterilis</i>	Barren strawberry
<i>Primula veris</i>	Cowslip
<i>Primula vulgaris</i>	Primrose
<i>Sanguisorba officinalis</i>	Great burnet
<i>Saxifraga granulata</i>	Meadow saxifrage
<i>Stachys officinalis</i>	Betony
<i>Succisa pratensis</i>	Devil's-bit scabious
<i>Trifolium medium</i>	Zigzag clover
<i>Trollius europaeus</i>	Globeflower
<i>Valeriana dioica</i>	Marsh valerian
<i>Viola lutea</i>	Mountain pansy

+4 positive indicator species – very special or rare species

<i>Alchemilla acutiloba</i>	a Lady's-mantle
<i>Alchemilla glomerulans</i>	a Lady's-mantle
<i>Alchemilla monticola</i>	a Lady's-mantle
<i>Alchemilla subcrenata</i>	a Lady's-mantle
<i>Alchemilla wichurae</i>	a Lady's-mantle
<i>Bartsia alpina</i>	Alpine Bartsia
<i>Carex capillaris</i>	Hair sedge
<i>Coeloglossum viride</i>	Frog orchid
<i>Crepis mollis</i>	Northern hawk's-beard
<i>Equisetum pratense</i>	Shade horsetail
<i>Euphrasia rostkoviana sensu lato</i>	an eyebright
<i>Galium boreale</i>	Northern bedstraw
<i>Gentiana verna</i>	Spring gentian
<i>Gentianella campsetris</i>	Field gentian
<i>Persicaria vivipara</i>	Alpine bistort
<i>Platanthera chlorantha</i>	Greater butterfly-orchid
<i>Primula farinosa</i>	Bird's-eye primrose
<i>Pseudorchis albida</i>	Small-white orchid
<i>Tofieldia pusilla</i>	Scottish asphodel

8. Botanical surveying – as a baseline for measuring future changes

- 8.1 Survey data should be gathered in sufficient detail to enable comparison between surveys undertaken before and after the addition of seed. Surveys should therefore only be carried out between about 15th June and 7th July in the North Pennines. This may mean a second visit to a field that was assessed as being suitable for harvesting or spreading earlier in the season. Surveyors can use the same form that they used for assessing suitability but it is a good idea to do these surveys as thoroughly as possible as this is the only chance to get a good baseline before the harvesting/spreading.
- 8.2 If surveyors are able to spend a few hours in a field, it is best to do 20 quadrats on a W-walk, recording the %cover of each species in each quadrat. Appendix 2. shows the Hay Time monitoring form.

9. Monitoring after treatment (seed harvesting or spreading)

- 9.1 It is best to use the same survey method for monitoring sites in the years following the treatment. For example, there is no point in doing a detailed (20 quadrat) survey after the treatment, if only a less detailed (without quadrats) survey was done as the baseline. If volunteers are involved in monitoring work and are able to survey extra fields, it is best to ask them to do a baseline of a field that will be worked on (harvesting or spreading) for the first time that year. It is a good idea to ask the same volunteers to survey the same fields year after year. Again, there is no point in doing these surveys before 15th June, although it is tempting to have a look earlier on.

- 9.2 In the first 3 years of the Hay Time project we monitored all the sites that we worked on every year - both donors and receptors. It is not necessary to continue this for every field for every year into the future.
- 9.3 For donor meadows, it is good practise to monitor them to ensure that they are not damaged by having green hay harvested from them. Early indications following 3 years of harvesting by the Hay Time project, suggest that seed harvesting using our methods appears to have virtually no impact on the vegetation. Even when the entire sward has been harvested from a distinct block of a field, we have not been able to detect any impact on the number of plants of annual species appearing in that block in the following year. If harvesting were to have any impact on the vegetation, it would be the annual species that would be most affected as these need to grow from seed every year. Therefore the approach now recommended for monitoring donor sites in the future for the Hay Time project is for one follow-up visit the year after harvesting, paying particular attention to the abundance of annual species. If there are any worrying signs, the field should be revisited. To be really sure, fields should be monitored after 1 year and again after 3 years.
- 9.4 Earlier surveys of donor sites should not be relied on. If a field is scheduled to be a donor site and was last surveyed in detail the previous year it should be revisited to double check that it hasn't changed eg. there is more abundant soft brome or the target species are not flowering. Fields can change quite dramatically from year to year.
- 9.5 For receptor sites, a longer monitoring programme is necessary. Changes may take a long time (>5 years) to become clear. A suggested programme of monitoring receptor sites might be: 1 year after, 2 years after, 4 years after, 7 years after and possibly more after that.

10. How to fill in the Hay Time monitoring form

- 10.1 The **farm, field number, date** and **surveyor's name(s)** boxes on the front are self-explanatory. On the back are listed the 68 most common species from the 3 years of survey undertaken by Hay Time botanists (2006-2008). The 20 most common species on this list are highlighted in bold, as an aide memoir, as they are generally present in most quadrats, in most fields. This may be especially useful for volunteers surveyors to remind them of which grasses to look for.
- 10.2 The locations of the quadrats do not need to be permanently marked or accurately recorded. The purpose of the survey is to get representative data for the field as a whole, rather than to record changes at fixed points. When the survey is repeated, quadrats will be chosen in different points in the field, but as long as enough quadrats are surveyed, the data should be reasonably representative of the field as a whole.
- 10.3 There are 20 columns for recording %cover in up to 20 quadrats. The boxes are small but all 20 can fit on one side of paper. Many people have a look in a quadrat first to see what species are there and then do the % covers at the

end when they have seen everything, before moving on to the next quadrat. Doing things this way, however, increases the chance of forgetting to record the %cover for something seen at the start. Some system of ticking each species off as you see it in order to remind yourself to do its %cover is useful.

- 10.4 The more quadrats done, the more useful and accurate the data obtained, so it is worthwhile encouraging volunteer surveyors to do all 20 if possible (although 15 is acceptable in most situations). This is quite tedious work for a volunteer after about the 7th or 8th quadrat, so this needs to be borne in mind.
- 10.5 There is space for extra species on the front side of the form.
- 10.6 At the time of survey the **F** and **A** columns are left blank as these can be calculated later. **F** means frequency which is recorded on a regular 5-point scale depending on how many quadrats out of the 20 the species was recorded in. The %covers are ignored for this bit. If less than 20 quadrats were completed, the number of quadrats completed must first be divided by 5 and then the number of quadrats in each frequency class must then be worked out.
- 10.7 The **A** stands for 'average % cover', which you calculate by adding all the %covers for that species and dividing by the total number of quadrats recorded. NB: you divide by the number of all quadrats recorded not by the number of quadrats that the species occurred in.

11. Scientific monitoring

- 11.1 At the start of the Hay Time project we asked Dr Roger Smith (University of Newcastle) for advice on what data we would need to gather in order to publish a paper about our results. The following is Dr Smith's recommendation as being the minimum we would need to do. The methodology takes more than a day per site for one person and 2 people are needed at the start to lay the grid out (about 3 hours). As plant identification needs to be more precise for this type of monitoring/surveying, it is vital that the surveyors are good botanists and can identify vegetative grasses.
- 11.2 As part of the Hay Time project, four sites are being monitored using our scientific monitoring methodology: two harvested sites – a species-rich donor site and an 'intermediate' yellow rattle donor site and two receptor sites – one which was species-poor and received green hay from an 'intermediate' yellow rattle field and the other, an 'intermediate' yellow rattle field that has received green hay from a species-rich donor site. All four sites have dry meadow vegetation.
- 11.3 In each case the survey methodology is the same. For the baseline survey, a grid of 60m x 60m is marked out on the ground using measuring tapes, compass and bamboo canes. An area of roughly 60m by 60m is chosen within the field that is reasonably representative of the main vegetation in the field (i.e. avoid edges and atypical banks or wet areas etc.). It is easier for measuring if the starting point for the grid is reasonably close to an edge, especially one that has obvious features that can be measured from.

- 11.4 The starting point of the 60m x 60m grid (e.g. one of the corner points) is marked first with a bamboo cane and in two more permanent ways. A metal plate is buried at this point which can hopefully be relocated in the future with a metal detector. A series of measurements is also taken between this start point and several obvious nearby features on the ground, such as gateposts, trees, etc. A sketch-map is drawn showing roughly the location of the grid and the features used for orientation with the start point of the grid. The measurements and compass bearings between these points are recorded on the map.
- 11.5 The first 60m line of the grid is then marked out by burying bits of metal and placing a bamboo cane at 10m intervals along the line. At the end point of this first 60m line another set of measurements is taken to obvious features and the ground and the relevant measurements and bearings recorded on the map. The compass bearing between the start and end point of this line is recorded as accurately as possible.
- 11.6 Using random numbers, six 10m x 10m plots are selected as permanent plots for the monitoring. First, these are marked on the sketch map. Once the rough location of where the first 10m by 10m plot should be has been worked out, the surveyor goes to the relevant bamboo cane along the start line and measures the relevant distance out at a bearing 90 degrees from the bearing along the first line. Each of the corner points of the 10m by 10m plots is marked with bits of buried metal and bamboo canes. The canes are labelled with the relevant plot number to avoid confusion later on.
- 11.7 Before the surveyor starts surveying, three plots are chosen as the 'control' plots and the other three are the 'treatment' plots. Remember to record which is which on the map or field notes.
- 11.8 In each of the 10m x 10m plots, botanical data are recorded from three 1m x 1m quadrats. Locate these 1m x 1m plots using random numbers and measuring tapes, e.g. using the numbers '7' and '3', measure 7m west along one line of the 10m x 10m plot and then 3m north into the plot. It is a good idea to avoid the first 1m or so of the plot so don't use '0' or '9'. This point can be the south-west corner for the first 1m x 1m quadrat. Repeat the process for the other two quadrats in this 10m x 10m plot. NB: the locations of these 1m x 1m quadrats are not permanently marked, when the survey is repeated in future choose another three quadrats using random numbers again.
- 11.9 Record cover of all plant species (vascular plants and bryophytes) in the quadrats to the nearest 5%. Below 5%, record as 1 (1 or 2 individuals only), 2 (several individuals) or 3 (many individuals). When the data is analysed, the data from the 3 quadrats in a 10m x 10m plot should be averaged before running statistical analysis so that just one set of figures per 10m x 10m plot is used.
- 11.10 Before surveyors leave the site after the baseline survey they should mark the 'treatment' and 'control' plots so that it is obvious that they are different. Put

barrier tape around the ‘control’ plots so that the contractors know not to harvest or spread hay in them. Mark the treatment plots with flags or bits of barrier tape on the corners to highlight where they are and instruct the contractors on the day to make sure they harvest or spread hay within them.

- 11.12 For repeat surveys, relocate the permanently marked points along the first line of the 60m by 60m grid and the corner points of the 10m x 10m plots using the instructions on the original sketch map, compass, measuring tape and metal detector.

12. Talking to the farmer on site

- 12.1 Sometimes a farmer will ask the project officer to have a look at their meadow without meeting up with them. If the project officer can meet with them, however, it offers a good opportunity to talk through how the field has been managed in the past and how it is managed now. Such discussions can offer a valuable insight into the subtle difference between meadows and may help explain why some meadows are more species-rich than others. It also enables the project officer to discuss any new management options and to explain the rationale behind any management changes they may wish to suggest. If the farmer has a potential donor or receptor site, then it gives the project officer a good opportunity to explain in some detail how restoration/enhancement works. We have found that this one-to-one contact with farmers is probably the best way of communicating effectively with them so it is worth setting aside some time for this even if it reduces the time available for meadow surveys.
- 12.2 It is also useful to take some leaflets which help explain the way the project works. We have produced 3 management leaflets specifically designed for farmers – ‘managing species-rich meadows for wildlife’, ‘restoring species-rich meadows for wildlife’ and ‘providing seed for restoring species-rich meadows’ (available via North Pennines AONB website: www.northpennines.org.uk). If the project officer knows that a field on the farm will be one that will be harvested from or have seed spread on, they can talk the farmer through the process step-by-step using the relevant leaflet.

13. Timing of seed harvesting

- 13.1 In an ideal world, we would harvest seed from different parts of a field at different times over the season in order to gather a wider variety of ripe seeds. The decision as to when to harvest depends on the target species and when their seeds ripen in the donor meadow. Yellow rattle seems to be at its best in the North Pennines between about 10th July and end of July. In species-rich fields with populations of late-flowering species like great burnet, knapweed, betony and meadowsweet then mid August is probably the best time. If these late-flowering species are not present then, mid July to the end of July is probably the best time to harvest. In reality, we have one chance to harvest and this can be heavily influenced by the weather, preparation of the receptor site and the availability of the contractors.

14. Methods of seed transfer

14.1 We harvest from no more than one third of a meadow in any year and will also not harvest from the same part of the meadow for at least three years. This gives the meadow plants a chance to replenish their seed bank. We use two types of harvesting machinery:

14.2 Harvesting with the small machinery

The smaller machines (the 'top-of-the-hay' harvester & spreader) were designed and built by Ian Fletcher, a farmer in North Yorkshire. They are used for cutting and spreading only the top portion of the crop ('hay concentrate'). Both harvester and spreader are towed by quad bike. The small size of these machines means that they can get into awkward places to harvest and spread provided the towing quad bike is sufficiently powerful. A set of plastic teeth at the bottom of the harvester acts as the cutting mechanism. Once the vegetation is cut it is sucked up through the funnel of the machine and blown out into the dumpy bag at the back.



Gathering 'hay concentrate' with the 'top-of-the-hay' harvester

14.3 Harvesting with the small machinery works well in dry weather and with dry vegetation. However, if the vegetation is wet, much of it falls to the ground after being cut. We normally wait for a dry day and do not start harvesting much before 10-11am to allow the dew to evaporate (unless the weather has been exceptionally hot as in 2006 when there was no dew). In periods of wet weather, we regularly check to see how wet the vegetation is once the rain stops. We have found that the machinery works adequately if we have had one dry day after a wet period, as long as we start harvesting around 5 or 6pm.

14.4 The height of the cutting teeth can be adjusted up or down. It is best to adjust them down as much as possible but this requires a little trial and error. Do a short run, adjust it and try again. If it is too high it can skim over key species such as red clover and pignut. If it is too low the bag fills up with leafy material very quickly and more of the farmer's crop is removed.

14.5 In order to avoid damaging the seed source, it is best wherever possible to harvest in strips, leaving 2 machine widths between each cut strip, rather than harvesting in blocks. Cutting strips all over the field also ensures that a variety of seed from across the field is harvested. However, if it gets late in the season and the farmer is anxious to make his hay, the only option may be to ask him to leave a block of one third uncut. It is usually best to mark out a block in the field with canes and flags or tape and show him which side of the canes to leave uncut.



Meadow after harvesting with the 'top-of-the-hay' harvester

14.6 Many farmers perceive that the 'top-of-the-hay' harvester is not going to leave them with much hay so they don't bother cutting the remaining vegetation, grazing it off instead. In fact, those who have cut their meadows after we have harvested them, have noticed little difference in the amount of hay they have made. It is worth trying to convince them that it really does have a minor impact even though it may look otherwise at the time. Harvesting from one third of a hectare produces about 15 dumpy bags of loose material filled two thirds. This is very little material compared to the number of tightly packed bales that would come off the same area.

14.7 The material harvested by these machines is full of seeds but there is also quite a lot of leafy material. In theory this is an advantage over material harvested by a brush harvester as it gives very small seeds something to stick to and means fewer of them get blown away or knocked off.



'Hay concentrate' harvested by the 'top-of-the-hay' harvester

14.8 Spreading with the small machinery

Seed in 'green hay' must be spread within an hour of harvesting. Beyond an hour, the vegetation starts to heat up and this will destroy the viability of the seed. The dumpy bags full of material are transported from one site to the other by loading them into a trailer. They are small enough to be man-handled fairly easily as long as they are not filled more than two thirds. If it is wet, they should be filled less than half way up to prevent them becoming too heavy. The standard spreading ratio we use is to spread the material on an area 3 times as big as the area it came from.

- 14.9 The small spreader is a like scaled-down version of a rear discharge muck-spreader. It is a small open trailer which can hold 2 or more bags of harvested material. A pulley system moves a gate along the trailer towards the back as it drives around the field. This pushes the vegetation towards the back of the machine. At the back an axle with spikes rotates which catch bits of the vegetation and throws it up and out of the back. In dry weather this works very well and the vegetation is spread fairly evenly. If the vegetation is wet, however, it comes out in a narrow line rather than being spread out or may come out in clumps. If it comes out lines or clumps it may be necessary to ask the farmer to spread it with a hay bob/tedder. When it is spread evenly it is difficult to spot the material on the ground as there is so little of it.



Spreading 'hay concentrate' with the small machine

- 14.10 If possible, cattle should be put in the field immediately to trample the seed in and toss the material about. The advantages of them trampling the seed in and creating germination niches far outweigh any disadvantages from them eating the seeds.

14.11 Harvesting with the big machinery

The big machinery used by the Hay Time project is an Amazone Groundkeeper mower-collector which is towed by a tractor. It works like a giant lawn-mower. It has a big bucket with a set of flails at the bottom which cuts the vegetation at the base. The mown vegetation does not hit the ground as it is cut directly into the bucket. This harvester is robust and can still work with wet vegetation although this makes the cut material much heavier. However, it is best not to work with the large machines when the ground is wet as the ground gets churned up by the tractor wheels and the soil will become more compacted.

14.12 It is good practise to harvest in strips rather than in blocks wherever possible. Because the tractor wheels are wider than the width of the bucket it would crush a lot of vegetation on either side of the cut strip if one strip is cut then two skipped before cutting another. Instead we cut three rows next to each other, then skip six rows and start again. If blocks are harvested they should be first marked out with canes.

14.13 Once the bucket is full (after travelling about 60m) its contents are tipped into a muck spreader. About 6 bucket loads fit into the spreaders used by the Hay Time contractors.



Harvesting with the Amazone mower-collector

14.14 Spreading with the big machinery

The harvested material is transported from one site to the other in the muck spreaders. If two muck spreaders of roughly the same size are used, it is possible to keep the harvester going constantly with the spreaders going backwards and forwards between the sites. This is ideal as the harvesting is the slowest part of the operation.

14.15 Spreading is a simple matter of turning the spreader on and churning the cut vegetation out at the side. This material is more bulky than that harvested by the small machine (probably over 50 times as bulky). It comes out quite thickly on the ground and can be clumpy. With this method it is a good idea to ask the farmer to go over the material with a hay bob/tedder to spread it out more evenly and shake out the seeds. Again, cattle should be let into the field to trample in the seeds.



Spreading green hay using a standard muck spreader

- 14.16 From 2006 to 2008 the standard spreading ratio used by the Hay Time project with this method was on an area 3 times as big as from the area harvested. Since 2009 we have adjusted this ratio so that we spread on an area 5 times as big as the area harvested from. This is because this method of harvesting is extremely efficient in gathering seeds and it also reduces the possibility of spreading harvested material so thickly that the vegetation is smothered.

15. Receptor site preparation

- 15.1 This is the same for both sets of machinery and is likely to be an important process as it will have a significant impact on how many new plants can germinate and get established.
- 15.2 Standard meadow restoration theory suggests that 30-50% bare ground is needed prior to seed spreading in order to ensure successful germination and establishment. In the first two years of the Hay Time project we asked farmers to prepare receptor fields themselves. This did not work very well. Most farmers only have chain harrows and these don't open up the surface as much as is needed.
- 15.3 Fields vary quite a lot in how open the sward is directly after being cut. Some are quite open with lots of soil visible and areas where the machine has dug into the ground. These may not need much, if any scarifying. Others that have been cut higher up can have a completely closed sward with no bare soil visible.
- 15.4 In 2008 we started asking the Hay Time contractors to create the necessary bare ground using their own set of spring tines. The cost of doing this was built

into the schemes. It is sometimes possible to ask them to tine several fields in one go if several schemes are in the same area but there is little point in doing this if the seed is not spread in those fields within the next few days because the sward closes up again. Spring tines are very effective in opening up the surface and the effect can look quite dramatic but it will gradually settle back down again.



Ground preparation using spring tines

- 15.5 Because the surface of the field is disrupted by the spring tines there is the potential for seeds lying just under the surface to germinate. This can lead to a flush of weeds as weed seeds tend to remain viable for a long time. This emphasises the importance of choosing the right fields to restore. Fields with a history of dock and/or thistle infestation should be avoided, even if they are now free of docks and thistles. Fields with a history of soft brome infestation are also best avoided, even if the soft brome has now gone.
- 15.6 In theory, heavy stocking with cattle can create bare ground prior to seed spreading. However in our experience this is more difficult to arrange and has unpredictable results. Creating bare ground mechanically is quicker, more straightforward and produces more predictable in its results.

16. Choosing which type of machinery to use

- 16.1 The small machinery is best suited to fields that are further apart as transport between the sites with this method involves many fewer trips. The big machinery has the advantage that it can pick up the seeds of lower-growing species, seeds that have already fallen on the ground and bits of soil which may include important micro-organisms that help some species to get established. However, as the material is so bulky and involves several trips to and fro, it works best if the fields are close together, probably no more than a mile apart.

17. Things to sort out before the harvesting season starts

- 17.1 It is a good idea to print out maps showing the fields to be harvested and where to spread the hay for each scheme separately. These should be clearly labelled and should show entrance and exit routes for the machinery as well as a suitable location for unloading the trailer. Maps should be sent to the contractors in advance but they should also be directed on site on the day of the scheme.

18. Working out the costs for each scheme

- 18.1 The costs of each scheme should be worked out as early as possible and sent to: the donor farmer (so they know how much to invoice the receptor farmer); the contractor (so they know how much to invoice the receptor farmer); the receptor farmer (so they know how much both the green hay and the contractor will cost) and, if the receptor farmer is in an agri-environment scheme, the Natural England officer dealing with the particular scheme (as the receptor farmer will be able to claim all or a proportion of the cost of the scheme through their agri-environment agreement). The sooner these costs are worked out and sent to Natural England, the less risk there is of delayed payments to the receptor farmer. Ideally this work would be done in the winter. In reality, much is done during the survey season as it is often only then that final arrangements can be made for where the work is going to be and which donor sites are involved. Under both the Countryside Stewardship Scheme and the Higher Level Scheme the receptor farmer can claim 100% of the costs of the harvesting/spreading work. Under the Environmentally Sensitive Area scheme, the farmer can claim 80% of the costs.
- 18.2 Figs 8 & 9 show examples of the spreadsheets we use to calculate the costs of each scheme. These were developed by our sister Hay Time project in the Yorkshire Dales. We use separate sheets for the green hay and hay concentrate methods.
- 18.3 The 'area of receptor' is the area that the hay will be spread on in the receptor rather than the total area of the field. The 'miles betwixt' is worked out by following the actual route that the machinery will have to go through via field gates and access points.

Fig 8. Example of spreadsheet for working out costs for a green hay (large machinery) scheme

Green hay harvesting and spreading

Donor site:

Receptor site:

Receptor site preparation date:

Harvesting and spreading date:

Values to change per scheme =		Values that you may want to change =	
Area to be harvested from donor (ha) =	0.60	Hay cost per ha =	£500
Area of receptor (ha) =	3.00	Scarifying cost =	£100
Distance to donor site (miles) =	30	Contractor hourly rate =	£90
Distance to receptor site (miles) =	30	Transport cost first day =	£140
Miles betwixt donor and receptor =	1	Transport cost additional days =	£80
Donor Grassiness Quotient (0.5 to 1) =	0.5	Hours of travel/working per day =	14
Volume of green hay per ha (m3) =	250	Number of trips between sites =	19
Time to fill hopper (mins) =	5	Setting up etc time (hrs) =	1
Volume of spreader (m3) =	16	Total operational time (hrs) =	12.1
Number of hoppers to a trailer =	4	Travel time to and from scheme (hrs) =	2.0
Time to cut a spreader load (mins) =	20	Total travel time (hrs) =	4.0
Time to deliver a spreader load (mins) =	5	Number of days on scheme =	2
Time to empty a full spreader (mins) =	10	Total estimated mileage =	218
		Total time (hrs) =	17
		Scarifying	£100
		Transport costs to and from scheme	£220
		Staff and machinery time on site and travel	£1,530
		Total contractor costs	£1,850
		Cost of green hay	£300
		Total cost =	£2,150
		Cost per receptor ha =	£717

Fig 9. Example of spreadsheet for working out costs for a hay concentrate (small machinery) scheme

Hay concentrate harvesting and spreading

Donor site:

Receptor site:

Receptor site preparation date:

Harvesting and spreading date:

Values to change per scheme =		Values that you may want to change =	
Area to be harvested from donor (ha) =	1.00	Hay cost per ha =	£300
Size of receptor (ha) =	3.00	Scarifying cost =	£100
Distance to donor site (miles) =	30	Contractor hourly rate =	£80
Distance to receptor site (miles) =	30	Transport cost first day =	£80
Miles betwixt donor and receptor =	4	Transport cost additional days =	£50
Donor Grassiness Quotient (0.5 to 1) =	0.5	Hours of travel/working per day =	12
Volume of hay concentrate per ha (m3) =	60	Number of trips between sites =	4
Number of bags =	30	Setting up etc time (hrs) =	1.5
Time to fill a bag (mins) =	5	Total operational time (hrs) =	9.2
Number of bags to a trailer =	9	Travel time to and from scheme (hrs) =	2.0
Time to cut a trailer load (mins) =	45	Total travel time (hrs) =	2.0
Time to deliver a trailer load (mins) =	7	Number of days on scheme =	1
Time to empty a full spreader (mins) =	7	Total estimated mileage =	148
Time to spread a trailer load (mins) =	63	Total time (hrs) =	12
		Scarifying	£100
		Transport costs to and from scheme	£80
		Staff and machinery time on site and travel	£960
		Total contractor costs	£1,140
		Cost of hay concentrate	£300
		Total cost =	£1,440
		Cost per receptor ha =	£480

18.4 It is a good idea to fill in a spreadsheet for each scheme and save it as a separate document for future reference. Having this is useful to show Natural England or the farmers or contractors in case there are any queries about how the costs were calculated. It also makes it easier to adjust the costs later on in the season if any aspect of the particular scheme changes (e.g. you have to use a different donor site, or the ground is too wet to travel on in part of the field etc.)

18.5 When all the costs have been calculated:

- send a summary of the contractor and hay cost of each scheme to the Natural England main contact(s) for the project who can circulate the information to the Natural England officer dealing with each scheme.
- send a summary of the relevant costs to each contractor with details of where to send the invoice (the receptor farmer's name and address) and how much to charge them.
- send letters to the donor farmers telling them how much to charge for the green hay, where to send the invoice (the receptor farmer's name and address) and an estimated date for doing the harvesting. NB: remind them not to cut their field until the harvesting has been done and ask them to get in touch if they are planning to cut their field.
- send letters to the receptor farmers outlining the costs of the green hay and the contractor and an estimated date for doing the spreading. Instruct them to send these invoices to Natural England when they make their claim.
- for ESA farmers, calculate how much (80%) of the costs Natural England will pay them.
- If a farmer is donating green hay for enhancing one of his fields from another field on his own farm, he gets paid the standard cost for this green hay from his agri-environment scheme. In this case, instruct him to send his invoice for the green hay directly to Natural England with his claim.

19. Co-ordination during the harvesting/spreading season

19.1 July and August are busy times for hay meadow restoration work. In good weather the Hay Time project can have 2 sets of contractors working at the same time in different parts of the AONB. This means that there are 4 sets of landowners to keep informed on that day. Important tasks are to:

- show the contractors the way in and at the end of the day show them the next site for the following day as they may want to store their machinery there.
- liaise with the 4 farmers whose farms will be involved on the following day.

19.2 At the start of the harvesting season it is a good idea to pencil in dates for every scheme and let everyone involved know of the plan. If the weather is favourable and there are no machinery problems it may be possible to stick to that schedule but this is rarely the case. When delays due to weather occur it is worth letting everyone involved in the schemes still to be completed know of the delay and an estimated revised time. However, if the weather is really bad for a while there is no point in phoning everyone up every couple of days. Most farmers understand the situation so there is no need to phone them so regularly.

20. Two stages of restoration

- 20.1 The Hay Time project follows advice for hay meadow restoration arising from Dr Roger Smith's hay meadow research and so plans restoration in two stages. The theory is that if a field has lost much of its species diversity, the soil flora will have been altered such that fewer microrhizal fungi are present and more bacteria are present in their place. Most plants (apart from weedy species) cannot establish and survive without forming a relationship with a microrhizal fungus. There may also be significant changes in the soil nematode communities which can influence which plant species can establish. Roger Smith's research suggests that introducing certain plant species encourages the population of microrhizal fungi to build up again. These species included yellow rattle, red clover, meadow buttercup and sweet vernal-grass.
- 20.2 When we set out to restore a field that has lost most of its species, we introduce good populations of these 1st stage species first. In order to do this we look for donor fields with abundant yellow rattle and red clover as most fields already have sweet vernal-grass and meadow buttercup. Roger Smith recommends waiting 5-10 years after introducing 1st stage species before progressing on to the 2nd stage. If a field already has the 1st stage species we go straight to the 2nd stage. The best donors for this stage are the most species-rich fields especially ones with good populations of the grade 3 or 4 species that are not currently in the receptor field.

21. Inputting survey data and creating reports

- 21.1 At the end of the harvesting/spreading season all the botanical survey data are entered onto the master Hay Time spreadsheet. These data are then used to generate reports, with management recommendations where appropriate, for each hay meadow surveyed. Fig 10 gives an example of one of these reports.

Fig 10. Example report for a North Pennines hay meadow

Scientific name	Common name	Group	Freq	Where	Damp	Early/late
Positive indicator species						
<i>Achillea millefolium</i>	Yarrow	2	1	b		
<i>Agrostis capillaris</i>	Common bent	1	3			
<i>Alchemilla xanthochlora</i>	a Lady's-mantle	3	1			
<i>Alopecurus geniculatus</i>	Marsh foxtail	1	1	e	damp	
<i>Anthoxanthum odoratum</i>	Sweet vernal-grass	1	2			
<i>Caltha palustris</i>	Marsh marigold	2	1	e	damp	early
<i>Campanula rotundifolia</i>	Harebell	3	1	b		late
<i>Centaurea nigra</i>	Common knapweed	3	1			late
<i>Conopodium majus</i>	Pignut	2	1	b		early
<i>Crepis mollis</i>	Northern hawk's-beard	4	1			
<i>Cruciata laevipes</i>	Crosswort	1	1	e		
<i>Cynosurus cristatus</i>	Crested dog's-tail	1	5			
<i>Dactylorhiza fuchsii</i>	Common spotted-orchid	3	1	e		
<i>Euphrasia arctica borealis</i>	an eyebright	2	1	b		
<i>Festuca pratensis</i>	Meadow fescue	1	1	g		

<i>Festuca rubra</i>	Red fescue	1	1			
<i>Galium palustre</i>	Common marsh-bedstraw	2	1	e	damp	
<i>Galium verum</i>	Lady's bedstraw	3	1	b		
<i>Geranium sylvaticum</i>	Wood crane's-bill	3	1			
<i>Helictotrichon pubescens</i>	Downy oat-grass	3	1	b		
<i>Hypochaeris radicata</i>	Cat's-ear	1	1			
<i>Lathyrus linifolius</i>	Bitter-vetch	3	1	b		
<i>Lathyrus pratensis</i>	Meadow vetchling	2	1			late
<i>Leontodon autumnalis</i>	Autumn hawkbit	1	1			
<i>Leontodon hispidus</i>	Rough hawkbit	3	1			late
<i>Leucanthemum vulgare</i>	Oxeye daisy	2	1			
<i>Linum catharticum</i>	Fairy flax	3	1	b		
<i>Lotus corniculatus</i>	Common bird's-foot-trefoil	3	1			
<i>Luzula campestris</i>	Field wood-rush	1	1	b		
<i>Pilosella officinarum</i>	Mouse-ear hawkweed	3	1	b		
<i>Plantago lanceolata</i>	Ribwort plantain	1	2			
<i>Potentilla erecta erecta</i>	Tormentil	3	1	b		
<i>Primula veris</i>	Cowslip	3	1	b		early
<i>Primula vulgaris</i>	Primrose	3	1	e		early
<i>Ranunculus acris</i>	Meadow buttercup	1	4			
<i>Rhinanthus minor minor</i>	Yellow-rattle	2	1			
<i>Sanguisorba officinalis</i>	Great burnet	3	1	e		late
<i>Stellaria graminea</i>	Lesser stitchwort	2	1			
<i>Succisa pratensis</i>	Devil's-bit scabious	3	1	b	damp	late
<i>Trifolium medium</i>	Zigzag clover	3	1	b		late
<i>Trifolium pratense</i>	Red clover	1	1			
<i>Trisetum flavescens</i>	Yellow oat-grass	2	2			
<i>Veronica chamaedrys</i>	Germander speedwell	1	3			
<i>Vicia cracca</i>	Tufted vetch	2	2			late
<i>Vicia sepium</i>	Bush vetch	1	2			
Negative indicator species						
<i>Anthriscus sylvestris</i>	Cow parsley	-2	1	e		
<i>Arrhenatherum elatius</i>	False oat-grass	-1	1			
<i>Bromus hordaceus hordaceus</i>	Soft-brome	-2	1			
<i>Cirsium vulgare</i>	Spear thistle	-2	1			
<i>Dactylis glomerata</i>	Cock's-foot	-1	5			
<i>Deschampsia cespitosa</i>	Tufted hair-grass	-1	1	e	damp	
<i>Juncus effusus</i>	Soft-rush	-1	1	e	damp	
<i>Lolium perenne</i>	Perennial rye-grass	-1	5			
<i>Phleum pratense</i>	Timothy	-1	3			
<i>Plantago major</i>	Greater plantain	-1	1	g		
<i>Ranunculus repens</i>	Creeping buttercup	-2	1			
<i>Stellaria media</i>	Common chickweed	-1	1			
<i>Trifolium repens</i>	White clover	-1	1			
<i>Urtica dioica</i>	Common nettle	-2	1	e		
Other species						
<i>Agrostis stolonifera</i>	Creeping bent		1	e		
<i>Alopecurus pratensis</i>	Meadow foxtail		4			
<i>Bellis perennis</i>	Daisy		1	b		
<i>Cerastium fontanum</i>	Common mouse-ear		2			

<i>Heracleum sphondylium</i>	Hogweed		1			
<i>Holcus mollis</i>	Creeping soft-grass		1	e		
<i>Poa annua</i>	Annual meadow-grass		1	g		
<i>Poa trivialis</i>	Rough meadow-grass		5			
<i>Potentilla anserina</i>	Silverweed		1	g		
<i>Rumex acetosa</i>	Common sorrel		5			
Total number of species		69				
Positive indicator species		113				
Negative indicator species		-29				
Total meadow score		84				

Where column

b = growing mainly on banks

g = growing mainly around gates

e = growing mainly on the field edges

Description

This field is mostly relatively species-poor. Most of the vegetation is dominated by a few grasses and a few common wild flowers. The vegetation is slightly richer in the north half compared to the south half. There are some small banks in the field where some extra species survive that have disappeared from the main, mown part of the field. There are a few plants of northern hawk's-beard on one of the banks. If the species on these banks and those growing only at the field edges were not counted then the vegetation in the main mown part of the field would score only 21 points. There are no major problems with weedy species here.

Recommendations

- Based on the vegetation alone, the field appears to have high potential for meadow restoration, although a soil test could help confirm this.
- If meadow restoration is attempted here then it would be best to introduce seed in two stages. The first stage would be to introduce seed from a more species-rich local meadow that contained abundant yellow rattle and red clover. After about 5 to 10 years the soil will hopefully be more suitable for other species and seed from field A could be introduced at that stage.
- As there are no real problems with weedy species here at present, it would be best to avoid feeding livestock in this field with hay or silage from other fields, as this may introduce seed of undesirable weedy species.

John O'Reilly – Hay Time project officer (May 2006 – April 2009)

Rebecca Barrett – Project Development Officer, North Pennines AONB Partnership

All images: Rebecca Barrett/NPAP

North Pennines AONB Partnership. 2009

Appendix 1.

A key to the main upland hay meadow communities in the North Pennines

1	Marsh marigold at least occasional or herb-poor vegetation with rushes, tufted hair-grass or common sedge at least frequent.	damp meadows 2
1	Marsh marigold rare or absent or if vegetation is herb-poor, then rushes, tufted hair-grass or common sedge are absent or less than frequent.	dry meadows 7
2	Marsh marigold at least occasional	(MG8) 3
2	Marsh marigold rare or absent	6
3	Species-rich vegetation with wood crane's-bill at least occasional, and/or at least 2 of bugle, pignut and wood anemone at least occasional	(MG8+) 3
3	Species-poor to species-rich vegetation with wood crane's-bill rare or absent, and/or no more than 1 of bugle, pignut and wood anemone at least occasional	4
4	Species-rich vegetation with 1 of the following at least frequent or at least 2 at least occasional - globeflower, marsh hawk's-beard, water avens, northern marsh-orchid or lady's-mantles.	(MG8n) 4
4	Species-poor or moderately species-rich vegetation with above species rarer or absent	5
5	Moderately species-rich vegetation with at least 2 group 2 species at least occasional.	(MG8y) 5
5	Species-poor vegetation with few if any group 2 species apart from marsh marigold.	(MG8-) 5
6	Common sedge at least frequent, tufted hair-grass and rushes less frequent.	(MG8s) 6
6	Tufted hair-grass at least frequent, common sedge and rushes less frequent.	(MG9) 6
6	Rushes at least frequent, tufted hair-grass and common sedge less frequent.	(MG10) 6
7	Moderately species-rich to species-rich grassland with at least one of the following at least frequent or at least 2 at least occasional – wood crane's-bill, lady's-mantles, globeflower, wood anemone, water avens, melancholy thistle, bugle or wood horsetail	(MG3) 8
7	Species-poor to species-rich vegetation with few if any of the characteristic northern hay meadow species listed above present	9
8	Very herb-rich grassland with the characteristic northern northern hay meadow species listed above prominent in the sward. Soft brome is usually rare or absent.	(MG3b) 8

8	Moderately herb-rich grassland with the characteristic northern northern hay meadow species listed above present but less prominent in the sward. Soft brome and perennial rye-grass are often frequent.	(MG3a)
9	Species-rich grassland with at least 4 group 2 or group 3 species at least occasional	10
9	Species-poor or moderately species-rich grassland with fewer than 4 group 2 or group 3 species at least occasional	11
10	Great burnet and meadowsweet usually at least frequent	(MG4)
10	Great burnet and meadowsweet usually rare or absent	(MG5a)
11	Moderately species-rich vegetation with at least one of the following at least abundant or 2 at least frequent – yellow-rattle, pignut, eyebright, rough hawkbit	(MG6+)
11	Usually species-poor vegetation with few if any group 2 or group 3 species.	12
12	Grassy vegetation without any crested dog's-tail.	(MG7) 13
12	Grassy vegetation or with some group 1 herbs, with crested dog's-tail at least occasional.	(MG6) 14
13	With meadow foxtail at least frequent but usually without any meadow fescue.	(MG7d)
13	With meadow foxtail and meadow fescue usually at least frequent.	(MG7c)
14	With sweet vernal-grass at least frequent.	(MG6b)
14	With sweet vernal-grass usually rare or absent.	(MG6a)

Dry meadows

MG3a sweet vernal-grass/wood crane's-bill grassland (soft-brome sub-community)

Moderately herb-rich grassland with some of the characteristic northern northern hay meadow species; wood crane's-bill, lady's-mantles, globeflower, wood anemone, water avens, melancholy thistle, bugle and wood horsetail, present but not as prominent in the sward as in MG3b. Soft brome and perennial rye-grass are often frequent. Rough hawkbit, yellow-rattle, field wood-rush, cat's-ear, quaking-grass, common bird's-foot trefoil and common knapweed are less common or absent here compared to MG3b.

MG3b sweet vernal-grass/wood crane's-bill grassland (quaking-grass sub-community)

Very herb-rich grassland with at least some of the characteristic northern northern hay meadow species; wood crane's-bill, lady's-mantles, globeflower, wood anemone, water avens, melancholy thistle, bugle and wood horsetail, prominent in the sward. Soft brome is usually rare or absent. Rough hawkbit, yellow-rattle, field wood-rush, cat's-ear, quaking-grass, common bird's-foot trefoil and common knapweed are preferential for this sub-community over MG3a.

MG4 meadow foxtail/great burnet grassland

Species-rich vegetation with frequent great burnet and meadowsweet, but without any of the characteristic northern northern hay meadow species; wood crane's-bill, lady's-mantles, globeflower, wood anemone, water avens, melancholy thistle, bugle and wood horsetail. Usually at lower altitudes (below 240m). May be just a variant of MG3 with a few species missing.

MG5a crested dog's-tail/common knapweed grassland (meadow vetchling sub-community)

Species-rich vegetation without great burnet or any of the characteristic northern northern hay meadow species; wood crane's-bill, lady's-mantles, globeflower, wood anemone, water avens, melancholy thistle, bugle and wood horsetail. Often has more common bird's-foot-trefoil than MG3 or MG4. Usually at lower altitudes (below 300m).

MG6+ perennial rye-grass/crested dog's-tail grassland (yellow-rattle sub-community)

Intermediate between MG3a and MG6b. More herb-rich than MG6a or MG6b. Often contains yellow-rattle, eyebright, pignut or sometime rough hawkbit. Sometimes has a few other group 2 species (e.g. bush vetch, meadow vetchling, red clover), but rarely any group 3 species present. Could be an impoverished version of MG3a or a more herb-rich version of MG6b.

MG6b perennial rye-grass/crested dog's-tail grassland (sweet vernal-grass sub-community)

Species-poor vegetation with few group 2 or group 3 species present. Typical herbs include white clover, creeping buttercup, common mouse-ear, meadow buttercup, common sorrel, germander speedwell, daisy, ribwort plantain, red clover, meadow vetchling, bush vetch, cat's-ear. Has a mixture of grasses including perennial rye-grass and crested dog's-tail. This sub-community is slightly more species-rich than MG6a and has sweet vernal-grass at least frequent.

MG6a perennial rye-grass/crested dog's-tail grassland (typical sub-community)

Species-poor vegetation with few group 2 or group 3 species present. Typical herbs include white clover, creeping buttercup, common mouse-ear, meadow buttercup, common sorrel, germander speedwell, daisy, ribwort plantain, meadow vetchling, bush vetch, red clover, cat's-ear. Has a mixture of grasses including perennial rye-grass and crested dog's-tail. This sub-community is slightly less species-rich than MG6b and usually has no sweet vernal-grass.

MG7d perennial rye-grass leys

Species-poor, improved grassy vegetation, without any crested dog's-tail and with few herbs other than meadow buttercup, white clover, dandelion, common mouse-ear, common sorrel, ribwort plantain, red clover, creeping buttercup, meadow vetchling. This sub-community has frequent meadow foxtail but usually no meadow fescue.

MG7c perennial rye-grass leys

Species-poor, improved grassy vegetation, without any crested dog's-tail and with few herbs other than meadow buttercup, white clover, dandelion, common mouse-ear, common sorrel, ribwort plantain, red clover, creeping buttercup, meadow vetchling. This sub-community has frequent meadow foxtail and meadow fescue.

Damp meadows (either above 360m or on damp soils at lower altitude)

Include *Carex nigra* grassland

MG8+ crested dog's-tail/marsh marigold grassland (intermediate with MG3b)

Vegetation intermediate between MG3b and species-rich MG8. It includes both marsh marigold and some characteristic MG3 species that do not appear in the MG8 floristic tables in Rodwell et al. (1992). These are wood crane's-bill, bugle, pignut and wood anemone. This vegetation may not be distinct from MG8n below.

MG8n crested dog's-tail/marsh marigold grassland (northern sub-community)

Species-rich MG8 vegetation which includes one or more of the characteristic northern upland hay meadow species that are listed in the MG8 table in Rodwell et al. (1992). These include globeflower, marsh hawk's-beard, water avens, northern marsh-orchid and lady's-mantles. It often also contains frequent pignut which is not included in the table in Rodwell et al. (1992).

MG8y crested dog's-tail/marsh marigold grassland (yellow-rattle sub-community)

Moderately species-rich vegetation without any of the characteristic northern upland hay meadow species found in MG8+ or MG8n (apart from pignut). Also without many (if any) other group 3 species, but with at least 2 group 2 species at least occasional. Often includes yellow-rattle, eyebright and/or pignut.

MG8- crested dog's-tail/marsh marigold grassland (species-poor sub-community)

Species-poor vegetation that resembles species-poor MG6, except it also contains marsh marigold. Typical herbs that can occur here include meadow buttercup, creeping buttercup, common sorrel and common mouse-ear. Usually very few other herbs present.

MG8s common sedge/creeping bent/marsh ragwort grassland

As described in Rodwell et al (2000) and Averis et al. (2004). Usually without any marsh marigold, but with mixture of some or all of creeping bent, common sedge, Yorkshire-fog, sweet vernal-grass, creeping buttercup, common sorrel, cuckooflower, meadow buttercup, sweet grasses and the moss *Calliergonella cuspidata*

MG9 Yorkshire-fog/tufted hair-grass grassland

Damp, usually herb-poor vegetation with prominent tufted hair-grass. More often a pasture or an abandoned meadow rather than an active meadow.

MG10 Yorkshire-fog/soft-rush rush-pasture

Damp, usually herb-poor vegetation with prominent soft rush and/or sharp-flowered rush. More often a pasture rather than a meadow. Can occur in lightly-grazed meadows where the field drains have become neglected. The typical subcommunity (MG10a) is the one most frequently encountered in North Pennines meadows.

A number of other vegetation communities occur on:

- **Uncut and/or unmanaged banks within meadows or on road verges or riverbanks**
MG3c, MG1e, MG5c, U4c, CG10
- **Damp areas and/or flushes within meadows**
M10, M23, M26, M27a

Indicator species list

Common name	Scientific name
a moss	<i>Calliergonella cuspidata</i>
Bugle	<i>Ajuga reptans</i>
Bush vetch	<i>Vicia sepium</i>
Cat's-ear	<i>Hypochaeris radicata</i>
Common bird's-foot trefoil	<i>Lotus corniculatus</i>
Common knapweed	<i>Centaurea nigra</i>
Common mouse-ear	<i>Cerastium fontanum</i>
Common sedge	<i>Carex nigra</i>
Common sorrel	<i>Rumex acetosa</i>
Creeping bent	<i>Agrostis stolonifera</i>
Creeping buttercup	<i>Ranunculus repens</i>
Crested dog's-tail	<i>Cynosurus cristatus</i>
Cuckooflower	<i>Cardamine pratensis</i>
Daisy	<i>Bellis perennis</i>
Dandelion	<i>Taraxacum agg.</i>
Eyebright	<i>Euphrasia sp.</i>
Field wood-rush	<i>Luzula campestris</i>
Germander speedwell	<i>Veronica chamaedrys</i>
Globeflower	<i>Trollius europaeus</i>
Great burnet	<i>Sanguisorba officinalis</i>
Lady's-mantles	<i>Alchemilla sp.</i>
Marsh hawk's-beard	<i>Crepis paludosa</i>
Marsh marigold	<i>Caltha palustris</i>
Marsh ragwort	<i>Senecio aquaticus</i>
Meadow buttercup	<i>Ranunculus acris</i>
Meadow fescue	<i>Festuca pratensis</i>
Meadow foxtail	<i>Alopecurus pratensis</i>
Meadowsweet	<i>Filipendula ulmaria</i>
Meadow vetchling	<i>Lathyrus pratensis</i>
Melancholy thistle	<i>Cirsium heterophyllum</i>
Northern marsh-orchid	<i>Dactylorhiza purpurella</i>
Perennial rye-grass	<i>Lolium perenne</i>
Pignut	<i>Conopodium majus</i>
Quaking-grass	<i>Briza media</i>
Red clover	<i>Trifolium pratense</i>
Ribwort plantain	<i>Plantago lanceolata</i>
Rough hawkbit	<i>Leontodon hispidus</i>
Rushes	<i>Juncus sp.</i>
Sharp-flowered rush	<i>Juncus acutiflorus</i>
Soft brome	<i>Bromus hordaceus hordaceus</i>
Soft-rush	<i>Juncus effusus</i>
Sweet grasses	<i>Glyceria sp.</i>
Sweet vernal-grass	<i>Anthoxanthum odoratum</i>
Tufted hair-grass	<i>Deschampsia cespitosa</i>
Water avens	<i>Geum rivale</i>
White clover	<i>Trifolium repens</i>
Wood anemone	<i>Anemone nemorosa</i>
Wood crane's-bill	<i>Geranium sylvaticum</i>
Wood horsetial	<i>Equisetum sylvaticum</i>
Yellow-rattle	<i>Rhinanthus minor</i>
Yorkshire-fog	<i>Holcus lanatus</i>

Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	F	A
<i>Achillea millefolium</i>																						
Agrostis capillaris																						
<i>stolonifera</i>																						
<i>Alchemilla glabra</i>																						
<i>xanthochlora</i>																						
<i>Alopecurus geniculatus</i>																						
pratensis																						
Anthoxanthum odorat																						
<i>Anthriscus sylvestris</i>																						
<i>Arrhenatherum elatius</i>																						
Bellis perennis																						
Bromus hordaceus hor																						
<i>Caltha palustris</i>																						
<i>Cardamine pratensis</i>																						
<i>Carex nigra</i>																						
<i>Centaurea nigra</i>																						
Cerastium fontanum																						
<i>glomeratum</i>																						
<i>Cirsium arvense</i>																						
Conopodium majus																						
<i>Cruciata laevipes</i>																						
Cynosurus cristatus																						
Dactylis glomerata																						
<i>Deschampsia cespitosa</i>																						
<i>Equisetum arvense</i>																						
<i>Euphrasia arctica s.l.</i>																						
Festuca rubra																						
<i>Filipendula ulmaria</i>																						
<i>Geranium sylvaticum</i>																						
<i>Helictotrichon pubescen</i>																						
<i>Heracleum sphondylium</i>																						
Holcus lanatus																						
<i>mollis</i>																						
<i>Hypochaeris radicata</i>																						
<i>Juncus acutiflorus</i>																						
<i>effusus</i>																						
<i>Lathyrus pratensis</i>																						
<i>Leontodon autumnalis</i>																						
<i>hispidus</i>																						
Lolium perenne																						
<i>Lotus corniculatus</i>																						
<i>Luzula campestris</i>																						
<i>Montia fontana</i>																						
<i>Myosotis discolor</i>																						
<i>Phleum pratense</i>																						
Plantago lanceolata																						
Poa trivialis																						
<i>Potentilla erecta erecta</i>																						
<i>Prunella vulgaris</i>																						
Ranunculus acris																						
<i>bulbosus</i>																						
repens																						
Rhinanthus minor																						
<i>Rhytiadelphus squaros</i>																						
Rumex acetosa																						
<i>obtusifolius</i>																						
<i>Sanguisorba officinalis</i>																						

