ENGLISH NATURE

Report Number
636

The condition of lowland BAP priority grasslands: results from a sample survey of non-statutory stands in England

English Nature Research Reports

working today
for nature tomorrow

English Nature Research Reports

Number 636

The condition of lowland BAP priority grasslands: results from a sample survey of non-statutory stands in England

A Report prepared for
English Nature, Defra and JNCC
FST 20-32-021/MA01009

Dr Eleanor J. Hewins [1]
Clare Pinches [2]
Jessica Arnold [1]
Mike Lush [1]
Dr Heather Robertson [2]
Sarah Escott [3]

[1] Just Ecology Environmental Consultancy Limited, The Old Wheelwrights, Ham Berkeley, Gloucestershire, GL13 9QH. 01453 811780
[2] English Nature, TWT, Northminster House, Peterborough, PE1 1UA
[3] RDS East, Eastbrook, Shaftesbury Road, Cambridge, CB2 2DR

ISSN 0967-876X

Acknowledgements

We wish to thank English Nature, Defra and JNCC who have funded this project. We would like to thank the following staff at English Nature and Defra for their assistance and comments on the draft report: David Glaves, Gy Ovenden, Mark Stevenson and Steve Peel (Defra). We would also like to thank Jeff Kirby, Johnny Turner and Galina Gardiner (Just Ecology) for their input.

We would like to thank all the additional botanical surveyors who have been involved in the collection of data, namely Juliet Bailey, Maurice Bailey, Claire Cornish, Liz Mackay, Joyce Moxton, Mike Prosser, Elaine Radford, James Riley, Johnny Turner and Hilary Wallace.

Finally, we acknowledge all the landowners who kindly allowed access to their land.

Summary

This project provides baseline data on the current extent and condition of a sample of non-statutory UK Biodiversity Action Plan (BAP) grasslands in the lowlands of England.

Approximately 500 non-statutory grassland sites were randomly selected from English Nature's Grassland Inventory. This inventory provides a register of known high quality grassland sites, greater than 0.5ha in size for each county. Sites were included in the inventory if they possessed post 1980 survey data demonstrating that they supported grassland of high botanical quality at the time of survey. The sample was stratified on the basis of the five lowland BAP priority grassland types: Purple Moor Grass Rush Pastures (PMGRP); Lowland Dry Acid Grassland (LDAG); Lowland Calcareous Grassland (LCG); Lowland Meadows (LM); and Upland Hay Meadows (UHM). In this way, approximately 100 sites were randomly selected within each priority grassland category.

The sample was further stratified to include an approximately equal number of sites within and outside agri-environment agreements for each priority grassland type. Since non-statutory grasslands have until recently been afforded little of the protection endowed on nationally designated sites (Sites of Special Scientific Interest and National Nature Reserves), it is on these grasslands that agri-environment agreements can contribute most in reducing loss rates and improving overall condition.

Each grassland stand accepted into the sample was mapped and then assessed using a modified version of English Nature's SSSI condition assessment methodology (Robertson & Jefferson 2000).

Survey was split into two components; a stand assessment and a structured walk. Surveyors firstly made an assessment of the entire grassland stand. Amongst other features, this involved recording the extent of the grassland community/ies of interest, attributes of the vegetation best assessed at the stand level, for example cover of herbs, litter and scrub, and frequencies of all vascular plant species encountered in the stand. A 'structured walk' comprising 20 stops was used to record indicator species and vegetation height within a 1m radius at each stop. Digital maps for each site were produced on a Geographical Information System (GIS). A full description of the survey method used, including details of the structured walk methodology and on mapping of stands can be found in a supporting report (Hewins and others 2004).

A total of 470 sites were included in the final sample, covering 483 separate grassland stands and 22 National Vegetation Classification communities.

Survey data were entered onto a bespoke database, and the grassland stand data then assessed against both the non-statutory (Robertson and others 2002) and SSSI condition assessment target (Robertson & Jefferson 2000). The draft non-statutory targets include lowered thresholds for some attributes, designed for potential use on priority grassland sites outside designation, where the quality of the grassland may be slightly lower than that on nationally designated sites.

Analysis of the grassland stand species data indicates that 24% of sites show most similarity, in terms of botanical composition, to agriculturally improved or neglected grassland

communities, rather than true priority grassland types. Unfortunately it was not possible to tell when this neglect or agricultural improvement had occurred.

Analysis of pass rates for the sample showed that overall only 21% of stands passed all mandatory non-statutory condition assessment targets, and hence could be considered to be in favourable condition. When the SSSI thresholds were applied, this figure dropped to 14%.

Upland Hay Meadows and Lowland Meadows were in the poorest condition of the priority grassland types, with only 7% and 18% of grassland in these categories in favourable condition respectively, when non-statutory condition assessment targets and thresholds were applied. Purple Moor Grass Rush Pasture stands did comparatively well, with a relatively high proportion (35%) in favourable condition. When grassland stands no longer conforming to priority grassland types were removed from the sample, and only those stands still fitting to priority grasslands were examined, the overall stsand pass rate rose to 27%. Condition results for each priority grassland type are presented in Table 1.

Table 1.

	% of stands in favourable condition	
Priority grassland type	**All stands**	**Priority grassland stands only**
Upland Hay Meadow	7	12
Lowland Meadow	18	23
Lowland Dry Acid Grassland	23	17
Lowland Calcareous Grassland	28	32
Purple Moor Grass and Rush Pasture	35	39
All grasslands	21	27

Stands failed most frequently because they lacked positive indicator species in sufficient number and at frequency levels characteristic of good quality semi-natural grasslands. Similarly, many stands failed because the proportion of non-grass plant species in the swards was too low. Other attributes which were significant in causing failure of particular grassland types were too high a cover of coarse grasses in Lowland Dry Acid Grasslands; negative indicator species in Lowland Calcareous Grasslands and rush cover in Purple Moor Grass Rush Pastures.

Analysis of vegetation heights in the sample shows that under-grazing or management neglect may be a particular issue on calcareous and acidic grasslands, as many more of these grasslands fail as a result of the vegetation being too long rather than too short.

Grasslands within agri-environment agreements were almost twice as likely to be in favourable condition as those outside agreements – this relationship was statistically significant. A significant positive relationship between presence of agreement and increased pass rate was also apparent for several individual attributes, in particular herb cover and positive indicator species. Furthermore, in the Upland Hay Meadow category, stands within agri-environment agreements were less likely to be show similarity to NVC types indicative of neglect or agricultural improvement compared to those meadows outside of agreements.

It is important to stress that any cause and effect relationship between condition and the presence of an agri-environment agreement cannot be reliably determined from this baseline survey and will only be decipherable on future re-survey of the stands, when differences in changes over time can be assessed for sites within and without agri-environment agreements. Although all sites were selected from the English Nature grassland inventories, which led to the assumption that they supported high quality grassland post 1980, we have no means of reliably determining their condition at time of entry into agri-environment agreement, and damage to the grasslands may have occurred before agri-environment agreements were introduced.

Correlation analyses performed on raw attribute data revealed some interesting relationships. Whilst some of the statistically significant correlations detected were intuitive, for example a positive correlation between sward height and litter cover, scrub cover and litter cover, others were less so. For example, stands with more scrub tended to support both more positive and more negative indicator species. This may be because the analysis is picking up a signal of agricultural improvement versus non-improvement; stands which are neglected are less likely to have been agriculturally improved and therefore have retained higher species diversity overall.

In conclusion, the results of this survey provide worrying evidence on the poor state of the lowland grassland resource outside the statutory sites series in England, with meadows faring particularly badly. Section 5 of this report provides a discussion of these findings in a wider context.

Evidently a variety of existing mechanisms will need to be pursued in tandem with the rolling out of Defra's recently launched Environmental Stewardship Scheme if improvements in the non-statutory priority grassland resource are to be maximised.

These are likely to include: site acquisition and management by nature conservation bodies; statutory notification where appropriate; influencing higher level policy, particularly in the livestock sector; promoting Grazing Animal Project initiatives and ensuring effective implementation of the new EIA regulations covering uncultivated land or semi-natural areas for intensive agricultural purposes. Furthermore improvements to the grassland inventory are required to enable effective targeting of grasslands for such schemes. A full list of recommended future work aimed at improving the condition of lowland grasslands is provided in Section 5.8.

A separate 'methodology and data analysis' report (Hewins and others 2004) outlines site selection, field methodology and data analysis. Issues concerning the quality of the grassland inventory data, site rejections rates and implications of the stand selection protocol on the results of the survey are summarised in Appendix 1.

Contents

1 Introduction

This project concerns the five lowland grassland types identified as priorities for conservation under the UK Biodiversity Action Plan (BAP) for which there are costed Habitat Action Plans (HAPs), namely: Purple Moor Grass and Rush Pastures (PMGRP); Lowland Dry Acid Grassland (LDAG); Lowland Calcareous Grassland (LCG); Lowland Meadows (LM) and Upland Hay Meadows (UHM) (UK Biodiversity Group 1995; UK Steering Group 1998).

Each plan sets targets for the conservation and restoration of semi-natural grasslands in the UK and has three broad targets: first, to arrest further loss of grassland; second, to improve the condition of existing grassland; and third, to re-create grassland of wildlife value. The second target of improving condition is divided between Sites of Special Scientific Interest (SSSIs) and non-statutory grassland sites.

The statutory conservation agencies, Department for Environment, Food and Rural Affairs (Defra) and other partners implementing these HAPs need to gather information that will allow an assessment to be made of progress towards meeting the targets. A key issue is to assess if grassland is still being lost, particularly on stands of priority grassland which lie outside designated sites. In the 1980s and 1990s individual surveys undertaken by Wildlife Trusts on county wildlife site grassland indicated that losses of grassland were still occurring at alarmingly high rates largely due to agricultural improvement (Plantife, 2002). In Derbyshire 91% of unimproved grasslands surviving in 1983 had disappeared by 1999 (Huston, 2001). As a second priority, information on the condition of the remaining species-rich grassland resource is required. Many semi-natural grasslands have become marginal to modern farming systems and have therefore suffered from problems such as lack of grazing and scrub invasion, resulting in deterioration in their condition.

In order to address some of these issues English Nature, Defra and the Joint Nature Conservation Committee (JNCC) commissioned this project to determine the condition and extent of a sample of 500 non-statutory BAP priority grasslands and thereby establish a baseline against which progress towards meeting the HAP targets could be measured.

The method used was a modified version of English Nature's rapid field condition assessment for lowland grassland features of interest[1] on SSSIs (Robertson & Jefferson 2000).

[1] For the purposes of grassland monitoring, a feature of interest is generally defined as a stand of a particular National Vegetation Community (NVC).

2 Methodology

2.1 Site selection

The sample was intended to consist of 500 randomly selected grassland sites in England. Each of the five priority grassland types to be represented by approximately 50 sites under agri-environment agreements and 50 outside of agri-environment[2]. The sample was selected from English Nature's Grassland Inventory using a sampling framework developed by Poulton (2000)[3]. A dossier of information together with a site map for each sample site had been prepared under a previous contract (McLaren 2002). The sample was selected from the total 'grassland inventory' shown in Table 1. As is evident from Table 1 approximately half (53%) of all grassland inventory sites are within agreements (1999 data) though the proportion in agreement varies according to priority grassland type.

Table 1. Total number of sites included within English Nature's Grassland Inventory[4]

BAP priority grassland type	Grassland inventory sites		Total
	AE agreement	Non-AE agreement	
Lowland Calcareous Grassland	858	1244	2102
Lowland Dry Acid Grassland	182	522	704
Lowland Meadows	1302	2471	3773
Upland Hay Meadows	295	134	429
Purple Moor Grass Rush Pastures	318	1026	1344
All grasslands	2119	3951	6070

It was not possible to survey many of the originally selected sample sites for a number of reasons. As a result 'additional sites' were randomly selected using the Poulton sampling framework to make up the shortfall. In total 1054 sites were selected using this approach. Rates and reasons for site rejection are discussed further in Appendix 1. The set of decision rules used by surveyors to determine whether grassland should be included or excluded from the sample were the main reason for the high site rejection rate. These decision rules are discussed in section 2.2 below.

[2] Agreements according to available 1999 data, modified where possible with 2000 data or information from the landowner

[3] Poulton (2000) produced an Access 2000 database holding the grassland inventory information, stratified by each of the five priority grassland types and by agri-environment agreement status. In addition a mechanism to draw the required random samples was developed.

[4] NB: Grassland Inventory categories do not exactly match BAP habitat definitions. Upland Hay Meadow sites were a subset of the mesotrophic grassland category, which also included Lowland Meadows. Some sites contained more than one habitat type.

2.2 Stand selection

It is important to note that habitats other than priority grassland frequently lie within the mapped boundaries of sites included on the grassland inventory, ie the site outline does not delimit the precise area of priority grassland present. Other communities present may include semi-improved/improved grassland or non-grassland habitats such as scrub, woodland or lowland heathland.

This issue of mapping resolution meant it was necessary for surveyors to determine the extent of communities corresponding with the selected priority grassland type once on site. In addition, because the sample of grassland sites sampled for this project needed to be representative of what is happening to the "population" of these grasslands in the country as a whole, it was essential that we avoided introducing bias and ensured that the sample reflected the range of current grassland condition states: favourable to unfavourable.

For these reasons a protocol was developed for surveyors to use when on site to guide their decision on identifying and selecting the area of priority grassland to be included in the sample (Hewins and others 2004). The selected area is referred to throughout this report as the 'stand'.

The key tenets of the grassland stand selection protocol are as follows. It aimed to avoid introducing bias by:

a. not sampling areas if there was no evidence to suggest they had supported unimproved grassland in the past;
b. not sampling areas which, on ecological assessment, could not feasibly support the selected grassland type, eg where purple moor grass rush pasture is indicated as occurring on a steep chalk slope;
c. not restricting sampling to areas "in good condition" in a stand which previous evidence suggested conformed to the selected priority grassland type in the past but is now largely unfavourable, because of under-grazing. Hence improved sites, which were no longer the priority grassland type, were still included if it was believed that they had been improved since the time the inventory was compiled, ie post 1980.

Only stands which had between 0.25ha and 16ha[5] of the selected priority grassland type were surveyed. When there was more than one stand of priority grassland type present >0.25ha, a maximum of two stands were assessed: the largest plus one other randomly selected. Only the priority grassland type for which the site had been selected was sampled (eg if the site had been selected as a Lowland Calcareous Grassland site, neutral grassland areas present on site were not sampled). Where stands were larger than 16ha they were divided into smaller blocks and a randomly selected sub-sample was identified.

[5] Areas of between 15-16 ha are thought to be the maximum extent across which observers can successfully integrate information visually when using English Nature's rapid condition assessment methodology for lowland grassland SSSIs (Robertson & Jefferson, 2000).

2.3 The sample

In total 483 grassland stands were included in the sample (Table 2). These stands occurred across 470 sites, representing 7.7% of the total 6070 sites within the grassland inventory.

Table 2. Grassland stands included within the sample

BAP priority grassland type	Grassland stands		Total
	AE Agreement	Non-AE agreement	
Lowland Calcareous Grassland	52	44	96
Lowland Dry Acid Grassland	40	41	81
Lowland Meadows	56	52	108
Purple Moor Grass and Rush Pastures	45	48	93
Upland Hay Meadows	57	48	105
All grasslands	250	233	483

Figure 1 shows the national distribution of all stands in the sample. The distribution of stands sampled within each of the five priority grassland types is shown in Appendix 2, Figures 1-5. Upland Hay Meadows stands are concentrated in the northern counties of North Yorkshire, Durham, Northumberland and Cumbria, reflecting the geographical restriction of this grassland type. Calcareous grasslands are clustered on the chalk and limestone of Wiltshire, Sussex and Gloucestershire, and Purple Moor Grass Rush Pastures in the damp lowlands of the southwest, eg the Culm grasslands, Devon. In contrast the sample of Lowland Dry Acid Grasslands and Lowland Meadows sites is more evenly distributed throughout England.

Table 3 gives statistics on stand area for each grassland type. Lowland Calcareous Grassland stands tended to be the largest and Upland Hay Meadow stands the smallest. There was a large variation in grassland stand size overall, with stands ranging from 0.2ha to 10ha. Stand size was usually a reflection of site size within the grassland inventory.

Table 3. Stand area statistics

	n	Total area (ha)	Average area (ha)	Range (ha)
Lowland Calcareous Grassland	96	357	3.7	0.3 - 10.0
Lowland Dry Acid Grassland	81	238	2.9	0.2 - 10.0
Lowland Meadow	108	295	2.8	0.3 - 10.0
Purple Moor Grass Rush Pastures	93	218	2.4	0.2 - 10.0
Upland Hay Meadows	105	203	1.9	0.4 - 8.4
All grasslands	483	1312	2.7	0.2 - 10.0

Figure 1. Distribution of sample stands by county

Figure 2 shows the range and number of NVC types against which stands were assessed within each priority grassland type. Although a range of NVC communities were assessed within each grassland type certain NVC types were rare within the sample (eg CG6, CG7, U1a, U1c, M22 and MG4). To some extent this is a reflection of the rarity of certain communities and also the degree to which the resource is under statutory nature conservation designations.

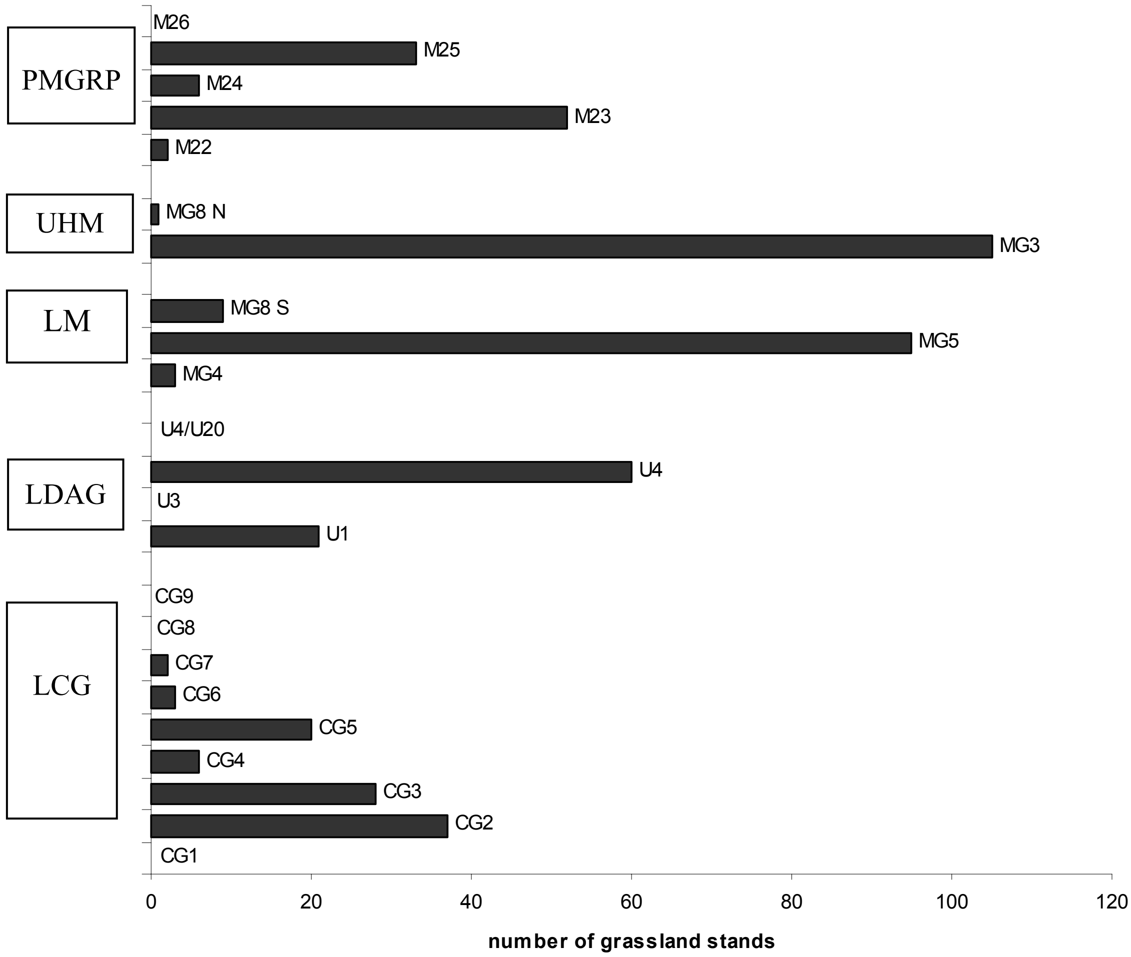

Figure 2. Representation of different NVC types within the sample

2.4 Site survey

Surveys were carried out between 27 May and 9 October in 2002 and between 1 May and 12 September in 2003. At each site the extent of the selected priority grassland habitat was mapped, using the stand selection protocol outlined in section 2.2.

Field survey of the selected stands was conducted in two stages – a 'whole stand assessment' and a 'structured walk'. Information gathered during the two stages was entered onto separate forms and a field map. The 'whole stand form' was used to record boundary information, evidence of management, other notable features (e.g ridge and furrow, anthills etc.) and vegetation attributes best assessed at the stand level (eg % cover herbs, litter, scrub, vegetation height etc.). Description of the stand, NVC type and DAFOR[6] frequencies of all vascular plants encountered in the stand were also recorded using this form. The structured walk form was used to record positive and negative indicator species present and vegetation height within a 1m radius of each of the 20 stops of the structured walk. A full description of the survey method used, including details of the structured walk methodology and mapping of stands can be found in a separate methodology and data analysis report Hewins and others (2004).

2.5 Data analysis

Collected attribute data were assessed using:

a. Draft condition assessment attribute thresholds for non-statutory grasslands (Robertson and others 2002), which apply lower thresholds for certain attributes; and
b. The SSSI grassland condition assessment attribute thresholds (Robertson & Jefferson 2000).

In the context of grassland monitoring an 'attribute' is defined as 'a characteristic of the grassland that most economically provides an indication of the condition of the interest feature to which it applies' (Robertson & Jefferson, 2000). Attributes included variables such as species composition, structure, herb cover, sward height, frequency or cover of species or species groups. A 'target' is a range of values for the attribute which need to be met for a stand to 'pass' a particular attribute assessment. Targets may be different for different habitat types or groups of NVC communities.

Mandatory attributes are so called because every one of the attribute targets needs to be met for a stand to be in 'favourable condition'. In contrast discretionary attributes do not need to be met for a site to be categorised as in favourable condition. Instead they are used to indicate potential problems which need to be addressed by changes in management. Discretionary attributes tend to be structural attributes, such as sward height or extent of bare ground etc.

Statistically significant differences in condition assessment pass rates between the five priority grassland types were tested using Pearson Chi-squared two-way contingency analysis with Yate's Correction applied where there were low degrees of freedom. T-tests were used

[6] Dominant, Abundant, Frequent, Occasional or Rare (Robertson & Jefferson , 2000). This project also included a locally abundant (LA) category.

to test for statistically significant differences in raw attribute data between agreement and non-agreement groups. A Pearson correlation analysis was used to test for significant correlations between attributes.

Grassland stand DAFOR lists were assigned to the closest matching NVC types using Tablefit (Hill 1996). Because the data were whole site species lists with DAFOR values, the DAFOR values were converted to values (1 – 5) and treated as pseudo-frequency scores using the 'species composition only' option (a > 50% goodness of fit was required). Some analyses were repeated excluding the stands which Tablefit matched to NVC types not encompassed by the priority grassland definitions, these are indicated in the text.

Results against non-statutory grassland condition assessment targets are reported throughout. For results against the SSSI thresholds please refer to Appendix 3.

3 The character of the sample

3.1 Tablefit analysis results

When stand species data was analysed using Tablefit (Hill, 1996) 24% of stands surveyed were found to show closest botanical similarity to NVC types indicative of agricultural improvement or neglect rather than to priority grassland. Summary results of this analysis are presented in Table 4.

Purple Moor Grass and Rush Pasture stands displayed closest similarity to NVC types equivalent to the priority grassland type, followed by Lowland Calcareous Grassland and Lowland Dry Acid Grasslands. Upland Hay Meadows and Lowland Meadows stands corresponded most poorly to target NVC communities. Just over half of stands in these two grassland types (58% and 61% respectively) matching to NVC types corresponding to the respective priority grassland categories. The remainder were more similar to NVC types which do not correspond to the priority grassland definitions and are instead communities indicative of agricultural improvement or neglect.

It is clear from Table 4 that stands which did not show best fit to priority grassland types tended to show closest match to NVC types associated with agricultural improvement (eg MG6, MG7, and MG9), neglect (eg MG1), or a combination of improvement, abandonment and water-logging (eg MG10, MG11 and MG9). There are differences between, and sometimes within, the five priority grassland types in terms of the management factors influencing botanical composition. For example, management neglect/abandonment appears to be a particularly important factor on Lowland Calcareous Grasslands as characterised by the high frequency of MG1 – *Arrhenatherum elatius*, False oat grass, grassland, a community indicative of neglect, amongst sites within this category.

Whilst there is no significant effect of agri-environment agreement status on correspondence to priority in the sample overall, a significant difference was detected in the Upland Hay Meadows category. Within this grassland type stands showing closest similarity to MG7 (indicating agricultural improvement) occurred more frequently in the non-agreement stands.

These analyses indicate a net loss of priority grassland to non-priority grassland types. Whilst no longer contributing to the priority grassland resource these sites do provide a sub-sample which may be used in the future to monitor achievement of grassland restoration targets. It should be noted that some of the key analyses in Section 4 have been performed excluding stands which no longer fit to the priority grassland definition.

Table 4. Nunmber of grassland stands within each of the priority grassland types which show best Tablefit fit to NVC communities indicative of neglect or agricultural improvement . Results are shown for all stands, those in agri-environment agreements (AE) and those not in agreement (non AE).
NVC communities corresponding to a LCG = CG2, CG3, CG4, CG5, CG6,CG7; b LDAG = U1, U3, U4; c UHM = MG3, MG8 north; d LM = MG4, MG5, MG8; e PMGRP = M22, M23, M24, M25.

	LCG [a]			**LDAG** [b]			**LM** [c]			**PMGRP** [d]			**UHM** [e]			**All Grasslands**		
	All	*AE*	*Non AE*	**All**	*AE*	*Non AE*	**All**	*AE*	*Non AE*	**All**	*AE*	*Non AE*	**All**	*AE*	*Non AE*	**All**	*AE*	*Non AE*
Sample size (n)	***96***	*52*	*44*	***81***	*40*	*41*	***108***	*56*	*52*	***93***	*45*	*48*	***105***	*57*	*48*	***483***	*250*	*233*
Communities indicative of neglect or agricultural improvement:																		
MG1 - *Arrhenatherum elatius*	**9**	*3*	*6*	**2**	*1*	*1*	**9**	*7*	*2*	**0**	*0*	*0*	**0**	*0*	*0*	**20**	*11*	*9*
MG6 - Lolium perenne-Cynosurus cristatus	**0**	*0*	*0*	**2**	*1*	*1*	**12**	*7*	*5*	**0**	*0*	*0*	**22**	*12*	*10*	**36**	*20*	*16*
MG7 - *Lolium perenne* leys	**1**	*0*	*1*	**0**	*0*	*0*	**2**	*0*	*2*	**2**	*0*	*2*	**15**	*2*	*13*	**20**	*2*	*18*
MG9 - *Holcus lanatus – Deschampsia cespitosa*	**0**	*0*	*0*	**3**	*1*	*2*	**15**	*8*	*7*	**5**	*2*	*3*	**7**	*1*	*6*	**30**	*12*	*18*
MG10 - Holcus lanatus – Juncus effusus	**0**	*0*	*0*	**0**	*0*	*0*	**1**	*1*	*0*	**2**	*1*	*1*	**0**	*0*	*0*	**3**	*2*	*1*
MG11 - Festuca rubra – Agrostis stolonifera – Potentilla anserina	**0**	*0*	*0*	**0**	*0*	*0*	**2**	*0*	*2*	**0**	*0*	*0*	**0**	*0*	*0*	**2**	*0*	*2*
SUB-TOTAL	**10**	*3*	*7*	**7**	*3*	*4*	**41**	*23*	*18*	**9**	*3*	*6*	**44**	*15*	*29*	**111**	*47*	*64*
Other community types (non-BAP type)																		
U4b - Festuca ovina – Agrostis capillaris – Galium saxatile	**1**	*1*	*0*	**0**	*0*	*0*	**0**	*0*	*0*	**0**	*0*	*0*	**0**	*0*	*0*	**1**	*1*	*0*
Scrub communities (W23, W24)	**0**	*0*	*0*	**3**	*2*	*1*	**1**	*1*	*0*	**0**	*0*	*0*	**0**	*0*	*0*	**4**	*3*	*1*
TOTAL	**11**	*4*	*7*	**10**	*5*	*5*	**42**	*24*	*18*	**9**	*3*	*6*	**44**	*15*	*29*	**116**	*51*	*65*
% BAP TYPE MATCH	***89***	*92*	*84*	***88***	*88*	*88*	***61***	*57*	*65*	***90***	*93*	*88*	***58***	*74*	*40*	***76***	*80*	*71*
% of sites with goodness of fit >50% to correct BAP type		73			32			82			59			33			57	

4 Results

4.1 Summary of grassland condition

Overall only 21% of grassland stands surveyed were in favourable condition when assessed against the non-statutory condition assessment thresholds. Figure 3 shows the pass rates for stands both across and within the five priority grassland types[7]. Upland Hay Meadows and Lowland Meadows were in the poorest condition of the priority grassland types, with only 7% and 18% of grassland in these respective categories in favourable condition. A relatively high proportion of Purple Moor Grass Rush Pasture stands (35%) passed condition targets. Lowland Dry Acid and Lowland Calcareous Grasslands had intermediate pass rates, 23% and 28% of sites passing all mandatory thresholds respectively. When the sub-set of sites identified by the Tablefit analysis as no longer conforming to priority grassland were excluded from the sample the overall pass rate increased to 27%. Relative differences in pass rates between priority grassland types remained the same. Results for each priority grassland type are presented in Figure 4.

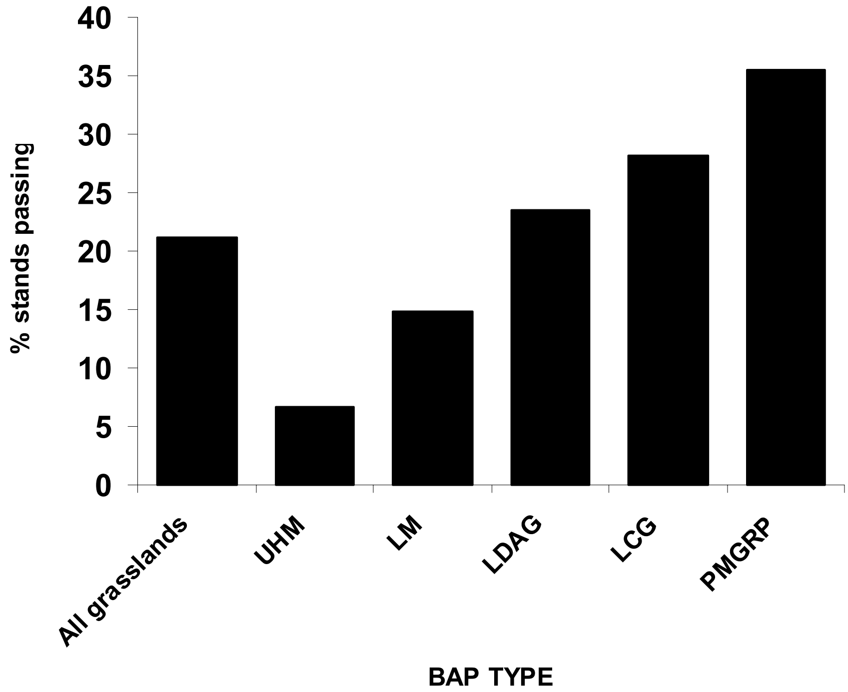

Figure 3. Percentage of stands in favourable condition for each priority grassland type

[7] Sample sizes should be borne in mind when interpreting % pass rate and the results of statistical analyses. Please note that for any particular grassland type, the number of stands against which an individual attribute is assessed is dependent on whether the attribute is used in the condition assessment protocol for all, or only a proportion of, NVC communities in that priority grassland type. Full data tables, showing any significant differences in pass rates or raw attribute data may be found in Appendix 5.

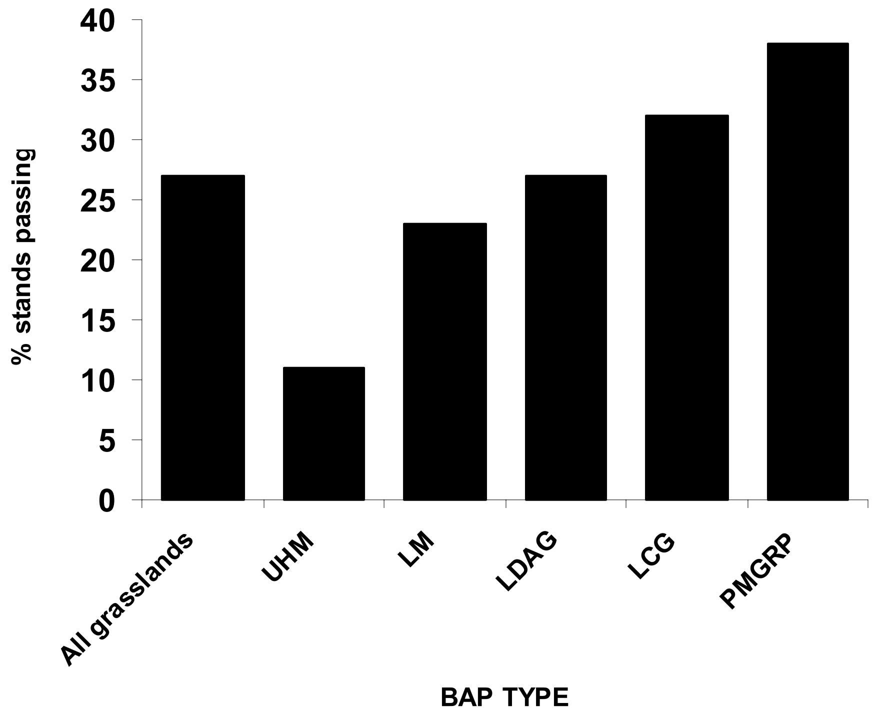

Figure 4. Percentage of stands in favourable condition for each priority grassland type on exclusion of sub-set of stands not conforming to priority grassland.

4.2 Pass rates for individual condition attributes

Overall grasslands failed most frequently against two mandatory condition attributes: namely positive indicator species and percentage cover of herbs relative to grasses (Figure 5). Only 39% of stands passed thresholds for the positive indicator species number and frequency attribute. The overall pass rate against the percentage herb cover attribute was 64%. A high percentage of stands did not meet the thresholds set for the discretionary attribute sward height. However, failure against this target alone would not cause a stand to be in unfavourable condition.

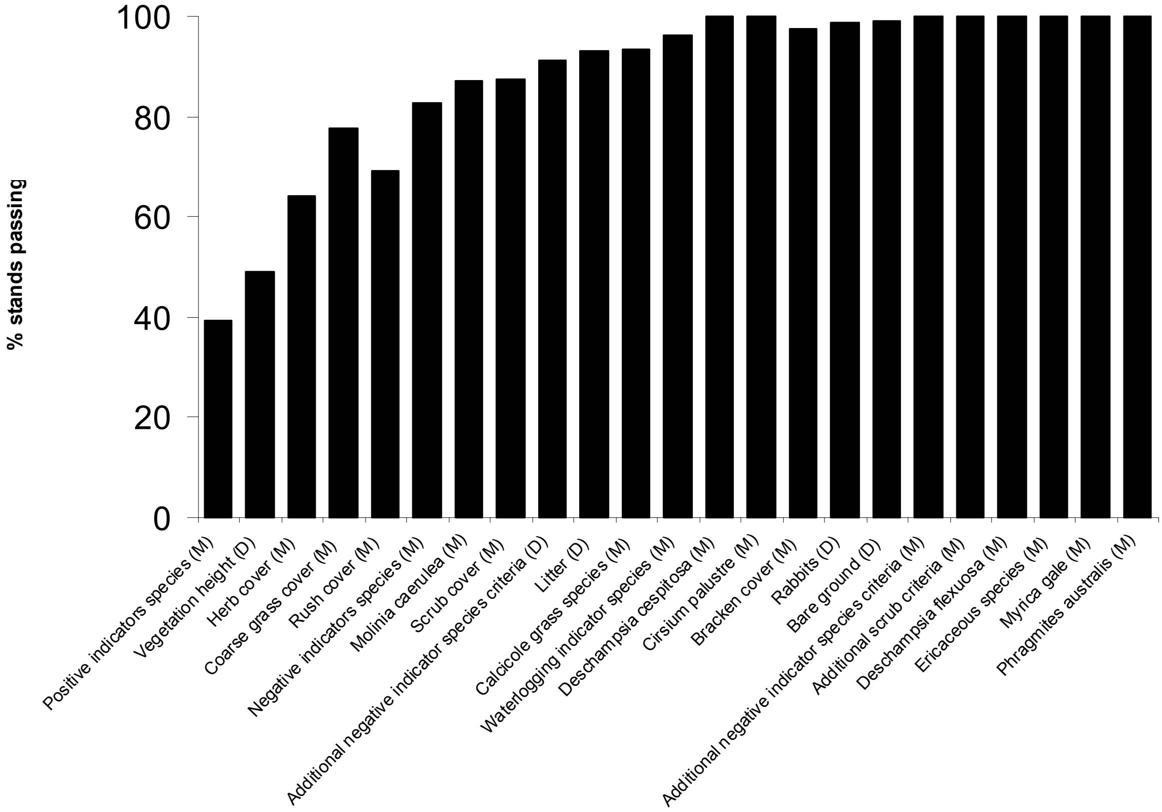

Figure 5. Attribute pass rates for all grasslands

Pass rates against attribute thresholds in each of the five BAP types are presented in Appendix 3 Tables 5 - 10. In each of the different priority grassland types, stands failed most frequently because they lacked positive indicator species in sufficient number and frequency and because the proportion of non-grass plant species in the swards was too low. Other frequent reasons for failure included too high a cover of rushes in Purple Moor Grass Rush Pastures, too high a frequency of negative indicator species in Lowland Calcareous Grasslands, too high a cover of coarse grasses (eg *Holcus lanatus,* Yorkshire fog and *Dactylis glomerata*, Cocks foot,) in Lowland Dry Acid Grasslands, and too low a cover of herbs in Lowland and Upland Hay Meadows. Pass rates against the non-statutory thresholds were consistently higher than the SSSI thresholds.

4.3 Number and frequency of positive indicator species

Figure 6 displays the frequency distribution of positive indicator species recorded during the structured walk across all stands sampled. Nearly all grasslands stands contained some positive indicator species, and hence may be considered to be restorable to some degree under appropriate management. In only 11 out of the 483 stands sampled were no positive indicator species recorded during the structured walk. Five of these stands showed best fit in the Tablefit analysis to neglected or improved grassland types. Of the remaining five, all had indicator species recorded within the stand assessment, though these were not recorded during the structured walk.

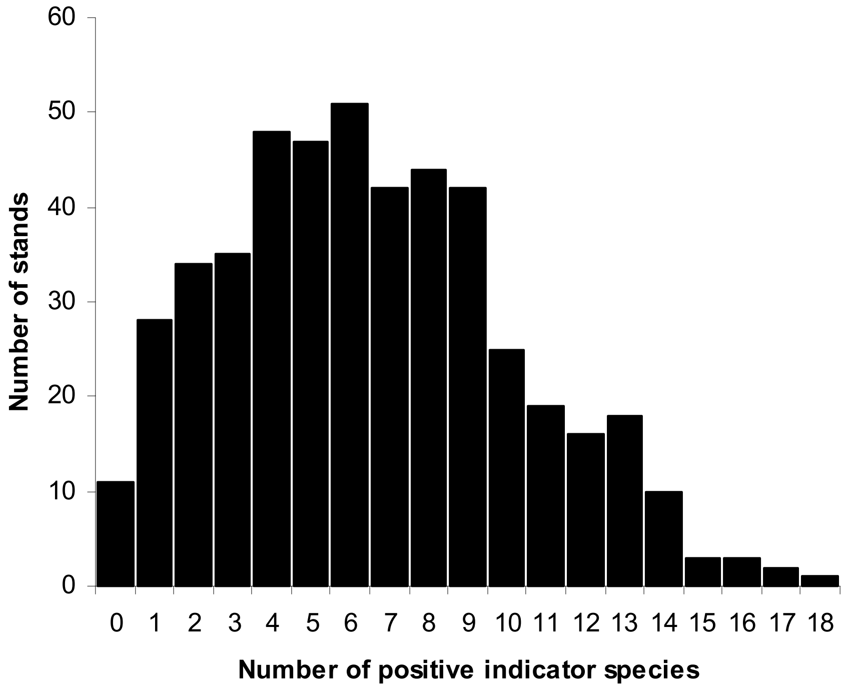

Figure 6. Frequency distribution of positive indicator species number recorded during the structured walk (all stands).

4.4 Effect of agri-environment agreement status on grassland condition

Differences in overall pass rates for stands within and outside of agri-environment agreements are presented in Figure 7. There is a highly significant positive relationship between increased pass rates against mandatory attributes and presence of an agri-environment agreement. Condition assessment pass rates increased from 14% on stands outside agreement to 27% on stands with agreement.

When priority grassland types were examined significantly more Purple Moor and Grass Rush Pasture and Lowland Meadow sites within agri-environment agreement passed the mandatory attribute thresholds when compared to those sites outside agreement, Figure 8. Full results are presented in Appendix 3; Tables 11 -16).

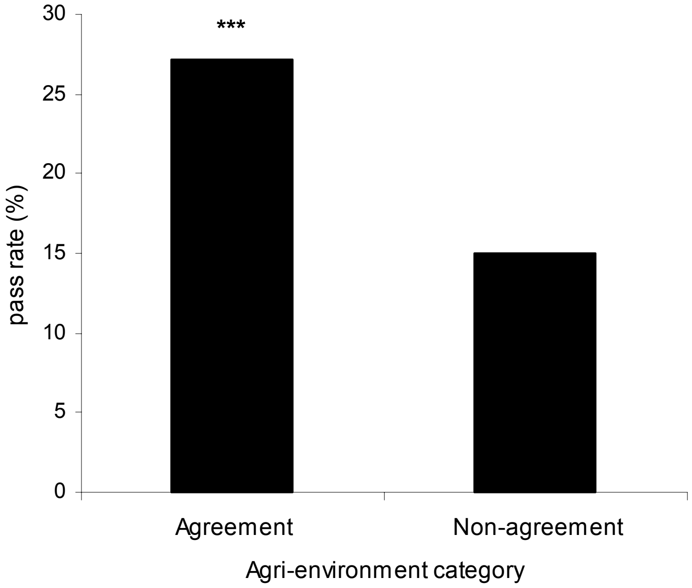

Figure 7. Percentage of stands in favourable condition within and outside of agri-environment agreement. All grasslands. Sig.diff. between agreement categories *** = $p < 0.001$

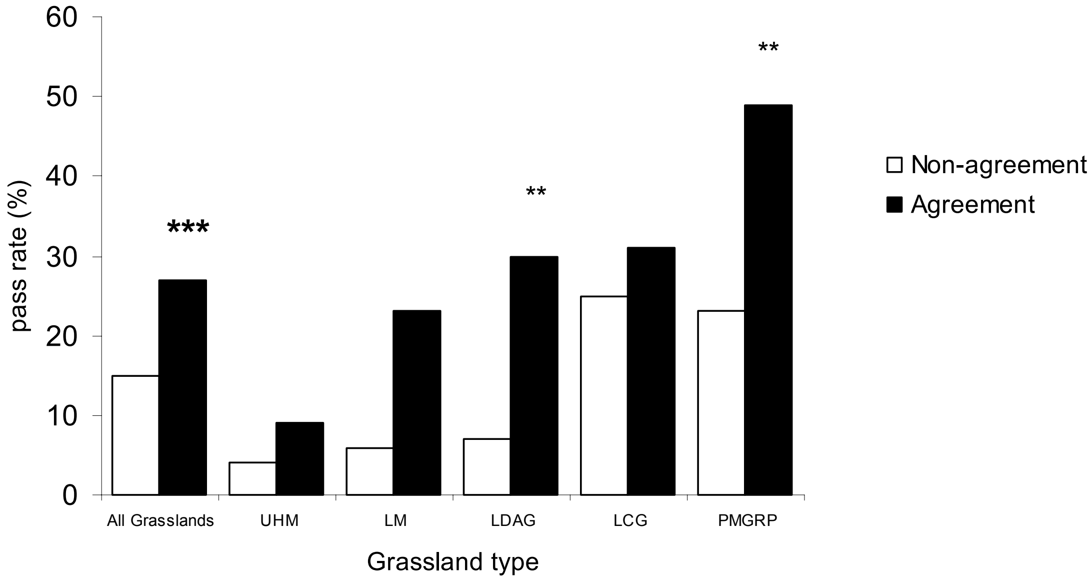

Figure 8. Percentage of stands in favourable condition within and outside of agri-environment agreement within each priority grassland type Sig.diff. between agreement categories *** = $p < 0.001$ ** = $p < 0.01$

Difference in pass rates against individual attributes between sites within and outside agri-environment agreement are presented in Figure 9. Stands with the agreement category showed a significantly higher pass rate for the following attributes: % herb cover, number and frequency of positive indicator species, % rush cover and % cover of Purple moor-grass, *Molinia caerulea*.

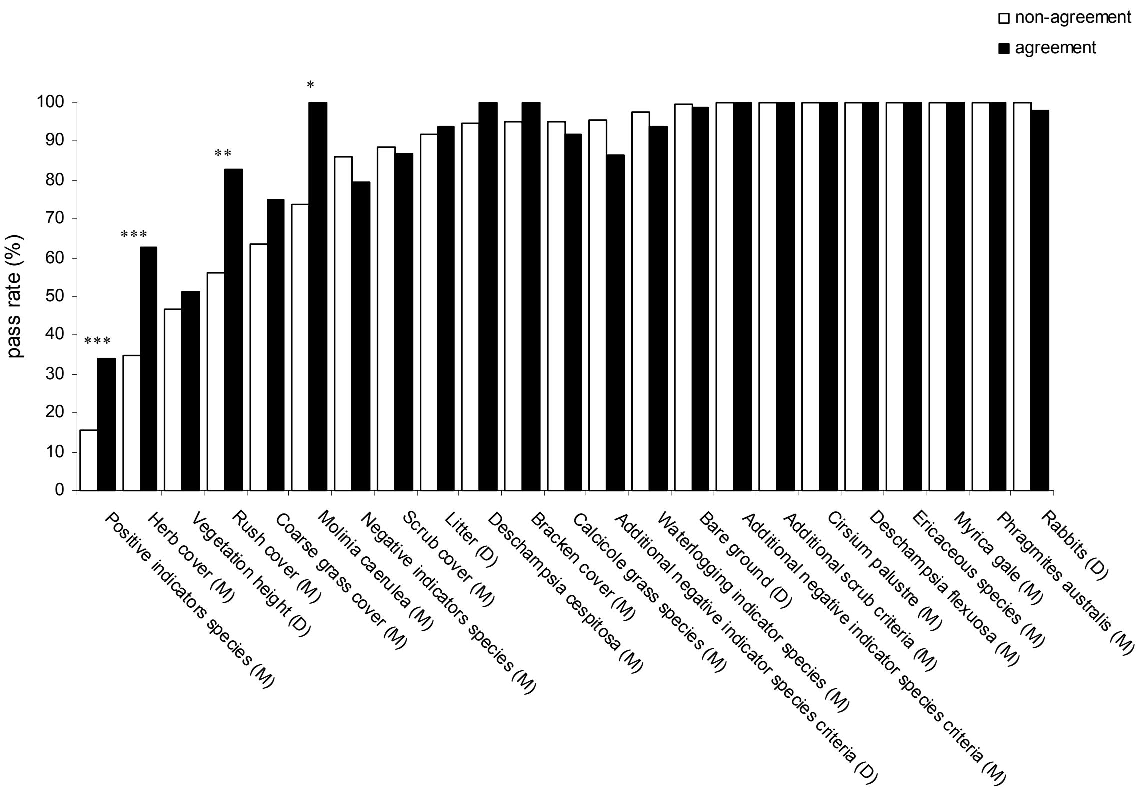

Figure 9. Differences in attribute pass rates for stands within and outside agri-environment agreements. Attributes assessed at <5 stands have been excluded. M = Mandatory attribute, D = Discretionary attribute. Sig.diff.: * = p < 0.05, ** = p < 0.01, *** = p < 0.00.

Differences in mean attribute values between stands within and outside agri-environment agreements were investigated using t-tests. The results, presented in Table 5 support the findings of the previous analysis. Stands within agri-environment agreements had a significantly higher number and frequency of positive indicator species and increased herb cover when compared to those outside agreements. However sample sites in agreement were also to found to have a significantly higher frequency of negative indicator species.

Table 5. Differences in mean attribute values between stands within and outside of agri-environment agreements (1999). n.s = not significant * = p < 0.05, ** = p < 0.01, *** = p < 0.001.

Attribute	Non- agreement (n)	Agreement (n)	P
% cover of water-logging indicator species	14.8 (177)	12.8 (188)	n.s.
% Scrub cover	3.1 (233)	2.9 (250)	n.s.
Vegetation height (drop disc) cm	14.3 (230)	13.6 (249)	n.s.
Juncus height (cm)	35.1 (81)	39.0 (74)	n.s.
Vegetation height (sward stick) cm	21.3 (230)	22.5 (250)	n.s.
% cover of negative indicator species	1.3 (227)	1.6 (242)	n.s.
% herb cover	37.5 (233)	44.8 (248)	**
% litter cover	6.9 (233)	4.9 (250)	n.s.
Positive indicator species			
No. occurring occasionally	3.0 (233)	4.2 (249)	***
No. occurring frequently	1.9 (233)	2.6 (249)	***
Negative indicator species			
No. occurring occasionally	0.4 (233)	0.5 (250)	n.s.
No. occurring frequently	0.1 (232)	0.2 (250)	*
% *Juncus* cover	30.0 (81)	20.4 (104)	*
Frequency of scrub and trees within stand (% of stands in each frequency category)	None = 68.4 Rare = 18.8 Occasional = 7.7 Frequent = 1.3 Abundant = 3.8	None = 67.2 Rare = 20.4 Occasional = 6.4 Frequent = 4.0 Abundant = 2.0	
Frequency of bracken (% of stands in each frequency category)	None = 94.4 Rare = 3.4 Occasional = 0.4 Frequent = 0.9 Abundant = 0.9	None = 93.6 Rare = 4.8 Occasional = 1.2 Frequent = 0.4 Abundant = 0	

The relationship between agri-environment agreement status and pass rates for individual attributes was also investigated for each priority grassland type (for full results of these analyses refer to Appendix 3; Tables 11 -16). These show that the positive relationship between presence of agri-environment agreements and increased cover of herbs was statistically significant in Lowland Calcareous Grasslands ($p<0.01$), Lowland Meadows ($p<0.001$) and Upland Hay Meadows ($p<0.05$), whilst a significant positive relationship between presence of agri-environment agreements and increased number and frequency of positive indicator species was detected in Lowland Calcareous Grasslands ($p<0.001$). A similar, albeit insignificant relationship was seen in Lowland Dry Acid Grasslands, Purple Moor Grass Rush Pastures, and Upland Hay Meadows.

The differences in mean attribute values between stands within and outside agri-environment agreement agreements in each individual grassland type were also investigated using t-tests. These results (Appendix 3, Tables 18-22) were similar to the relationships highlighted by the analysis of attribute pass rates across all grasslands. A statistically significant positive relationship between presence of agri-environment agreements and increased frequency of negative indicator species was found in Lowland Dry Acid Grasslands.

4.5 Trends in vegetation height

Results of assessment against the sward height attribute are presented in Table 6 for each priority grassland type. Pass rates against this attribute are highest in Upland Hay Meadows, with the 8% of hay meadow sites that fail doing so because they were too short. Pass rates are lowest in Lowland Dry Acid Grasslands, with all 77% failing because the sward was too long. However, in acid grasslands significantly more swards passed height thresholds within agri-environment agreements than outside of such agreements ($p<0.01$). The 51% of Lowland Calcareous Grasslands which failed sward height thresholds failed due to swards that were too tall. Failure rates for sward height were high in Purple Moor Grass Rush Pastures, 76% fail and in all cases failure arose as a result of high rush cover. Differences in drop disc and sward height vegetation height measurements may be found in Appendix 4.

Table 6. Reasons for stand failure of the sward height attribute within each grassland type. Sward heights measured with a sward stick. Sig. diff. ** = p <0.01.

	All grasslands	LCG	LDAG	LM	PMGRP	UHM
			All stands			
% failing	51	51	77	56	76	8
- too long	68	100	100	98	0	0
- too short	4	0	0	2	0	100
- too high rush cover	28	0	0	0	100	0
			Agreement (1999)			
% failing	49	44	65**	58	82	5
- too long	67	100	100	100	0	0
- too short	2	0	0	0	0	100
- too high rush cover	30	0	0	0	100	0
			Non agreement (1999)			
% failing	53	50	90**	54	70	10
- too long	69	100	100	97	0	0
- too short	5	0	0	3	0	100
- too high rush cover	27	0	0	0	100	0

4.6 Correlations between attributes

Pearson correlation analyses were performed between the key attributes and significant results are displayed in Table 7. A significant positive correlation was found between the height of the vegetation and litter cover – taller vegetation tending to have more litter associated with it. In addition vegetation height, as measured by a sward stick, was correlated with *Juncus* height, *Juncus* cover, and water-logging indicator species (which includes *Juncus* spp.).

When the vegetation height was measured with a drop disc, there was a significant negative correlation between vegetation height and negative indicator species (both cover and frequency in the structured walk) – the shorter the sward the more negative indicator species (weeds). Shorter swards also had significantly lower herb content (when measured with a drop disc). Herb cover was also correlated with *Juncus* height and cover, and positive indicator species frequency. There is likely to be auto-correlation between these attributes as *Juncus* species were treated as ‘herbs’ as opposed to graminoids in the condition assessment methodology.

There tended to be lower cover of negative indicator species (weeds), and more positive indicator species in stands with more *Juncus* and water-logging indicator species (wetter soils). Sites with more scrub tended to have more litter, more positive indicator species and, interestingly, more negative indicator species.

Table 7. Correlation between key attributes. Note sample sizes - not all attributes measured for all stands. Significance of correlation, n.s = not significant, *=p<0.05, **=p<0.01, ***=p<0.001

	Sward height cm		***Juncus* height**	**% cover of herbs**	**% cover of water-logging indicators**	**% cover of Scrub**	**Negative indicator species**		**Positive indicator species**	
	Sward stick	**Drop disk**					**% cover**	**No. occasional**	**No. occasional**	**No. frequent**
Vegetation height (drop disc)	0.743*** n=479	-								
Juncus height	0.785*** n=155	0.699*** n=155	-							
% cover of herbs	n.s	0.206*** n=476	0.435*** n=153	-						
% cover of water-logging indicators	0.166** n=363	0.501*** n=362	0.426*** n=139	0.403*** n=363	-					
% cover of litter	0.195*** n=480	0.183*** n=479	n.s	-0.166*** n=481	n.s	0.277*** n=483				
Negative indicator species										
% cover of	n.s	-0.115* n=464	-0.305*** n=149	n.s	-108* n=351	n.s	-			
No. occurring occasionally	n.s	-0.159*** n=478	-0.217** n=155	n.s	-0.113* n=364	0.142** n=483	0.396*** n=468	-		
No. occurring frequently	n.s	0.134** n=477	-0.178* n=154	n.s	-0.102* n=634	n.s	0.395*** n=467	0.655*** n=482		
Positive indicator species										
No. occurring occasionally	n.s	0.040 n=478	0.339*** n=155	0.385*** n=479	0.142** n=365	0.162*** n=482	n.s	0.091** n=481	-	
No. occurring frequently	n.s	-0.24 n=478	0.303*** n=155	0.344*** n=479	n.s	0.168*** n=482	n.s	0.089* n=481	0.915*** n=482	-
% *Juncus* cover	n.s	0.462** n=182	0.327*** n=119	0.550*** n=183	0.979*** n=185	n.s	-0.208** n=176	n.s	0.222** n=185	0.091 n=185

5 Discussion

5.1 Condition of lowland priority grasslands in England

5.1.1 Overall pass rates

Only 21% of the non-statutory grassland stands surveyed for this project were found to be in favourable condition, ie passed all mandatory non-statutory attribute thresholds. When the more demanding SSSI thresholds were applied the proportion in favourable condition fell to 14%. These figures compare to 53% of grassland in SSSIs being in favourable condition[8]. Since most non-statutory grasslands receive little of the protection and attention afforded to SSSI grasslands (English Nature 2004) this difference is not surprising. Indeed reported rates of grassland loss and intensification during the 1980s and early 1990s (Huston, 2001; Plantlife 2002) would suggest that there is every likelihood that the condition of the inventory sites may have deteriorated substantially in the period between 1980 and today.

Table 8. The percentage of non-statutory grasslands and SSSI grasslands in favourable condition.

	% favourable condition		
	Non-statutory stands		SSSI sites
	Non-statutory thresholds	SSSI thresholds	SSSI thresholds*
UHM	7	2	68
LM	16	8	53
LDAG	21	16	52
LCG	28	22	54
PMGRP	35	24	40
All grasslands	21	14	53

*Note the % of sites recorded as being in the condition category 'unfavourable recovering' is not included in the SSSI figures to ensure improved comparability between results. SSSI condition information is derived from English Nature SSSI condition report (English Nature, 2004) for all grassland types except UHM where information comes from 'State of nature: the upland challenge report' (English Nature, 2001).

Interestingly, the rank order of grassland types by their condition is the exact inverse of grassland condition on SSSIs as recorded by English Nature as Table 8 demonstrates. Within SSSIs Purple Moor Grass and Rush Pastures are in the poorest condition of the five lowland grassland priority types with 40% in favourable condition, whilst being in the best condition on non-statutory sites with a comparatively high 35% in favourable condition. In contrast, 68% of Upland Hay Meadows within SSSIs are in favourable condition compared to only 2% of stands outside the designated site series. It is possible that the disparity between grassland

[8] It should be noted that condition results collated from SSSI are not directly comparable with those collected on non-statutory sites as part of this survey. This is because SSSI condition categories are based (in part) on the judgment of conservation officers whilst the sample survey condition results are based on assessment using a rigorously applied methodology. This difference in methodology may mean that condition assessments made during this survey are more stringent than those applied to SSSIs leading to more 'unfavourable condition' assignations.

condition within and outside of SSSIs is partially related to variation amongst the five priority grassland types in the number and quality of grassland stands designated as SSSIs. For example, since a relatively large proportion of Upland Hay Meadow sites are designated, it is likely that there are relatively few high quality sites of good condition outside of the SSSI series.

Analysis of grassland stand species data would appear to lend further weight to the assertion that the condition of grassland inventory sites has deteriorated substantially in the past 20 years; almost a quarter of grassland stands surveyed display closest botanical similarity to improved or neglected non-priority grassland communities. Neglect and agricultural intensification are known to be major drivers of change in British vegetation in the period 1978-1990 (Firbank and others 2000). Nevertheless; it was felt that the inclusion of those stands that no longer conformed to the definition of priority grassland types in many of the analyses in this report was appropriate. This is because a key aim of this survey is to provide baseline condition data for a sample of sites known to have been priority grassland in the past against which future changes in condition can be assessed. Consequently it is envisaged that on re-survey in 10-15 years time we will be able to assess relative change in condition within this 'improved/neglected' component of the sample, in addition to the sample component shown to conform to a priority grassland type by the Tablefit analysis.

5.1.2 Direct loss

One percent (11 sites) of the sites investigated during the site selection process had been developed or turned into arable land. A further 116 sites which were actually visited had been improved but are still permanent grassland. These figures do not include the unknown (probably small) number of sites where dossier information or landowner liaison did not unequivocally identify site loss, and the site was not visited for this to be confirmed.

A study of grassland loss and damage in Worcestershire (Worcestershire Wildlife Trust 2000) found that 37% of sites were destroyed in the period 1974 to 2000. However, this figure includes sites destroyed by agricultural improvement or scrub and bracken encroachment. If losses attributable to these factors are removed and only sites that were no longer grassland are included (ploughed, wooded, quarries), the percentage site loss falls to approximately 3%. Though not directly comparable, these figures suggest that the findings of this study are perhaps not unrealistic.

5.1.3 Reasons for condition assessment failure

The two key attributes on which grasslands of all types failed most frequently were herb cover and positive indicator species. Overall 61% of stands lacked positive indicator species in sufficient number and at frequency levels characteristic of good semi-natural grassland. Similarly, 36% of stands failed because the proportion of non-grass plant species in the swards was too low (% herb cover attribute).

Intensive management activities (eg over-grazing, nutrient enrichment), improvement (eg drainage, re-seeding) and management neglect (eg under-grazing/lack of mowing) may all lead to poor grassland condition, particularly through increased dominance of grasses in the sward and through the creation of condition in which desirable forb species are unable to compete for light, nutrients and regeneration niches.

Such widespread failure against these two critical condition attributes raises real concerns about the ability of grasslands to recover from inappropriate management particularly when habitat loss and fragmentation has led to the impoverishment of lowland grassland species pools. The lack of potential seed sources in the surrounding landscape may mean that the potential for grassland recovery or re-establishment from natural colonisation is very low (Walker and others 2004; Poschlod and others 1998; Bullock and others 2002). This problem may be confounded because of the widespread loss of farming practices that formerly transported grassland species between sites (eg shepherding, folding, hay-strewing). Their disappearance may mean that many grassland species are now isolated within a sea of intensively farmed land (Walker and others 2004; Strykstra and others 1997; Poschlod & Bonn, 1998).

However, there may be grounds for optimism; the fact that only five stands (1% of the sample) possessed no positive indicators in the sward suggests that on the majority of sites there may be at least some scope for natural re-colonisation under better management.

5.1.4 The relative impacts of neglect and agricultural improvement

Further analysis of the individual attribute pass rates and the Tablefit analysis of plant communities indicated that there existed differences between, and sometimes within, the priority grassland types in terms of the different factors influencing botanical composition and their relative importance.

The relatively high incidence of MG1 - *Arrhenatherum elatius*, False oat grass, grassland within the Lowland Calcareous Grassland sample indicates that under-grazing and management abandonment may be a key reason for unfavourable condition within this grassland type. Under-grazing or complete absence of grazing management is recognised as a major problem on many lowland grassland SSSIs (Townshend and others 2004), particularly those occurring as remnant fragments within predominantly arable landscapes. The fact that all 51% of Lowland Calcareous Grassland stands which fail the sward height attribute do so because the sward is too tall also points to management neglect as being a major problem for calcareous grasslands.

Conversely MG6 - *Lolium perenne - Cynosurus cristatus,* Rye grass and Crested Dog's tail and MG7 *Lolium perenne*, Rye grass leys (both communities indicative of agricultural intensification) were most frequently encountered with the Lowland Meadow and particularly the Upland Hay Meadow sample. It has long been recognised that meadows are more vulnerable to improvement than some of the other grassland types. A more unusual finding of the Tablefit analysis is the high proportion of sites showing closest similarity to MG9 - *Holcus lanatus – Deschampsia cespitosa,* Yorkshire Fog – Tufted Hair grass, grassland. This floristically poor community is characteristic of permanently moist, periodically inundated circum-neutral situations and is often indicative of neglect. Its' high frequency in the Lowland Meadow and Upland Hay Meadow sample may indicate abandoned pasture or meadows – where the drainage infrastructure has been neglected.

Interestingly a similar trend towards more inundated communities has been identified on a number of Lowland Meadow SSSIs where drainage systems are known to have fallen into disrepair (Clare Pinches, pers. comm.). This problem might be expected to be accentuated on non-statutory sites where there is less incentive to reinstate drainage. This finding also concurs with the results of botanical monitoring carried out on Upland Hay Meadow sites within the Pennine Dales Environmentally Sensitive Area between 1987 and 2002 which detected increased moisture in combination with other factors as having a detrimental impact on herb richness (Critchley and others 2004)

A high proportion of stands within the Purple Moor Grass and Rush Pasture category failed on the attribute concerned with desirable rush cover/rush height, sites typically failing because the cover of tall rushes was too high. This trend may be linked to nutrient enrichment and/or waterlogging, or conversely a relaxation in the grazing management of these grassland types. The Tablefit results for this priority grassland category also indicate some divergence in the type of mismanagement potentially driving change in the vegetation. Stands in this category which no longer showed "best fit" to NVC types characteristic of the Purple Moor Grass and Rush Pasture type tended to either show signs of improvement and drainage (most similarity to MG7 *Lolium perenne* leys, Rye grass) or combinations of improvement and under-grazing/over-grazing and increasing waterlogging as indicated by their closest fit to MG9 - *Holcus lanatus – Deschampsia cespitosa*, Yorkshire fog – Tufted hair grass, and MG10 *Holcus lanatus – Juncus effusus*, Yorkshire fog – Soft rush grasslands.

Stands surveyed within the Lowland Dry Acid Grassland category similarly indicate that both management neglect and agricultural intensification are having detrimental impacts on the vegetation. The finding that 23% of sites had swards too tall to pass the sward height attribute for this grassland category suggest that under-grazing and management neglect may be a major driver. However the fact that swards also frequently failed on cover of coarse grass attribute suggests unfavourable condition as a result of nutrient enrichment.

Correlation analyses produced some interesting findings. Whilst some relationships were intuitive, for example, taller vegetation was found to be associated with higher litter cover, whilst shorter swards had the lowest levels of herb cover, more weeds and fewer positive indicator species other relationships were less so. Stands with more scrub typically supported both more positive and more negative indicator species.

This apparent dichotomy may be explained by the fact that scrub may be more likely to colonise and establish on semi-natural sites which are extensively managed and had more positive indicators. Any subsequent scrub control on such sites may encourage weeds to colonise the resultant disturbed ground. Alternatively rabbit warrens commonly situated amongst scrub may encourage weeds to colonise disturbed ground. The correlation analysis may therefore be picking up a signal of improvement versus non-improvement as characterised by neglect. Sites which are neglected are less likely to have been improved and therefore have retained higher species diversity. This relationship is interesting as it suggests there is greater recovery potential on neglected as opposed to semi-improved/improved sites. As such, targeting agri-environment agreements to neglected sites to reinstate appropriate management may result in a larger conservation gain over a shorter period than targeting sites to comparatively species limited semi- improved sites.

5.2 Effect of agri-environment agreements

5.2.1 Overall pass rates

There was a significant positive relationship between favourable condition and presence of an agri-environment agreement, across the grassland stands surveyed. Approximately twice as many (27%) sites within agri-environment agreements were in favourable condition as those outside of agreements (15%). This relationship was statistically significant in Purple Moor Grass and Rush Pasture, and the same general trend was seen in the other grassland types, though this was not statistically significant. A positive relationship with agri-environment agreement was seen for pass rates against the positive indicator species attribute across all stands surveyed.

Inclusion within agri-environment agreement was positively correlated with improved pass rates for a range of attributes but significantly for herb cover (LCG, LM and UHM), positive indicator species (LCG, LDAG, PMGRP, UHM) and desirable covers of rushes and *Molinia caerulea,* Purple moor grass (PMGRP). These are all important mandatory attributes which suggest that agri-environment agreements may be valuable in securing suitable management on non-statutory grasslands. Agri-environment agreements stands also had significantly increased pass rates against the vegetation height attribute in Lowland Dry Acid Grasslands, with fewer stands failing due to under-grazing.

Interestingly, significantly more stands within agri-environment agreements failed the negative indicator species attribute compared to those outside ($p<0.1$). Although care needs to be taken in interpreting the significance of this result, it suggests that agreement sites maybe more subject to weed problems, possibly because they are more likely to be grazed (and hence be subject to higher levels of disturbance) rather than abandoned; or perhaps because the use of chemical weed control tends to be restricted on agreement land. However, another study on Countryside Stewardship Scheme grassland showed that the vast majority of grassland was not weedy and was managed satisfactorily (Carey and others 2002).

It should be stressed that any interpretation regarding the effect of agreement status on grassland condition is largely speculative. A cause and effect relationship between condition and agreement presence cannot be reliably determined from the present dataset and will only be decipherable on future resurvey of the sites. This is because although all sites were selected from the English Nature grassland inventories, indicating that they supported high quality grassland post 1980, there are no means of reliably determining their condition at time of entry into agri-environment agreement. Furthermore, it should be noted that agri-environment schemes were not established until the mid-late 1980's, and hence some of these losses may pre-date such schemes. Consequently it would be inappropriate to make a judgement on the effectiveness of agri-environment agreements in improving/maintaining condition of grassland from this survey alone.

An alternative hypothesis to explain the higher pass rates within agreement sites is that grasslands in good condition are more likely to have been entered into agri-environment agreements in the first place. A recent review of the Countryside Stewardship Scheme found that land within agreements is of higher ecological quality than that outside agreements (Carey and others 2000), and more effective targeting may have led to general improvements in the quality of land entering agreements.

Results for Upland Hay Meadows are particularly interesting. Though there was no significant difference overall in pass rate between stands within and outside agreements, many more of the grasslands identified as being agriculturally improved by the Tablefit analysis were outside scheme agreements. This would appear to suggest that agri-environment agreements are either successfully selecting and/or protecting these meadows. However there is evidence to suggest that the schemes may not be improving the condition of these grasslands. Following a re-survey of quadrats in the Pennine Dales ESA Critchley and others (2004) suggest that there is no apparent recovery of grassland condition in the short-term, despite the presence of agri-environment agreements.

5.2.2 Unfavourable recovering condition and non-statutory grasslands

In general it does appear likely that agreements are improving grassland condition through prescriptions which enhance or maintain the wildlife value of grasslands, perhaps even on those stands which failed the condition assessment overall (as these may have been in poor condition prior to being entered into an agri-environment agreement, or deteriorated before a scheme was in place). The SSSI condition data in Table 8 do not include stands of vegetation described as being in 'unfavourable recovering'. This term is used by English Nature to describe a site/stand which has failed a formal condition assessment but is under management considered to be sufficient to achieve favourable condition in future. Sites in both favourable condition and unfavourable recovering condition contribute towards the Defra's PSA target for 95% of SSSIs to be in favourable condition by 2010.

Currently no analogous condition category exists for non-statutory grassland stands and without detailed management information it is difficult to accurately predict what proportion of those sites deemed unfavourable in this survey might be under management which will guarantee their long term favourability.

However it could be assumed that those stands under agri-environment agreement options or tiers, specifically targeted at improved grassland management or restoration could be considered to be 'unfavourable recovering'. Analysis of the sample site data suggests that 18% of failing grasslands were in such tiers and would fall into the unfavourable recovering category.

5.3 Evaluation of the methodology

5.3.1 Differences between SSSI and non-statutory thresholds

The non-statutory thresholds were developed in order to assess whether the application of lower thresholds is more appropriate for certain attributes on undesignated priority grasslands (Robertson and others 2002). Application of these lower thresholds may mean that the condition assessment methodology is less able to detect impacts of, for example, nutrient enrichment, and indicate the conditions under which grassland of high quality can survive with less certainty. However, if non-statutory grasslands of a lower botanical quality are being assessed then the SSSI thresholds may be set unduly high.

Results of this survey show that more sites passed using the non-statutory thresholds than the SSSI thresholds (21% compared to 14%), and for individual attributes where non-statutory thresholds were different to SSSI thresholds (eg herb cover and positive indicator species - the two most important attributes determining grassland condition). However, the use of non-statutory thresholds did not unduly alter the importance of attributes or the relationship between pass rates and agri-environment agreements. The appropriateness of applying these lower thresholds on non-statutory sites rather than a single SSSI threshold applicable across undesignated as well as designated grasslands would therefore appear justified.

During a SSSI condition assessment, structural attributes, such as sward height and litter cover, are treated as discretionary. Failure against discretionary attributes does not in itself cause condition assessment failure. This approach is taken because these attributes are relatively easy to change within a short time scale, and/or because they only apply under certain management situations (for example a minimum vegetation height for meadows, a maximum vegetation height for pastures). However, discretionary thresholds (and vegetation height in particular) may still be used to indicate management suitability, or as an early warning of possible site management issues, and even 'recovering' status to some extent.

Within the SSSI monitoring framework it is possible to make judgements for individual sites with the benefit of a full management history. However, when non-statutory sites were visited during this survey, there was often very little indication as to the management history of a site and so within the two meadow grassland types pass rates against discretionary attributes such as vegetation height need to be interpreted carefully.

In Upland Hay Meadows the small proportion (8%) of grasslands that failed vegetation height thresholds did so because the swards were too short. The SSSI condition assessment suggests that the minimum sward height (5cm) should only apply where this seems sensible given the site management (Robertson & Jefferson 2000). These stands were grazed at the time of survey but still supported a hay meadow type plant community and were therefore included within the sample.

Similarly, the upper vegetation height thresholds for some Lowland Meadows communities (MG8 and MG5) should only be applied when the site is pasture. Due to the lack of full management history, vegetation height thresholds have been applied generically. It is therefore more difficult to draw conclusions regarding under- or over-grazing in Upland Hay Meadows or Lowland Meadows.

With the exception of the Upland Hay Meadows mentioned above, very few grasslands failed because they were too short (ie under-grazed). Defra are currently using slightly higher vegetation height thresholds (3cm) to indicate over-grazing in upland bent-fescue and calcareous grasslands (Glaves 2003; Nisbet and others 2003) than used in this survey. These were developed from a detailed field trial on moorland sites aimed at identifying suitable attributes and targets to define heavy grazing. Though these targets were designed for different habitats (ie upland grasslands rather than lowland), if similar thresholds were adopted into the grassland condition assessment methodology then it is possible that it would become more sensitive to inappropriate intensive grazing regimes.

Some mandatory attributes had a 100% pass rate (eg additional negative indicator species, cover of *Deschampsia flexuosa*, Wavy hair grass, Ericaceous species, *Phragmites australis*, Common reed, *Myrica gale,* Bog myrtle, pleurocarpus bryophytes, *Cirsium palustre,* Marsh thistle and lichens). Though none of these attributes resulted in a stand failure it is argued that they still have a role to play within the condition assessment framework to detect very specific drivers of unfavourable condition which may not have been encountered within this sample of sites and for this reason should not be viewed as uninformative. Recording these attributes requires very little extra time and effort compared to the time taken to travel to the site and complete the structured walk across it. Similarly attributes which have been shown to be closely related by the Pearson's correlation analysis, for example herb cover and vegetation height should arguably be retained within the methodology as failure against these may reflect different problems.

5.4 Improving grassland condition

Clearly the results of this survey provide worrying evidence of the poor state of the lowland grassland resource outside the statutory sites series in England. Only 21% of stands passed all mandatory non-statutory condition assessment targets, and hence could be considered to be in favourable condition. There is evidently an urgent need to improve the condition of non-statutory grassland stands if the BAP target of securing favourable condition over as near to 100% as is practical is to be achieved by 2015 (2010 for PMGRP). Agri-environment agreements may already go some way to meet this target, but despite this only 27% of stands within agri-environment agreements were in favourable condition. The effect of agri-environment agreements on grassland condition in this study may be limited since some deterioration in grassland quality may have already occurred before the schemes were set up and at this point in time it is impossible to determine unequivocally the direction and magnitude of botanical change. Like their SSSI counterparts, non-statutory grasslands are owned and managed by a diverse range of groups and individuals each with their own range of issues concerning site management.

However, there may be some grounds for optimism. Defra's new Higher Level Environmental Stewardship Scheme launched earlier this year (2005) has a greater focus on conservation outcomes. Good targeting of agreements should provide an agricultural environment more conducive to achieving favourable or recovering grassland condition, where possible, on non-statutory sites. Similarly, although low number and frequency of positive indicators present a major obstacle to habitat recovery and achieving good condition in future, the fact that only five sites (1% of the sample) possessed no positive indicators in the sward suggests that on the majority of sites there may be at least some scope for restoration from natural re-colonisation under appropriate management.

Evidently a variety of existing mechanisms will need to be pursued in tandem with the rolling out of Defra's new scheme if major improvements in the non-statutory priority grassland resource are to be realised. These are likely to include: site acquisition and management by nature conservation bodies; statutory SSSI notification where appropriate; influencing higher level policy, particularly in the livestock sector; promoting the Grazing Animal Project initiatives and ensuring effective implementation of the new EIA regulations covering uncultivated land or semi-natural areas for intensive agricultural purposes. If we are able to apply and successfully promote these mechanisms now and in the coming years, perhaps on re-survey of the sample in 10 years time we will glean the rewards with improvements in condition of these grasslands and no, or reduced, observed losses.

5.5 Recommended actions for grassland conservation

- Investigate ways of improving uptake of agri-environment agreements, particularly for enhancement tiers, and ensure that these tiers meet the needs for restoration of grasslands to favourable condition.
- Target agri-environment agreement initiatives to grassland inventory sites supporting priority grassland. Note that having a reliable and up to date grassland inventory is invaluable in guiding cost effective targeting (see Appendix 5).
- Provide financial support to local schemes that aim to advise land managers, particularly those managing BAP grasslands that are not in agri-environment agreements (for example FWAG, local Wildlife Trust schemes, etc.).

- Fund and encourage further research into best management practices on priority lowland grassland types.
- Raise awareness of the importance of lowland priority grasslands.
- Protect priority grasslands from further loss through developing effective Environmental Impact Assessment and planning procedures.
- Ensure appropriate monitoring of priority grassland both within and outside SSSIs and ensure that results of monitoring can be clearly linked to current and desired management practices.
- Spend available resources wisely, considering the likelihood of success of restoration schemes on the most degraded sites (presence of positive indicator species at low frequencies within the stand and in surrounding area).
- Set up a working group to drive development of methodology, survey initiation and reporting on the assessment of habitat condition.

5.6 Suggestions for further work

Condition assessment methodology:

- Review and develop condition assessment attributes and attribute thresholds. For example were any of the indicator species found to be redundant? Are thresholds set at the correct level?
- Consider whether any new indicator species should be included (full DAFOR data collected at the stand level during the survey could be used to assess the utility of any potential new indicators).
- Modify the 'localised bare ground around rabbit warrens' attribute to include an area disturbed by rabbits as a percentage of the site, rather than 0.25ha, which may be acceptable in a 16ha stand, but not on a 0.5ha stand.
- Consider modifying vegetation height assessments to be more flexible with regard to site management, and consider increasing height thresholds to make the method more sensitive to intensive grazing regimes in line with Defra's over-grazing thresholds.
- Develop a standard methodology for treating grassland types which do not fit neatly within the NVC. This could involve the combination of attribute thresholds from the most similar NVC types.
- Develop restorability attributes.

Monitoring:

- Consider a desk-top review of the management of the grasslands in this survey (through reviewing agri-environment agreements and/or consultation with landowners and local wildlife groups); in order to understand whether any that failed the condition assessment could be classified as 'unfavourable recovering'.
- Devise a 'layered' approach to condition assessment within the Defra monitoring framework for agri-environment sites. In this way easy, quick to assess and important attributes (such as herb cover) could be assessed relatively frequently by Advisers or agreement holders, while the more complex attribute recording could be done less

frequently by skilled ecological staff. More detailed sampling could be undertaken on a sub set of sites.

- Repeat this baseline survey in the future to detect changes in grassland condition over time, draw conclusions on the drivers of this change and evaluate the effectiveness of the agri-environment schemes in conserving grasslands.
- Consider soil analysis as a supplement to botanically based condition assessments, particularly when considering restoration potential.
- Consider the use of multivariate analysis techniques to further explore reasons for unfavourable condition.

Suggestions for future work to improve the grassland inventories may be found in Appendix 5.

6 References

ADAS & SQW. 2003. *The mid-term evaluation of the England Rural Development Programme.* Wolverhampton: ADAS Consulting Ltd, and Cambridge: SQW Limited.

BULLOCK, J.M., and others. 2002. Plant dispersal and colonization processes at local and landscape scales. *In*: BULLOCK, J.M., KENWARD, R.E., HAILS, R., eds. *Dispersal Ecology* 279-302. Oxford: Blackwell Scientific Publications.

CAREY, P.D., and others. 2000. *Monitoring and evaluation of the Countryside Stewardship Scheme. Module 2: The ecological characterisation of land under agreement*. Centre for Ecology and Hydrology.

CAREY, P.D., and others. 2002. Grassland in the Countryside Stewardship Scheme - is it good , bad or ugly? *In*: FRAME, J., ed. *Conservation Pays? Reconciling environmental benefits with profitable grassland systems.* Chippenham: British Grassland Society Occassional Symposium 36.

CRITCHLEY, C.N.R, and others. 2004. *Upland hay meadows in the Pennine Dales Environmentally Sensitive Area: Vegetation change between 1987 and 2002 and its relation with management practices and soil properties*. ADAS Report to Defra. Otterburn: ADAS.

ENGLISH NATURE. 2001. *State of nature: the upland challenge report*. Peterborough: English Nature.

FIRBANK, L.G., and others. 2000. *Causes of change in British vegetation. ECOFACT Volume 3*. Grange-over-Sands: Institute of Terrestrial Ecology.

GLAVES, D.J. 2003). *Developing revised methods to assess overgrazing on moorland: the Moorland Appraisal Pilot Project (MAPP) consultation draft*. Defra Rural Development Service and Welsh Assembly Government.

HEWINS, E.J., LUSH, M.J. & ARNOLD, J. 2004. *Monitoring of Biodiversity Action Plan (BAP) Grasslands: Methodology and data analysis.* A report to Defra and English Nature. Contract: FST 20-32-021/MA01009. Berkeley: Just Ecology Environmental Consultancy.

HILL, M.O. 1996. *TABLEFIT, Version 1.0, for Identification of Vegetation Types.* Monks Wood: Institute of Terrestrial Ecology.

HUSTON, K. 2001. *Derbyshire grassland survey 1997-99*. Derby: Derbyshire Wildlife Trust.

McLAREN, R. 2002. *Report on monitoring of grassland Biodiversity Action Plan Thresholds: Preparation of site dossiers.* Contract VT0122. Cambridge: ADAS.

NISBET, A., SHEPHERD, M., & BRADLEY, C. 2003. Overgrazing thresholds for a rapid appraisal method. Exeter: Defra Rural Development Service.

PLANTLIFE. 2002. *England's Green Unpleasant Land? – Why urgent action is needed to save England's wildflower grasslands*. London: Plantlife, and The Wildlife Trusts.

POSCHLOD, P., and others. 1998. Species richness in calcareous grasslands is affected by dispersability in space and time. *Applied Vegetation Science*, 1, 75-90.

POSCHLOD, P., & BONN, S. 1998. Changing dispersal processes in the central European landscape since the last ice age - an explanation for the decrease of plant species richness in different habitats? *Acta Botanica Neerlandica*, 47, 27-44.

POULTON, S.M.C. 2000. Sampling framework for monitoring of grassland Biodiversity Action Plan thresholds. *English Nature Research Reports*, No 338.

ROBERTSON, H.J., & JEFFERSON, R.J. 2000. Monitoring the condition of lowland grassland SSSIs: Part I: English Nature's rapid assessment method. *English Nature Research Reports,* No 315.

ROBERTSON, H.J., BINGHAM, J., & SLATER, I. 2000. Monitoring the condition of lowland grassland SSSIs: Part II: A test of the rapid assessment approach. *English Nature Research Reports*, No 315.

ROBERTSON, H.J., and others. 2002. *Monitoring grassland Biodiversity Action Plan thresholds: condition and restoration assessment methodologies for non-statutory grasslands*. Peterborough: English Nature

RODWELL, J.S., ed. 1991. *British Plant Communities 2: Mires and heaths*. Cambridge: Cambridge University Press.

RODWELL, J.S., ed. 1992. *British Plant Communities 3: Grassland and montane communities.* Cambridge: Cambridge University Press.

STACE, C. 1999. Field Flora of the British Isles. Cambridge: Cambridge University Press.

STRYKSTRA, R.J., VERWEIJ, G.L., & BAKKER, J.P. 1997. Seed dispersal by mowing machinery in a Dutch brook valley system. *Acta Botanica Neerlandica*, 46, 387-401.

UK BIODIVERSITY GROUP. 1998. *Tranche 2 Action Plans: Volume II – terrestrial and freshwater habitats.* London: HMSO.

UK STEERING GROUP. 1995. *Biodiversity: the UK Steering Group Report*. London: HMSO.

WALKER, K.J, and others. In press 2004. *The restoration and re-creation of species-rich lowland grassland on land formerly managed for intensive agriculture in the UK. Biological Conservation.*

WORCESTERSHIRE WILDLIFE TRUST. 2000. *Losses of Special Wildlife Site grassland in Worcestershire since 1975.*

Appendix 1. Site rejection and stand selection

Table 1 shows that 368 sites were rejected prior to survey; 35% of the 1054 total available sites. Sites were most commonly rejected because either the owner was not known or had refused permission, because the site was a SSSI or in the wrong agri-environment agreement category, or because previous survey information from the site dossier or elsewhere clearly indicated that the site did not contain any or enough of the habitat type for which the site was selected (other unselected BAP habitats may still have been present).

Table 1. Reasons for site rejections prior to survey

Reason for rejection	No. of sites rejected
Ownership details not reasonably obtainable	125
Ecological/size reasons – clearly apparent from previous survey data	99
Site is SSSI or in wrong agreement category	62
Access refused by landowner	54
Site destroyed (developed or arable)	9
Merseyside – dossier information not available	8
Inventory mapping error	4
Missing dossier	4
Site has been mown	2
Access to site is dangerous	1
TOTAL	368 (35% of 1054 sites in total sample)

Table 2 shows that site rejections prior to visit were greatest in acid grasslands (43%) and Lowland Meadows (41%), and lowest in Lowland Calcareous Grasslands (24%) and Upland Hay Meadows (26%). A similar proportion of agri-environment agreement (36%) and non-agreement (34%) sites were rejected from the sample. However further analysis of the data showed that only 24% of rejected agreement sites were rejected because the landowner was not contactable compared with 54% of rejected non-agreement sites. Therefore inclusion in an agri-environment agreement made obtaining access permission much easier.

Table 2. Sites rejected in each habitat group prior to survey

Grassland category	Rejected prior to visit	Number of possible sites in sample	% rejection
LCG			
• Agreement	16	71	23%
• Non-agreement	25	99	25%
• TOTAL	(41)	(170)	(24%)
LDAG			
• Agreement	46	93	49%
• Non-agreement	43	116	37%
• (TOTAL)	(89)	(209)	(43%)
PMGRP			
• Agreement	39	111	35%
• Non-agreement	43	117	37%
• TOTAL	(82)	(228)	(36%)
LM			
• Agreement	64	134	48%
• Non-agreement	47	140	34%
• TOTAL	(111)	(274)	(41%)
UHM			
• Agreement	14	85	16%
• Non-agreement	31	88	35%
• TOTAL	(45)	(173)	(26%)
TOTAL			
• Agreement	179	494	36%
• Non-agreement	189	560	34%
• TOTAL	(368)	(1054)	(35%)

Of the 608 sites that were visited, 23% were rejected by the surveyor at or after the time of survey. The reasons for these rejections are show in Table 3 below. By far the most common reason for rejection was that there was none, or not enough, suitable habitat of the correct BAP habitat type on the site. Recent mowing, wrongly allocated agreement status, inclusion in an SSSI, mapping errors, loss of grassland and access issues all accounted for smaller numbers of on-site rejections. In these instances it had not been possible from analysis of the dossier information alone to reject the site pre-visit.

Table 3. Reason for on-site rejections

Reason for rejection	Number of sites rejected
None/not enough habitat of desired type present	112
Site has been mown	9
Site is in wrong agreement category/is SSSI	4
Site too dangerous to survey (quarry)	3
Access refused	3
Dossier map error	2
Site is no longer grassland (arable)	2
Unsuccessful cold call (owner not contacted)	2
TOTAL	137 (23%)

Table 3 shows that rates of on-site rejection were highest in Lowland Dry Acid Grasslands (33%) and were lowest in Upland Hay Meadows (13%) and Lowland Calcareous Grasslands (15%). Fewer agri-environment sites were rejected on visiting (16%) than non-agreement sites (28%) in all habitat groups.

Table 4. Sites visited and rejected in each habitat group (Excludes second stands of same BAP habitat type)

Grassland category		Accepted	Rejected on visit	Total	% rejection
LCG					
	Agreement	48	6	54	11%
	Non-agreement	43	10	53	19%
	(TOTAL)	(91)	(16)	(107)	(15%)
LDAG					
	Agreement	39	10	49	20%
	Non-agreement	41	29	70	41%
	(TOTAL)	(80)	(39)	(119)	(33%)
PMGRP					
	Agreement	43	13	56	23%
	Non-agreement	47	22	69	32%
	(TOTAL)	(90)	(35)	(125)	(28%)
LM					
	Agreement	53	11	64	17%
	Non-agreement	51	21	72	29%
	(TOTAL)	(104)	(32)	(137)	(23%)
UHM					
	Agreement	57	5	62	8%
	Non-agreement	48	10	58	17%
	(TOTAL)	(105)	(15)	(120)	(13%)
TOTAL					
	Agreement	240	45	285	16%
	Non-agreement	230	92	322	28%
	(TOTAL)	(470)	(137)	(608)	(23%)

Discussion

35% of sites selected from the grassland inventory did not meet the criteria necessary for a site visit to take place (as *per* the survey protocol). For 27% (99) of these sites, inspection of previous survey information revealed that the site contained less than 0.25ha of the BAP grassland type for which they were selected (though other priority grassland types may have been present). In some cases this arose as a result of an error or ambiguity in the 'grassland type' field identified in the grassland inventory. It should be noted that the broad 'grassland type' classifications within the grassland inventory digital dataset do not completely match BAP priority grassland groupings. In particular, because no distinction was made between Upland Hay Meadow (UHM) and Lowland Meadow (LM) communities in the original inventory, the location of UHM sites, as defined by the MG3 *Anthoxanthum odoratum – Geranium sylvaticum,* Sweet vernal grass and Wood cranesbill, community had to be inferred from the known distribution of sites within 127 tetrads. Sites known to contain LM and with grid references in this list of 127 tetrads were consequently identified in the site sampling framework as UHM. Clearly this approach resulted in a number of erroneous assignations to the UHM priority grassland type.

23% of those sites visited by surveyors were rejected at the visit stage (on-visit). The majority (82%) of these were rejected for ecological reasons, ie less than 0.25ha of the selected grassland type being present on site (other grasslands types may have been present). In none of these instances was it possible to reject these sites prior to visiting them due to lack of, ambiguous, or erroneous previous survey information.

Quality of previous survey information varied greatly from county to county, as did the ease by which it was obtained. Previous survey information did not always quantify the extent of the priority grassland. In addition whilst NVC sub-community survey data existed for some sites, others had only a species list or were described as simply 'U', 'MG', 'CG', 'M' indicating the fact they support grassland of an acidic, neutral, calcareous or marshy nature but not indicating the NVC type or whether the community was either a) priority grassland type or b) a lowland type. Others were supported by survey data which used terminology which could apply to more than one BAP type. For example 'marshy grassland' could apply to both PMGRP types (eg M23) or LM types (eg MG8). Surveyors found inaccuracies in previous survey maps or NVC classifications for sites which were not rejected.

Surveyors had to use ecological judgment once in the field to decide where previous survey data was reliable and when it was not. However, the assumption was made that generally information supporting the inventory was reliable, unless there was clear evidence to the contrary. For example the sample includes a number of sites which were found to be agriculturally improved and in which there was no other nature conservation interest which might explain the site's inclusion on the inventory. In these cases the assumption was made that these particular sites must have contained priority grassland at the time when the survey underpinning the site's inclusion on the inventory was undertaken, and had subsequently deteriorated due to improvement or poor management.

The rates of on-site rejection were highest in Lowland Dry Acid Grasslands (33%), and were lowest in Upland Hay Meadows (13%) and Lowland Calcareous Grasslands (15%). This suggests that the selection of acid grasslands may have been less reliable perhaps because of less detailed survey information supporting inclusion of these sites within the inventory. Acid grasslands are known to have benefited from less grassland surveys than Upland Hay Meadows or calcareous grasslands.

A small number of mapping errors were found in the inventory which resulted in site rejection (6 sites, 0.5% of the inspected inventory sites). In these cases the grassland inventory polygon was clearly located incorrectly.

Sites were rejected for a number of non-ecological reasons: owners were not contactable or refused access permission, the site was recently mown, access to the site was dangerous, the site was in an SSSI, or in the wrong agreement category (because agreement status had changed since the sample was selected). Fewer sites in agri-environment agreements were rejected due to lack of ownership information than those outside of an agri-environment agreement.

The protocol for stand inclusion is discussed in full in Hewins and others (2004). To be representative of what is happening to the "population" of grassland inventory sites in the country as a whole, the sample needed to include the range of current states (favourable to unfavourable) of BAP priority grasslands sites which were previously known to support unimproved grassland. Both 'good' and 'bad' areas were included. These included areas which had been identified having been degraded since the time the inventory was compiled. The assumption was made that these sites were priority grassland (albeit in unfavourable condition) at the time the grassland inventory was made, and have been kept in the sample. This allows the sample to monitor the full range of grasslands in the UK, and gives scope for detecting improvement from degraded or heavily modified grassland communities on re-survey of the sampled site. When stands did not fit neatly into the NVC a judgment was made as to the nearest NVC type.

Overall, 24% of surveyed stands did not match a BAP type and instead bore closest botanical similarity to grassland communities indicative of improvement or neglect.

Appendix 2. Distribution of sample sites

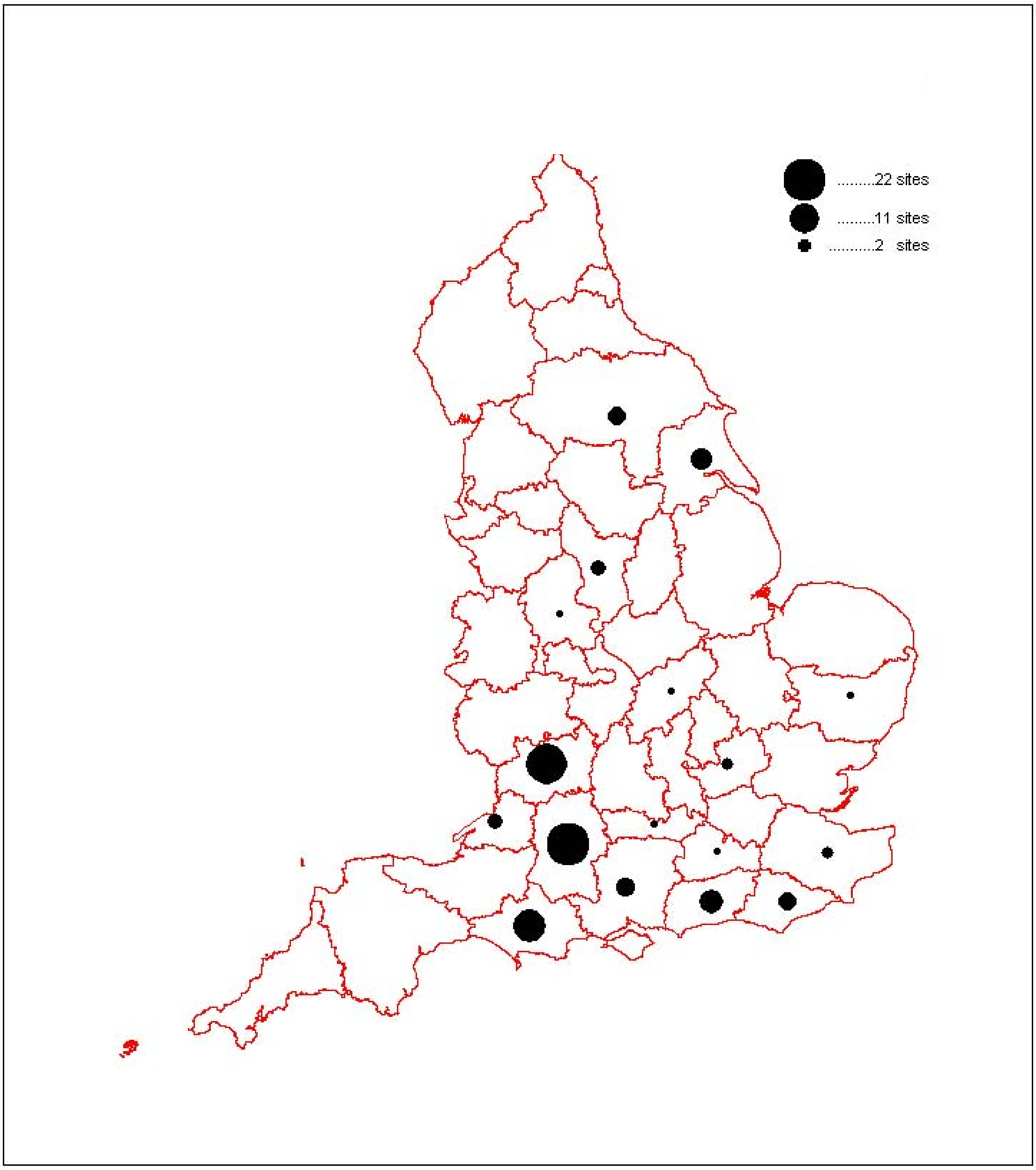

Figure 1. Distribution of Lowland Calcareous Grassland stands by county

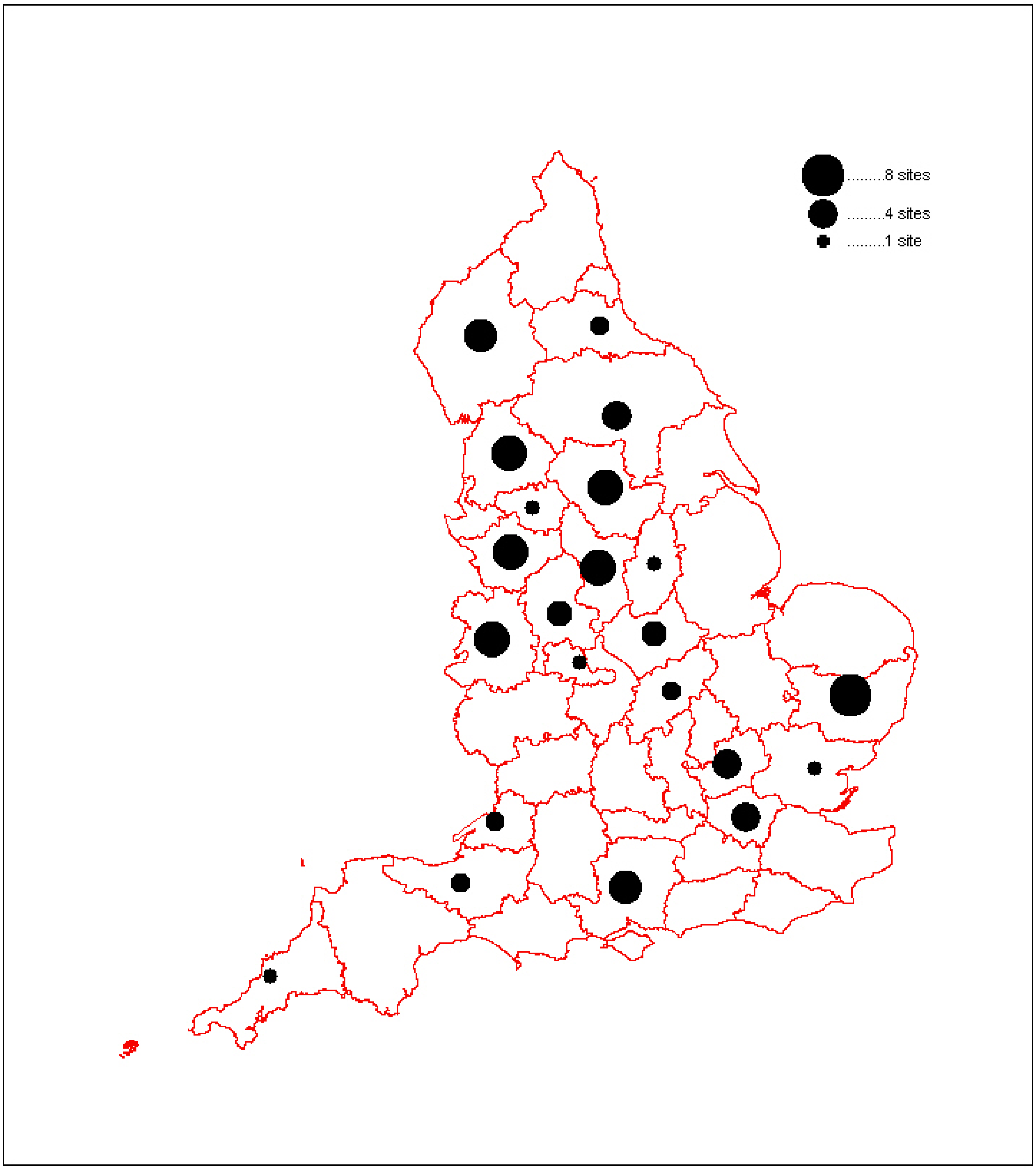

Figure 2. Distribution of Lowland Dry Acid Grassland stands by county

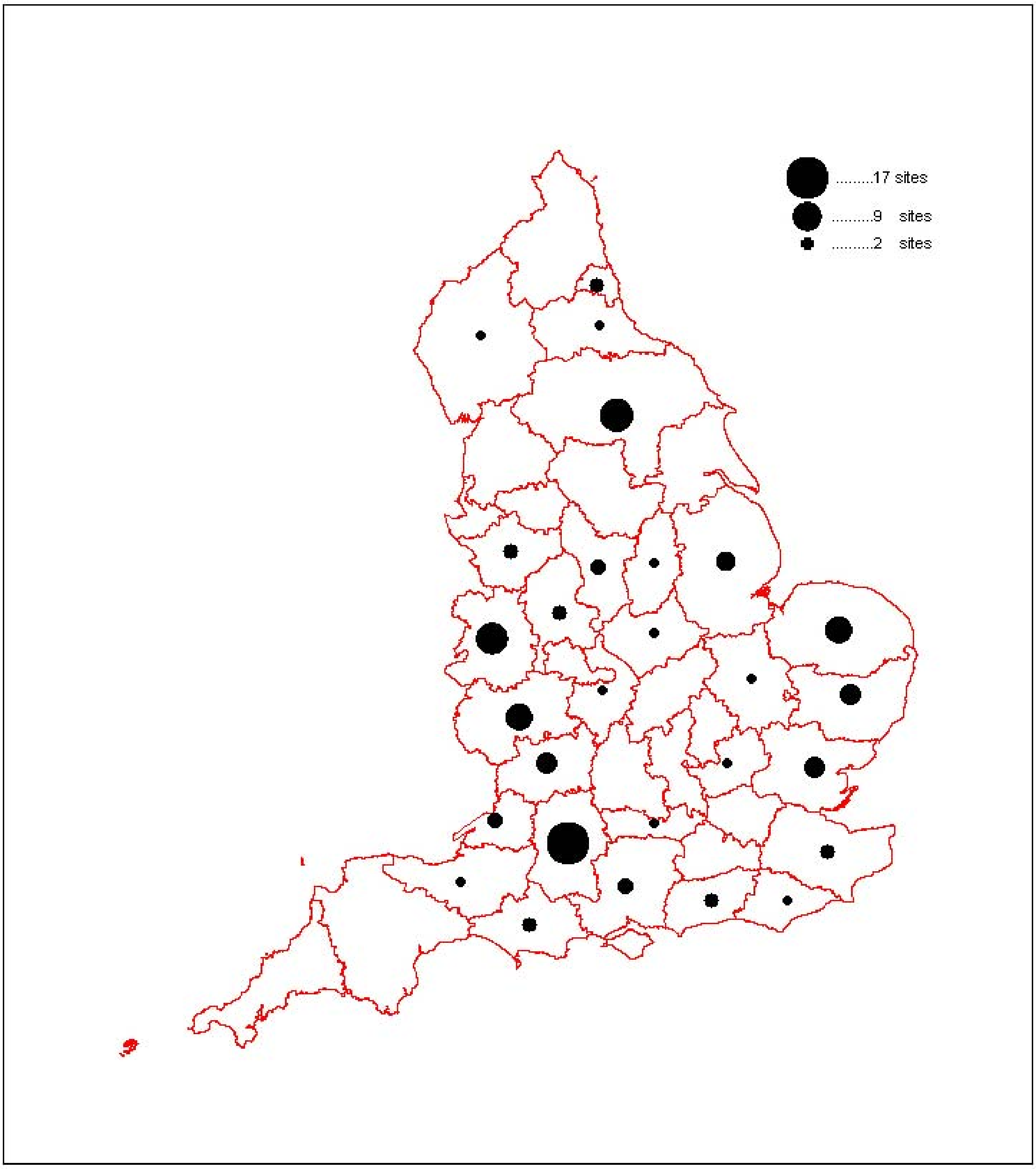

Figure 3. Distribution of Lowland Meadow stands by county

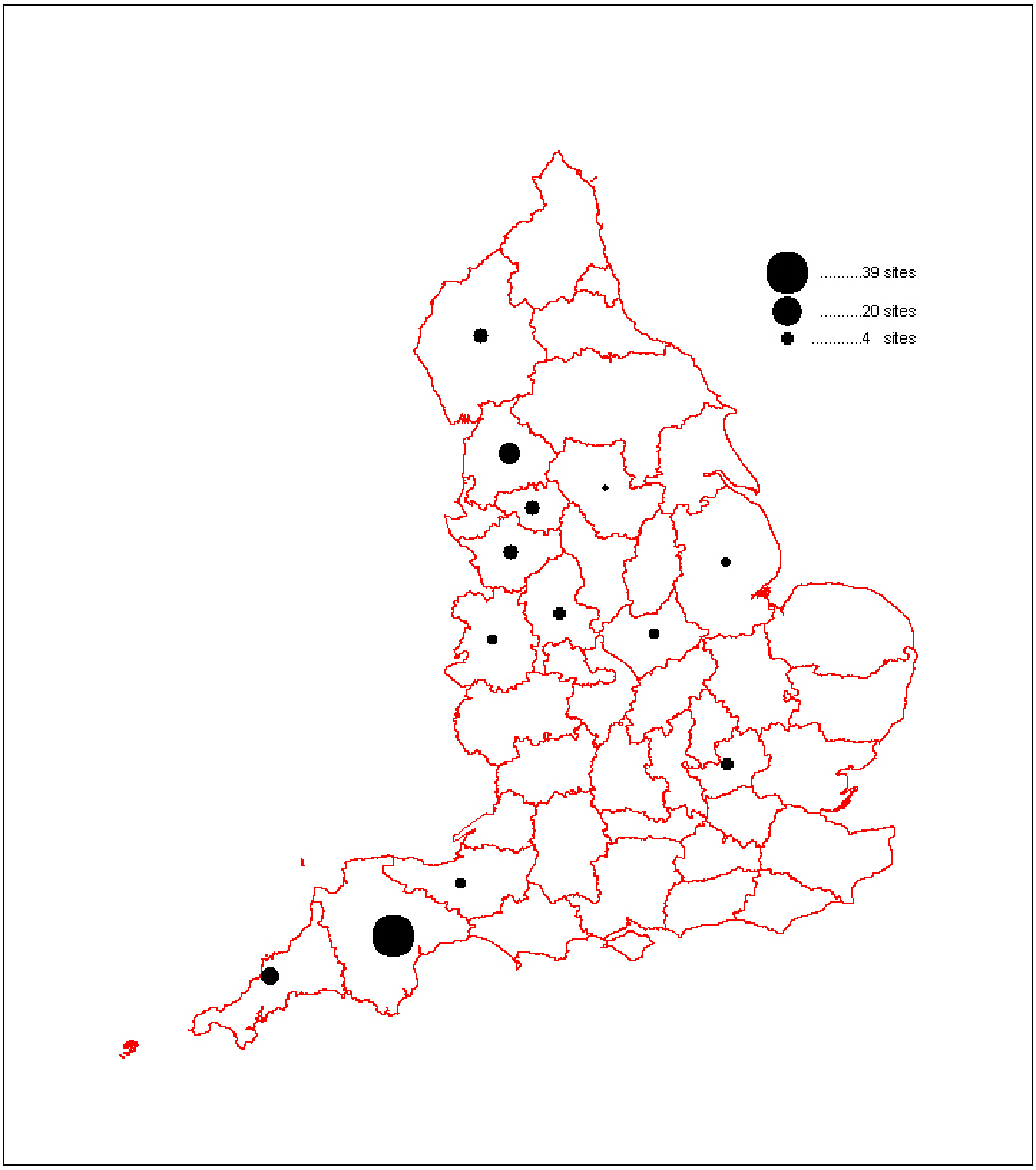

Figure 4. Distribution of Purple Moor Grass and Rush Pasture stands by county

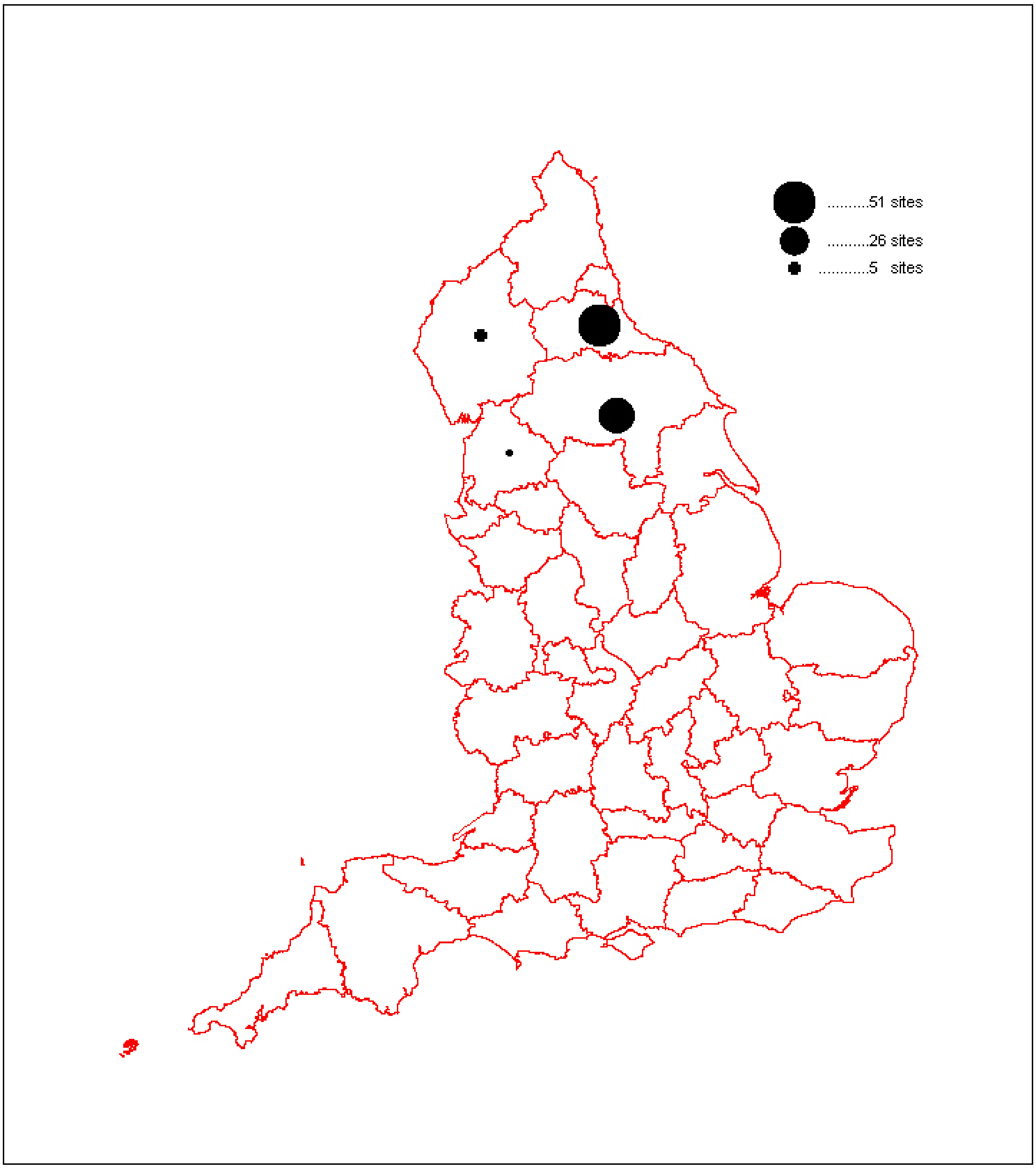

Figure 5. Distribution of Upland Hay Meadow stands by county

Appendix 3. Data summary tables

Table 5. All Grasslands

	n[1]	% stands passing each attribute	
		SSSI thresholds	**Non-statutory thresholds[2]**
MANDATORY ATTRIBUTES			
Herb cover	299	49	64***
Negative indicator species	483	83	-
Positive indicator species	482	25	39***
Scrub cover	483	88	-
Special positive indicator species	3	0	-
Lichen cover	2	50	-
Additional negative indicator species criteria	104	100	100
Calcicole grass species	91	93	-
Bracken cover	81	98	98
Additional scrub criteria	78	100	-
Coarse grass cover	81	69	78
Deschampsia flexuosa	17	100	100
Ericaceous species	64	100	-
Pleurocarpus bryophyte cover	2	100	-
Waterlogging indicator species	163	96	96
Rush cover	94	69	-
Molinia caerulea	39	87	-
Cirsium palustre	39	100	-
Deschampsia cespitosa	40	98	100
Phragmites australis	39	100	100
Myrica gale	39	100	-

Table 5. (continued)

		% stands passing each attribute	
DISCRETIONARY ATTRIBUTES	n[1]	SSSI thresholds	Non-statutory thresholds[2]
Vegetation height (sward stick)	483	49	-
• Failing because sward too tall		(68)	-
• Failing because sward too short		(4)	-
• Failing because too much/tall rush		(28)	-
Litter	483	93	-
Bare ground	483	99	-
Rabbits	177	99	-
Additional negative indicator species criteria	124	91	-
ALL MANDATORY ATTRIBUTES	483	14	21**
ALL ATTRIBUTES	483	6	8
Non- assessed attributes:			
Risk of scrub invasion	376	93	-
Risk of bracken invasion	83	94	-
Vegetation height (drop disc)	482	61	-

[1] Number of sites at which attribute was assessed

[2] When different from SSSI thresholds. Significance of difference between SSSI and non-statutory pass rates: *=$p<0.05$, **=$p<0.01$, ***=$p<0.001$.

Table 6. All Lowland Calcareous Grasslands

	n[1]	% stands passing each attribute target	
		SSSI thresholds	**Non-statutory thresholds[2]**
MANDATORY ATTRIBUTES			
Herb cover	87	64	80*
Negative indicator species	88	74	-
Positive indicator species	90	53	74**
Scrub cover	88	67	-
Lichen cover	1	0	-
Calcicole grass species	82	93	-
Bracken cover	1	100	-
Additional scrub criteria	1	100	-
Coarse grass cover	1	100	100
Deschampsia flexuosa	1	100	100
Pleurocarpus bryophyte cover	1	100	-
DISCRETIONARY ATTRIBUTES			
Vegetation height (sward stick)	89	49	-
• Failing because sward too tall		100	-
• Failing because sward too short		0	-
• Failing because too much/tall rush		0	-
Litter	86	81	-
Bare ground	86	100	-
Rabbits	86	98	-
Additional negative indicator species criteria	2	0	-
ALL MANDATORY ATTRIBUTES	96	22	28
ALL ATTRIBUTES	96	17	18
NON-ASSESSED ATTRIBUTES			
Risk of scrub invasion	87	89	-
Risk of bracken invasion	2	100	-
Vegetation height (drop disc)	88	83	-

[1] Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, otherwise -Significance of difference between SSSI and non-statutory pass rates: *=p<0.05, **=p<0.01, ***=p<0.001.

Table 7. All Lowland Dry Acid Grasslands

		% stands passing each attribute target	
	n[1]	SSSI thresholds	Non-statutory thresholds[2]
MANDATORY ATTRIBUTES			
Negative indicator species	81	83	-
Positive indicator species	80	21	38*
Scrub cover	81	81	-
Lichen cover	1	100	-
Bracken cover	80	98	98
Additional scrub criteria	77	100	-
Coarse grass cover	80	69	78
Deschampsia flexuosa	16	100	100
Ericaceous species	64	100	-
Pleurocarpus bryophyte cover	1	100	-
DISCRETIONARY ATTRIBUTES			
Vegetation height (sward stick)	79	23	-
• Failing because sward too tall		100	-
• Failing because sward too short		0	-
• Failing because too much/tall rush		0	-
Litter	81	91	-
Bare ground	81	98	-
Rabbits	81	100	-
Additional negative indicator species criteria	17	71	-
ALL MANDATORY ATTRIBUTES	81	16	23
All ATTRIBUTES	81	2	7
NON-ASSESSED ATTRIBUTES			
Risk of scrub invasion	81	94	-
Risk of bracken invasion	81	94	-
Vegetation height (drop disc)	78	38	-

[1] Number of sites at which attribute was assessed

[2] When different from SSSI thresholds, otherwise -.

Significance of difference between SSSI and non-statutory pass rates: *=p<0.05, **=p<0.01, **=p<0.001.

Table 8. All Purple Moor Grass Rush Pastures

		% stands passing each attribute target	
	n[1]	**SSSI thresholds**	**Non-statutory thresholds[2]**
MANDATORY ATTRIBUTES			
Negative indicator species	93	97	-
Positive indicator species	93	35	52*
Scrub cover	93	89	-
Waterlogging indicator species	54	100	100
Rush cover	93	69	-
Molinia caerulea	39	87	-
Cirsium palustre	39	100	-
Deschampsia cespitosa	39	97	100
Phragmites australis	39	100	100
Myrica gale	39	100	-
DISCRETIONARY ATTRIBUTES			
Vegetation height (sward stick)	92	24	-
• Failing because sward too tall		0	-
• Failing because sward too short		0	-
• Failing because too much/tall rush		100	-
Litter	93	95	-
Bare ground	93	100	-
Additional negative indicator species criteria	93	97	-
ALL MANDATORY ATTRIBUTES	93	24	35
ALL ATTRIBUTES	93	5	6
NON-ASSESSED ATTRIBUTES			
Risk of scrub invasion	93	87	-
Vegetation height (drop disc)	92	24	-

[1] Number of sites at which attribute was assessed
[2] When different from SSSI thresholds, otherwise -.
Significance of difference between SSSI and non-statutory pass rates: *=p<0.05, **=p<0.01, **=p<0.001.

Table 9: All Lowland Meadows

		% stands passing each attribute target	
	n[1]	**SSSI thresholds**	**Non-statutory thresholds[2]**
MANDATORY ATTRIBUTES			
Herb cover	100	43	61*
Negative indicator species	108	63	-
Positive indicator species	108	13	27*
Scrub cover	108	95	-
Special positive indicator species	3	0	-
Additional negative indicator species criteria	1	100	-
Waterlogging indicator species	108	94	94
DISCRETIONARY ATTRIBUTES			
Vegetation height (sward stick)	111	44	-
• Failing because sward too tall		98	-
• Failing because sward too short		2	-
• Failing because too much/tall rush		0	-
Litter	109	94	-
Bare ground	109	98	-
Additional negative indicator species criteria	12	92	-
ALL MANDATORY ATTRIBUTES	108	8	16
ALL ATTRIBUTES	108	3	5
NON-ASSESSED ATTRIBUTES			
Risk of scrub invasion	103	100	-
Vegetation height (drop disc)	111	59	-

[1] Number of sites at which attribute was assessed
[2] When different from SSSI thresholds, otherwise -.
Significance of difference between SSSI and non-statutory pass rates: *=p<0.05, **=p<0.01, **=p<0.001.

Table 10. All Upland Hay Meadows

	n[1]	% stands passing each attribute target	
		SSSI thresholds	**Non-statutory thresholds[2]**
MANDATORY ATTRIBUTES			
Herb cover	105	40	51
Negative indicator species	105	96	-
Positive indicator species	105	4	10
Scrub cover	105	99	-
Additional negative indicator species criteria	103	100	100
Waterlogging indicator species	1	100	-
Rush cover	1	100	-
Deschampsia cespitosa	1	100	100
DISCRETIONARY ATTRIBUTES			
Vegetation height (sward stick)	105	92	-
• Failing because sward too tall		0	-
• Failing because sward too short		100	-
• Failing because too much/tall rush		0	-
Litter	105	100	-
Bare ground	105	100	-
ALL MANDATORY ATTRIBUTES	105	2	7
ALL ATTRIBUTES	105	2	5
NON-ASSESSED ATTRIBUTES			
Risk of scrub invasion	3	100	-
Vegetation height (drop disc)	105	93	-

[1] Number of sites at which attribute was assessed
[2] When different from SSSI thresholds, otherwise -.
Significance of difference between SSSI and non-statutory pass rates: *=p<0.05, **=p<0.01, **=p<0.001.

Table 11. ALL GRASSLANDS: % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		**SSSI thresholds**		**Non-statutory thresholds**[2]	
MANDATORY ATTRIBUTES	**Agreement**	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
Herb cover	158	141	63	35***	75	52***
Negative indicator species	250	233	80	86	-	-
Positive indicator species	249	233	34	15***	48	30***
Scrub cover	250	233	87	88	-	-
Special positive indicator species	1	2	0	0	-	-
Lichen cover	1	1	0	100	-	-
Additional negative indicator species criteria	56	48	100	100	100	100
Calcicole grass species	49	42	92	95	-	-
Bracken cover	40	41	100	95	100	95
Additional scrub criteria	38	40	100	100	-	-
Coarse grass cover	40	41	75	63	83	73
Deschampsia flexuosa	7	10	100	100	100	100
Ericaceous species	33	31	100	100	-	-
Pleurocarpus bryophyte cover	1	1	100	100	-	-
Waterlogging indicator species	81	82	94	98	94	99
Rush cover	46	48	83	56**	-	-
Molinia caerulea	20	19	100	74*	-	-
Cirsium palustre	20	19	100	100	-	-
Deschampsia cespitosa	21	19	100	95	100	100
Phragmites australis	20	19	100	100	100	100
Myrica gale	20	19	100	100	-	-

Table 11. (continued) ALL GRASSLANDS: % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		SSSI thresholds		Non-statutory thresholds[2]	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	251	232	51	47	-	-
• Failing because sward too tall			67	(69)	-	-
• Failing because sward too short			2	(5)	-	-
• Failing because too much/tall rush			30	(27)	-	-
Litter	250	233	94	92	-	-
Bare ground	250	233	99	100	-	-
Rabbits	92	85	98	100	-	-
Additional negative indicator species criteria	60	64	87	95	-	-
All Mandatory attributes	250	233	19	8***	27	15***
All attributes	250	233	7	5	10	6
Non-assessed attributes						
Risk of scrub invasion	193	184	92	93	-	-
Risk of bracken invasion	41	42	98	90	-	-
Vegetation height (drop disc)	250	232	65	58	-	-

[1] Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 12. Lowland Calcareous Grasslands % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		SSSI thresholds		Non-statutory thresholds[2]	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
MANDATORY ATTRIBUTES						
Herb cover	51	43	78	53**	88	74
Negative indicator species	52	44	71	82	-	-
Positive indicator species	51	44	76	32***	90	59***
Scrub cover	52	44	67	73	-	-
Lichen cover	1	0	0	-	-	-
Calcicole grass species	49	42	91	95	-	-
Bracken cover	0	1	-	100	-	-
Additional scrub criteria	0	1		100	-	-
Coarse grass cover	0	1		100		100
Deschampsia flexuosa	0	1		100		100
Pleurocarpus bryophyte cover	1	0	100		-	-
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	52	44	56	50	-	-
• Failing because sward too tall			100	100	-	-
• Failing because sward too short			0	0	-	-
• Failing because too much/tall rush			0	0	-	-
Litter	52	44	79	89	-	-
Bare ground	52	44	100	100	-	-
Rabbits	52	44	96	100	-	-
Additional negative indicator species criteria	1	1	0	0	-	-
ALL MANDATORY ATTRIBUTES	52	44	29	14	31	25
ALL ATTRIBUTES	52	44	19	14	17	18
NON-ASSESSED ATTRIBUTES						
Risk of scrub invasion	52	44	87	93	-	-
Risk of bracken invasion	1	1	100	100	-	-
Vegetation height (drop disc)	52	44	88	80	-	-

[1] Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, , otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 13. Lowland Dry Acid Grasslands % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		SSSI thresholds		Non-statutory thresholds[2]	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
MANDATORY ATTRIBUTES						
Negative indicator species	40	41	80	85	-	-
Positive indicator species	40	40	30	13	48	28
Scrub cover	40	41	85	78	-	-
Lichen cover	0	1		100	-	-
Bracken cover	40	40	100	95	100	95
Additional scrub criteria	38	39	100	100	-	-
Coarse grass cover	40	40	75	63	83	73
Deschampsia flexuosa	7	9	100	100	100	100
Ericaceous species	0	31	100	100	-	-
Pleurocarpus bryophyte cover	0	1		100	-	-
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	40	39	35	10 **	-	-
• Failing because sward too tall			100	100	-	-
• Failing because sward too short			0	0	-	-
• Failing because too much/tall rush			0	0	-	-
Litter	40	41	93	90	-	-
Bare ground	40	41	98	98	-	-
Rabbits	40	41	100	100	-	-
Additional negative indicator species criteria	7	10	57	80	-	-
ALL MANDATORY ATTRIBUTES	40	41	23	10	30	7
ALL ATTRIBUTES	40	41	3	2	10	2
NON-ASSESSED ATTRIBUTES						
Risk of scrub invasion	40	41	98	90	-	-
Risk of bracken invasion	40	41	98	90	-	-
Vegetation height (drop disc)	39	39	56	21	-	-

[1] Number of sites at which attribute was assessed. [1] When different from SSSI thresholds, otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 14. Purple Moor Grass Rush Pastures: % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		SSSI thresholds		Non-statutory thresholds[2]	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
MANDATORY ATTRIBUTES						
Negative indicator species	45	48	93	100	-	-
Positive indicator species	45	48	44	27	60	44
Scrub cover	45	48	87	92	-	-
Waterlogging indicator species	25	29	100	100	100	100
Rush cover	45	48	82	56**	-	-
Molinia caerulea	20	19	100	74*	-	-
Cirsium palustre	20	19	100	100	-	-
Deschampsia cespitosa	20	19	100	95	100	100
Phragmites australis	20	19	100	100	100	100
Myrica gale	20	19	100	100	-	-
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	45	47	18	30	-	-
• Failing because sward too tall			0	0	-	-
• Failing because sward too short			0	0	-	-
• Failing because too much/tall rush			100	100	-	-
Litter	45	48	100	90*	-	-
Bare ground	45	48	100	100	-	-
Additional negative indicator species criteria	45	48	93	100	-	-
ALL MANDATORY ATTRIBUTES	45	48	33	15 *	49	23**
ALL ATTRIBUTES	45	48	4	6	7	6
NON-ASSESSED ATTRIBUTES						
Risk of scrub invasion	45	48	84	90	-	-
Vegetation height (drop disc)	45	47	18	30	-	-

[1] Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 15. Lowland Meadows % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		% pass SSSI thresholds		% pass on-statutory thresholds[2]	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
MANDATORY ATTRIBUTES						
Herb cover	50	50	60	26***	78	44***
Negative indicator species	56	52	63	64	-	-
Positive indicator species	56	52	18	8	34	19
Scrub cover	56	52	95	96	-	-
Special positive indicator species	1	2	0	0	-	-
Additional negative indicator species criteria	0	1		100	-	-
Waterlogging indicator species	56	52	91	96	91	98
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	57	52	42	46	-	-
• Failing because sward too tall			100	97	-	-
• Failing because sward too short			0	3	-	-
• Failing because too much/tall rush			0	0	-	-
Litter	56	52	98	91	-	-
Bare ground	56	52	96	100	-	-
Additional negative indicator species criteria	7	5	86	100	-	-
ALL MANDATORY ATTRIBUTES	56	52	13	4	23	8*
ALL ATTRIBUTES	56	52	4	2	5	4
NON-ASSESSED ATTRIBUTES						
Risk of scrub invasion	54	49	100	100	-	-
Vegetation height (drop disc)	57	54	54	63	-	-

[1] Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 16 Upland Hay Meadows % attribute pass rates for stands within and outside agri-environment agreements (1999).

	n[1]		**% pass SSSI thresholds**		**% pass Non-statutory thresholds[2]**	
	Agreement	**Non agreement**	**Agreement**	**Non agreement**	**Agreement**	**Non-agreement**
MANDATORY ATTRIBUTES						
Herb cover	57	48	51	27*	61	40*
Negative indicator species	57	48	93	100	-	-
Positive indicator species	57	48	7	0	14	6
Scrub cover	57	48	98	100	-	-
Additional negative indicator species criteria	56	47	100	100	100	100
Waterlogging indicator species	0	1	-	100	-	100
Rush cover	1	0	100	-	-	-
Deschampsia cespitosa	1	0	100	-	100	-
DISCRETIONARY ATTRIBUTES						
Vegetation height (sward stick)	57	48	95	90	-	-
• Failing because sward too tall			0	0	-	-
• Failing because sward too short			100	100	-	-
• Failing because too much/tall rush			0	0	-	-
Litter	57	48	100	100	-	-
Bare ground	57	48	100	100	-	-
ALL MANDATORY ATTRIBUTES	57	48	4	0	9	4
ALL ATTRIBUTES	57	48	4	0	9	0*
NON-ASSESSED ATTRIBUTES						
Risk of scrub invasion	2	1	100	100	-	-
Vegetation height (drop disc)	57	48	96	90	-	-

[1]Number of sites at which attribute was assessed. [2] When different from SSSI thresholds, otherwise -. Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 17. Comparison of overall pass rates between BAP habitat types

Priority grassland type	LCG n =96	LDAG n=81	LM n=108	PMGRP n=93	UHM n=105
SSSI thresholds					
• All Mandatory attributes	22	16	8	24	2
• All attributes	17	2	3	5	2
Non-statutory thresholds					
• All Mandatory attributes	28	23	16	35	7
• All attributes	18	7	5	6	5

Table 18. Lowland Calcareous Grasslands: differences in mean attribute values between sites within and outside of agri-environment agreements

Attributes	**Non Agreement (n)**	**Agreement (n)**	**P**
% Scrub cover	8.0 (44)	7.8 (52)	n.s.
Vegetation height (drop disc) cm	9.8 (44)	9.3 (52)	n.s.
Vegetation height (sward stick) cm	15.7 (44)	16.9 (52)	n.s.
% cover of negative indicator species	1.4 (44)	3.3 (52)	n.s.
% herb cover	42.5 (44)	55.2 (52)	**
% litter cover	9.9 (44)	12.3 (52)	n.s.
Number of occasional positive indicator species	5.5 (44)	7.7 (51)	***
Number of frequent positive indicator species	3.8 (44)	5.4 (51)	***
Number of occasional negative indicator species	0.6 (44)	0.8 (52)	n.s.
Number of frequent negative indicator species	0.2 (43)	0.3 52)	n.s.
Frequency of scrub and trees (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=61.4 R=22.7 O=9.1 F=0 A=6.8	N=34.6 R=42.3 O=9.6 F=11.5 A=1.9	

Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 19. Lowland Dry Acid Grasslands: differences in mean attribute values between sites within and outside of agri-environment agreements.

Attribute	Non Agreement (n)	Agreement (n)	*P*
% Scrub cover	4.4 (41)	2.7 (40)	n.s.
Vegetation height (drop disc) cm	10.1 (39)	6.4 (39)	n.s.
Vegetation height (sward stick) cm	16.7 (39)	9.1 (40)	***
% cover of negative indicator species	1.5 (40)	2.0 (40)	n.s.
% herb cover	17.0 (40)	22.5 (40)	n.s.
% litter cover	7.9 (41)	5.5 (40)	n.s.
Number of occasional positive indicator species	1.9 (40)	3.0 (40)	**
Number of frequent positive indicator species	0.1 (41)	0.3 (40)	n.s.
Number of occasional negative indicator species	0.2 (41)	0.7 (40)	*
Number of frequent negative indicator species	1.2 (40)	1.8 (40)	*
Frequency of scrub and trees (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=53.7 R=17.1 O=19.5 F=4.9 A=4.9	N=67.5 R=17.5 O=12.5 F=2.5 A=0	
Frequency of bracken (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=73.2 R=14.6 O=2.4 F=4.9 A=4.9	N=82.5 R=7.5 O=7.5 F=2.5 A=0	

Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 20. Lowland Meadows: differences in mean attribute values between sites within and outside of agri-environment agreements.

Attribute	Non Agreement (n)	Agreement (n)	*P*
% cover of water-logging indicator species	1.4 (52)	4.5 (56)	n.s.
% Scrub cover	1.1 (52)	1.2 (56)	n.s.
Vegetation height (drop disc) cm	13.6 (52)	13.5 (56)	n.s.
Vegetation height (sward stick) cm	24.9 (52)	26.9 (56)	n.s.
% cover of negative indicator species	2.9 (52)	2.0 (54)	n.s.
% herb cover	28.5 (52)	39.6 (56)	**
% litter cover	8.0 (52)	2.8 (56)	n.s.
Number of occasional positive indicator species	2.5 (52)	3.3 (56)	n.s.
Number of frequent positive indicator species	1.5 (52)	1.9 (56)	n.s.
Number of occasional negative indicator species	0.8 (52)	0.7 (56)	n.s.
Number of frequent negative indicator species	0.3 (52)	0.4 (56)	n.s.
Frequency of scrub and trees (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=67.9 R=30.2 O=1.9 F=0 A=0	N=76.8 R=19.6 O=3.6 F=0 A=0	
Frequency of bracken (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=96.2 R=3.8 O=0 F=0 A=0	N=92.9 R=7.1 O=0 F=0 A=0	

Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Table 21. Purple Moor Grass Rush Pastures: differences in mean attribute values between sites within and outside of agri-environment agreements.

Attribute	Non Agreement (n)	Agreement (n)	*P*
% cover of water-logging indicator species	52.4 (48)	45.2 (45)	n.s.
% Scrub cover	2.9 (48)	2.8 (45)	n.s.
Vegetation height (drop disc) cm	26.2 (47)	27.9 (45)	n.s.
Juncus height (cm)	49.9 (42)	56.1 (43)	n.s.
Vegetation height (sward stick) cm	30.5 (47)	38.5 (45)	n.s.
% cover of negative indicator species	0.2 42)	0.3 (45)	n.s.
% herb cover	57.7 (48)	54.8 (43)	n.s.
% litter cover	8.0 (48)	3.3 (45)	n.s.
Number of occasional positive indicator species	3.5 (48)	4.8 (45)	*
Number of frequent positive indicator species	0.0 (48)	0.1 (45)	n.s.
Number of occasional negative indicator species	0.1 (48)	0.2 (45)	n.s.
Number of frequent negative indicator species	2.0 (48)	2.6 (45)	n.s.
% *Juncus* cover	50.1 (48)	43.7 (45)	n.s.
Frequency of scrub and trees (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=58.3 R=20.8 O=10.4 F=2.1 A=8.3	N=53.3 R=22.2 O=8.9 F=6.7 A=8.9	

Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001.

Table 22. Upland Hay Meadows: differences in mean attribute values between sites within and outside of agri-environment agreements.

Attribute	**Non Agreement (n)**	**Agreement (n)**	***P***
% cover of water-logging indicator species	0.2 (48)	1.9 (56)	n.s.
% Scrub cover	0.0 (48)	0.1 (57)	n.s.
Vegetation height (drop disc) cm	11.3 (48)	11.3 (57)	n.s.
Vegetation height (sward stick) cm	17.1 (48)	20.3 (57)	n.s.
% cover of negative indicator species	0.1 (48)	0.2 (51)	n.s.
% herb cover	39.6 (48)	48.4 (57)	n.s.
% litter cover	0.8 (48)	1.1 (57)	n.s.
Number of occasional positive indicator species	1.4 (48)	2.5 (1.7)	***
Number of frequent positive indicator species	0.9 (48)	1.4 (57)	*
Number of occasional negative indicator species	0.1 (48)	0.1 (57)	n.s.
Number of frequent negative indicator species	0.0 (48)	0.1 (57)	n.s.
Frequency of scrub and trees (proportion of stands) N=none, R= rare, O=occasional, F=frequent, A=abundant, % of stands. There may be a potential invasion risk when >occasional within the stand.	N=97.9 R=2.1 O=0 F=0 A=0	N=98.2 R=1.8 O=0 F=0 A=0	

Significance of difference between sites within and outside of agri-environment agreements: *=p<0.05, **=p<0.01, ***=p<0.001 (*)=p<0.1.

Appendix 4. Methods of measuring vegetation height

This survey used both a sward stick and a drop disc to measure vegetation height, although only the sward stick was used in the condition assessment. Table 29 summarises the differences sward height results found by applying these two measuring methods. On average the drop disc gave lower measures of vegetation height than the sward stick, and the standard error (SE) of the sward stick measurements was greatest (ie there was greater variability).

Table 29. Comparison of vegetation height measurements using drop disc or sward stick

	Drop disc (cm)	sward stick (cm)	disc:stick ratio
Average	13.9	25.4	0.7
Count	9703	9703	9652
min	0	0	0
max	110	200	9
SE	0.128	0.239	0.005

Appendix 5. Suggestions for future work on the grassland inventories

The following suggestions for future work on the English Nature grassland inventories are made:

- Re-survey grassland inventory sites to:
    - Improve quality and detail of survey information and to include extent of habitat and classify within NVC/BAP priority habitat types;
    - Provide information on site loss and enable updating of inventory accordingly.
    - Correct mapping errors.
    - Expand the digital grassland inventory dataset to include survey details, data source, areas of each type of grassland etc.
    - Keep records of ownership of grassland inventory sites, so as to assist and speed up future survey work. A database may be designed for this task.
    - Identify sites currently not on the inventory.

English Nature is the Government agency that champions the conservation of wildlife and geology throughout England.

This is one of a range of publications published by:
External Relations Team
English Nature
Northminster House
Peterborough PE1 1UA

www.english-nature.org.uk

Cover printed on Character Express, post consumer waste paper, ECF.

ISSN 0967-876X

Cover designed and printed by Status Design & Advertising, 2M, 5M, 5M.

Front cover photographs:
Top left: Using a home-made moth trap.
Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
Paul Glendell/English Nature 23,020
Main: Identifying moths caught in a moth trap at Ham Wall NNR, Somerset.
Paul Glendell/English Nature 24,888

Awarded for excellence