Natural England Commissioned Report NECR156

Assessment of the effect of Environmental Stewardship on improving the ecological status of grassland, moorland and heath

Correlative analysis of datasets to assess the degree of success in the delivery of Environmental Stewardship objectives

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Foreword

Natural England commission a range of reports from external contractors to provide evidence and advice to assist us in delivering our duties. This project is supported by the Rural Development Programme for England, for which Defra is the Managing Authority, part financed by the European Agricultural Fund for Rural Development: Europe investing in rural areas.

Background

This study is one of three to correlatively analyse datasets to assess the degree of success in the delivery of Environmental Stewardship (ES) objectives. The studies are particularly relevant to ES, but do not discount the effects of earlier agri-environment schemes such as Environmentally Sensitive Areas and the Countryside Stewardship Scheme. The objectives for the project are to:

- Provide clear evidence of the extent to which existing ES scheme options have delivered against specific stated objectives or environmental outcomes by using appropriate extensive datasets, suitable for analysis both in spatial and temporal terms.
- Provide recommendations for future monitoring of ES option outcomes and requirements for data gathering or data coordination within and between existing monitoring schemes, including the potential for additional data gathering or modifications to monitoring protocols where this could be undertaken at little additional cost.

The aim is to evaluate how well Government funded agri-environment interventions are providing improved trajectories towards the planned objectives of the schemes.

This study looked at the ecological status of three key habitats (grassland, moorland and heath) within and outwith Higher Level Scheme agreements to examine whether the management options selected were having the intended impact on the status of the habitat.

The results of this report, NECR157 - *Assessing the importance of spatial location of agri environment options within the landscape to butterflies* and NECR158 - *Assessment of the effects of Environmental Stewardship on landscape character* will contribute to a wider analysis of similar linkages between management options and ES objectives, which will be used to help formulate and implement the next Rural Development Programme for England.

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Further information
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Executive Summary

1. This study looked at the ecological status of three key habitats (grassland, moorland and heath) within and outwith Higher Level Scheme (HLS) agreements to examine whether the management options selected were having the expected impact on the status of the habitat.

2. Information on ecological status of HLS options came from a CEH/NE/Defra project to baseline first year agreements and from a separate study of 2-4 year old agreements within six National Character Areas (NCAs). Ecological status for the three habitats in the wider countryside was characterized using vegetation survey data from the Countryside Survey 2007.

3. The sample of HLS options examined in the baseline survey indicates that the options have been well targeted. For grassland (HK) options, 89% of the sites examined were judged to be targeted correctly. For moorland and upland (HL) options, 98% were correctly situated, while for heath (HO) options 83% were judged to be correctly targeted. Incorrect targeting mainly consisted of maintenance options being applied where restoration was more appropriate.

4. The vegetation surveys indicated that within the range of National Vegetation Classification types present within areas under HLS options, the distribution of habitat classes was different on land that had been under agreement for 2-4 years compared to land in the first year of agreement.

5. Locations chosen for HLS options on improved and neutral grassland have been well targeted, with higher coverage of forbs and stress tolerant plants, and higher species richness than for those habitats in the wider countryside. There was no significant difference between the vegetation composition of locations of HLS options on moorland compared to equivalent habitats in the wider countryside.

6. The condition of features detailed on Farm Environment Plans (FEPs) was assessed in both the baseline and 2-4 year-old agreement studies. There was some evidence that features were in better condition on the 2-4 yr old agreements. Condition scores tended to be lower for features on moorland than those on grassland. Differences in the habitat composition of sites in the two surveys (baseline and 2-4 yr old agreements) may confound direct comparison of the headline condition scores between overall condition of features entering HLS agreements and those managed under a HLS agreement for 2-4 years. Assessment of the impact that HLS has on feature condition has therefore been done by examining the difference in the proportion of similar features in each condition class within the two surveys.

7. The Indicators of Success for the options were RAG (Red-Amber-Green) scored for the implementation of options in both baseline and NCA studies. The proportion of options assessed as Green in the agreements that had been in place for 2-4 years was lower than for

options in the new agreements. The proportion of Red scores was similar between the new and established agreements with the proportion of Amber scores increasing. This may be due to surveyors being less uncertain about the risk of failure in the established agreements while giving the new agreements the ‘benefit of the doubt’.

8. Overall, given the short period in HLS agreement for most of the sites, this study has not been able to show that HLS consistently improves all features and habitats when applied, but it has shown that HLS has generally been well targeted with management options chosen that are suitable for the condition of the habitat at the chosen location.

Contents

1. Introduction

This report is part of a series of studies commissioned to determine the extent to which environmental changes can be attributed to the impacts of agri-environment schemes, and within those schemes, individual agreements. The studies are particularly relevant to Environmental Stewardship, but do not discount the effects of earlier agri-environment schemes such as Environmentally Sensitive Areas (ESAs), and the Countryside Stewardship Scheme (CSS).

This analysis aims to provide clear evidence of the extent to which Higher Level Stewardship (HLS) options for grassland, moorland and heathland deliver their specific stated objectives and environmental outcomes. HLS options are the most carefully targeted, and onerous of the ES options, usually requiring carefully prescribed management activities.

The report draws on the work undertaken for the joint CEH/NE/Defra project 'Monitoring of Higher Level Stewardship' and, as such, reflects contributions from Owen Mountford (CEH Wallingford), Simon Smart (CEH Lancaster), Peter Carey (Bodsey Ecology) and Richard Pywell (CEH Wallingford). The key analytical approaches involved the direct comparison of agreement land under HLS with corresponding habitats in the wider countryside. Data representing non-agreement land was drawn from the most recent campaign of Countryside Survey (Carey *et al.* 2008) (which has a poor representation of some of the habitats considered in this report, e.g. heathland).

Since Environmental Stewardship (ES) has only been operative since 2005/6, with most agreements having been in place for much less time than that, the capacity to demonstrate the impact of ES alone (separate from previous agri-environment schemes) is limited. However, the NERC Centre for Ecology and Hydrology worked with Natural England and Defra from 2008-2012 to create a baseline assessment of HLS for the whole of England from which progress toward the desired outcomes could be assessed [NERC project NEC03703 - Monitoring of Higher Level Stewardship – Mountford *et al*. 2010, 2011, 2012; 2013]. The baseline included a random sample of agreements (174 in total) in their first year, stratified in terms of the main HLS options represented on each land holding, with a detailed appraisal of the agreement design and implementation, the condition of the targeted features and the likelihood that desired outcomes would be met (hereafter referred to as the **baseline survey**). Thus the sampling focussed on grassland options in 2009 and 2011 (especially HK6, HK7 and HK8), moorland options (HL9, HL10 and HL11) in 2010 and heathland options in 2011 (HO1, HO2, HO3 and HO4). This baseline survey was complemented by a survey of 62 HLS agreements from six National Character Areas (NCAs) that had been in place for 2-4 years and where the

agreements included grassland, moorland and lowland heathland options (hereafter referred to as **NCA study**).

The preliminary results of the surveys conducted as part of the CEH/NE/Defra project were presented in Mountford *et al.* 2010, 2011 and 2012. The final report for this project is published as Mountford *et al*. 2013 and contains several elements of direct relevance in meeting the objectives of this study.

2. Hypotheses

The objective of the analyses was to determine whether, and to what degree agri-environment agreements, specifically HLS, were contributing to the enhancement of grassland, moorland and heathland habitats.

Our specific hypotheses were as follows:

1. HLS agreements have been targeted to maximise the expected benefit from the agreement.
2. Habitats and vegetation on agreement land selected for Higher Level Stewardship is of higher quality (as measured by species-richness and other ecological indicators) than equivalent habitats on land that was not under agreement.
3. Feature condition and progress towards Indicators of Success are better on land that has been under agreement for some time than on land which is just entering agreement.

3. Methods

The hypotheses were rigorously tested using quadrat data from the CEH/NE/Defra project on HLS (**Baseline Survey**), and this approach is described in detail in the methodology below. However, it should be borne in mind that the greater part of the HLS data available were for agreements in their first year, when divergence due to agri-environment management between HLS land and the wider countryside might be expected to be relatively slight, or influenced either by the previous agri-environment history of the holding or by the criteria used to select holdings for HLS. Hence the results of these comparative analyses of HLS with wider countryside data will essentially provide a test of the effectiveness of HLS selection. This baseline assessment will also form the basis for future tests of HLS effectiveness.

Indications of the improved ecological status of grassland, heathland and moorland can be gained from condition assessments of habitat features, and from assessment of the Indicators of Success (IoS)[1] for relevant options on the surveyed agreements. These assessments were also mainly available for new agreements. However, since these more qualitative analyses were made by expert field ecologists, they do provide some tentative prediction as to the likely progress of the habitat under HLS management toward its desired outcomes, although the actual success after 10 years could only be weakly inferred.

3.1 Data available

CEH and FERA were directly responsible for gathering much of the monitoring data for HLS, and had direct access to other monitoring information. Within the CEH/NE/Defra project (Monitoring of Higher Level Stewardship), the final analyses of data were completed in autumn 2012 (Mountford *et al.* 2013), with access to data from Countryside Survey (CS).

3.2 Qualitative analyses – Feature Condition and Indicators of Success

In addition to this comprehensive comparison with CS data (quantitative analysis described below), other analyses for the present project include vegetation composition and feature condition[2] in HK, HL and HO options as revealed by the CEH/NE/Defra project. Where the CEH survey focussed on agreements that were > 2 years old (**NCA study**) or where it was the subject of a baseline survey by *Just Ecology* (Hewins *et al.* 2008), a more reliable assessment of progress could be made. The presence of EK and EL options was recorded as part of the

[1] HLS agreements have IoS drafted specific to each option, and preferably tailored to the agreement and the particular land parcel, to allow the Natural England advisor and agreement holder to judge whether the agri-environment management is working, and to see whether adjustments are needed.

[2] The main assessment of condition related to FEP feature condition, but where SSSI features were present data were collected that were consistent with a generic Common Standards Monitoring assessment.

mapping exercise in the CEH/NE/Defra project, rather than directly through quadrats and condition assessments, and none of the agreements surveyed contained HLS option HE11.

In this project, the team identified those HK, HL and HO options that were most commonly present in the HLS agreement monitoring data and where the impacts of management on vegetation composition and quality could be more readily assessed (see Table 1). For this purpose, the team compared measures of:

1. Condition assessments in Farm Environment Plans[3] (FEP) and later surveys; and
2. Mapping of target priority habitats for HK, HL and HO options.

The team also reviewed the detailed appraisals made in the CEH/NE/Defra project of HK, HL and HO options *i.e.:*

1. Indicators of Success (IoS) of the HLS agreements [IoS for each option are set out in full within part 3 of the standard HLS agreement documentation]; and
2. Observed option and agreement outcomes and those predicted by expert panels.

3.3 Quantitative Analysis – comparison with Countryside Survey

The underlying approach to the analyses in both the CEH/NE/Defra project (**baseline survey**) and the present Correlative Analysis was to compare the vegetation composition and habitat condition under ES options with equivalent data from Countryside Survey (CS) and thus to assess whether any improvement could be demonstrated in the biodiversity and broader environmental condition of grassland, moorland and heath under ES.

3.4 Analytical methods

The observed botanical diversity in monitored agreements was compared with the expected diversity for the same Broad Habitats[4] derived from the corresponding land classes using the Countryside Survey vegetation survey for plots outside of ES. This analysis examined the presence of relevant indicator species or total species richness.

Species presence and cover data were extracted for the so called "X plots"[5] from Countryside Survey. X plots are located randomly but away from linear features to sample vegetation in unenclosed land, fields and woodlands; the full X plot is 200 m^2 in size. As part of CS2007, a 1m x 1m nested quadrat was censused at the centre of each X plot to enable comparison with

[3] The FEP records the features identified on each land holding proposed for HLS, together with a statement on their condition and may also suggest suitable HLS management options.

[4] The UK Biodiversity Action Plan defined *Broad Habitat* categories (UK Biodiversity Steering Group, 1995, 1998), which are intended to be comprehensive and exclusive, and have been cross-referenced to the *National Vegetation Classification* by Jackson (2000).

[5] See www.countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007/CS_UK_2007_TR2.pdf

data from agri-environment monitoring schemes. These CS data can thus be directly compared with grassland quadrats gathered as part of the HLS survey.

Table 1 ELS and HLS options addressed in this chapter.

ELS Options for grassland outside the Severely Disadvantaged Areas (SDAs)	
EK1	Take field corners out of management
EK2	Permanent grassland with low inputs
EK3	Permanent grassland with very low inputs
EK4	Management of rush pastures
ELS Option for mixed stocking on grassland	
EK5	Mixed stocking
ELS Options for grassland & moorland inside Severely Disadvantaged Areas (SDAs)	
EL1	Take field corners out of management in SDAs
EL2	Permanent grassland with low inputs in SDAs
EL3	Permanent grassland with very low inputs in SDAs
EL4	Management of rush pastures in SDAs
EL5	Enclosed rough grazing
EL6	Unenclosed moorland rough grazing
HLS Options for grassland, moorland and lowland heathland	
HE11	Enhanced strips for target species on intensive grassland
HK6	Maintenance of species-rich, semi-natural grassland
HK7	Restoration of species-rich, semi-natural grassland
HK8	Creation of species-rich, semi-natural grassland
HL9	Maintenance of moorland
HL10	Restoration of moorland
HL11	Creation of upland heathland
HO1	Maintenance of lowland heathland
HO2	Restoration of lowland heathland on neglected sites
HO3	Restoration of forestry areas to lowland heathland
HO4	Creation of lowland heathland from arable or improved grassland

Some other less frequent broad habitats (Dwarf Shrub Heath and Bog) required further processing of CS data because the HLS monitoring used a 4m x 4m quadrat in these habitats but in CS X plots the nearest nest sizes were 2m? x 2m and then 5m? x 5m. Species richness and composition was imputed for a 4m x 4m plot size by fitting a species area curve equation to each CS plot and estimating the richness at this area given the solution of each fitted curve. The difference in species richness between the imputed estimate and the richness observed at the

2m x 2m nest was then used to select individual species to add in to the species list so as to allow computation of adjusted response variables. This was achieved by selecting species present at higher nest sizes in order of their occurrence in the cumulative species list and then by their cover if more than one species was eligible for selection. Species area curves were fitted in WinBUGS using a random slopes and intercepts model (Kéry 2010) to fit $S=c.A^z$ (where S = species richness in nest size A and c and z are parameters estimated for each CS X plot).

3.5 Land class adjustments to CS data

Although some vegetation samples may share a Broad Habitat assignment, differences in response variables would be expected between upland and lowland, or eastern and western examples. For such habitats, targeting concentrated in lowland areas (as was the case in the first year of the baseline survey *i.e.* 2009) would probably lead to a sample that is somewhat different in character from more upland, northern and western situations and so result in an unfair comparison. To ensure appropriate like-with-like comparisons the land class distributions of plots for Dwarf Shrub Heath, Bog and Acid Grassland were examined and any major upland versus lowland imbalances between HLS and CS samples were addressed by removing or adjusting where necessary the proportions of land classes represented in the CS. This resulted in adjustments for some habitats as follows:

- Acid Grassland: Reduction in the number of CS plots in CEH land class 22e (mid and northern Pennines) to the same proportional contribution of the land class as found in the HLS survey sample.
- Dwarf Shrub Heath: No change was made but it should be noted that the HLS survey had many samples located in CEH Land Class 6e in Cornwall and Devon, which is an area represented by fewer samples in CS. The most comprehensive representation of this Broad Habitat in CS is based on samples from the Lake District and Pennines (CEH land classes 17, 18 and 19). Overall there were too few plots to allow for a feasible adjustment to the sample.

3.6 HLS quadrat data

6446 plots were present in the HLS **baseline survey** database. Of these just 100 plots could not be assigned to a single land class (being on the boundary between classes) and 93 plots had no Broad Habitat assignment (being intermediate between habitats). Only 1 plot occurred in both CS and HLS datasets, leaving 6254 plots to be compared with CS data. Of the HLS plots, 46% were assigned to unique Broad Habitats in the field and 54% were assigned probabilistically.

The National Vegetation Classification (NVC) (Rodwell 1991-2000) describes the vegetation of Britain in a series of types that are given a full scientific name (*e.g. Lolium perenne-Cynosurus cristatus* grassland) and a code number *e.g.* MG6, meaning the sixth described type within the mesotrophic grasslands. These types are defined both by their characteristic floristic composition and the environmental conditions under which they occur.

The probabilistic assignment was made using the profile of National Vegetation Classification (NVC; Rodwell 1991-2000) vegetation types to which each plot was classified using the MAVIS software on groups of plots (Smart 2000). MAVIS allows analysis of vegetation data using different types of classifications developed for Great Britain i.e. Countryside Vegetation System (CVS), Ellenberg scores for light, fertility, wetness and pH (Hill *et al.* 2004), competitor scores (derived from the CSR model of Grime *et al*. 1979, 1995, 2007), as well as allocation to the NVC. An outline of the use of MAVIS is presented in an Appendix to this report.

This process allotted the most likely broad habitat for each of these plots based on the observed distribution of broad habitats by NVC units obtained from the cross-tabulation of those 46% of plots with field assignments. This observed matrix was used to compute the parameters of a multinomial model in WinBUGS. Given the profile of NVC allocations for each of the unknown plots, an assignment was made based on the most likely broad habitat estimated from 1000 draws from the model for each plot. This process allocated 95% of the unknown plots to Neutral Grassland. Therefore, in the HLS versus CS comparisons that followed, all plots, whether assigned by surveyor or using MAVIS, were analysed within a single analysis, with the exception of those in Neutral Grassland which were compared against the 'known' field-assigned group and also against the subset of plots assigned probabilistically.

In total, 1479 CS plots were available that occurred in the same land classes and broad habitats as the HLS plots (Figure 1). Few CS plots were available for comparisons for Bog (20 plots) and the results must therefore be treated with more caution than those for the other Broad Habitats. For calcareous grassland there were too few CS samples (7) available for make a meaningful comparison between the HLS and CS plots.

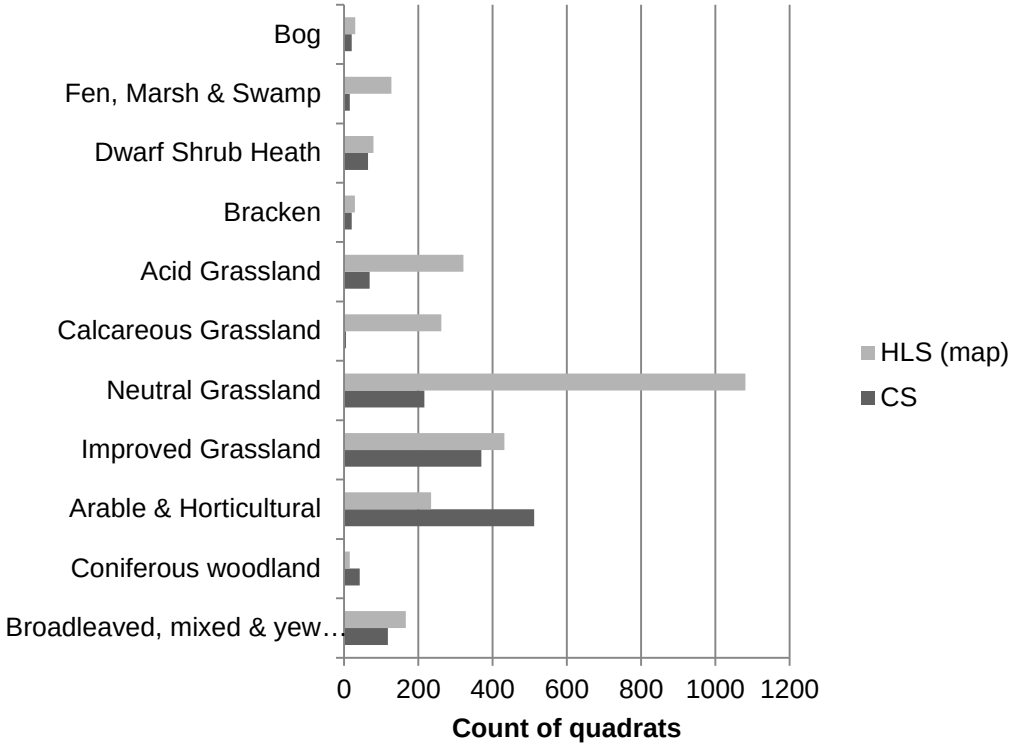

Figure 1 Counts of quadrats assigned to Broad Habitats in HLS monitoring and Countryside Survey datasets.

3.7 Analysis of comparisons between CS and HLS

Statistical models were used to test the effect of survey membership (CS or HLS) on deviations from the overall mean of each response variable. Where this test is significant, in a long run of such comparisons of land represented by each survey it is likely that the two surveys do differ in terms of the response variable. Statistical steps were also taken to cope with the fact that plots in the same 1km square for Countryside Survey, or agreement number for HLS plot, or wider CEH Land Class, were likely to be more similar to each other. This similarity can unduly increase the power of the tests and so an objective means of down-weighting similar plots within such spatial 'blocks' was necessary. Different kinds of models were fitted depending upon the type of response variable analysed. For example species richness values are integer counts that cannot go below zero while bigger mean counts can also have more variation about that mean in a sample of plots. Likewise, cover data can be highly skewed with some very high numbers along-side many zeroes. Analyses were carried out using *proc mixed* or *proc glimmix* in SAS (SAS Institute Inc 2009). *Proc glimmix* in particular is a generalised linear modelling procedure that allows the user to specify distributions of the residual error that are more likely to fit data that consist of many zero values accompanied by a relatively small proportion of larger integers.

Together, these two well established SAS procedures provide a comprehensive set of statistical modelling tools that can help model a range of data types whilst still including random spatial blocking effects within which sample plots were nested such as the 1km square or HLS agreement. Both SAS procedures and SAS in general is a professional, very widely used analytical software system. The use of *proc glimmix* and *proc mixed* are very well established in the scientific literature and the tools of choice that underpin several texts and papers written by world experts (*e.g.* Singer 1998).

3.8 Choice of appropriate response variables

Species lists and taxonomies were made consistent by a prior inspection and allocation of problematic species. Such difficulties mainly referred either to instances where the field teams were unable to separate two (or more) taxa and used a generalised category or where the species was absent from the CS data altogether, as was the case for many nationally rare or alien species. In particular bryophyte species are not comprehensively recorded in CS data and so, together with rarities and aliens, were excluded from all calculations for the purposes of the CS versus HLS comparison. Having unified the treatment of taxa between schemes, fifteen response variables were calculated for each plot (see Table 2 for their names and description).

Table 2 Response variables calculated from the species presence and cover in each HLS and CS plot. Values for Grime indices were extracted from Grime *et al.* (1995) and Ellenberg values from Hill *et al.* (1999) and see Hill *et al.* (2000).

Response variable	Description
Grass:forb ratio	Ln (percentage of grass cover+0.5 / percentage of forb cover+0.5). High values equate with high cover of grasses versus cover of forbs. Where no grass or forb cover was present the plot did not contribute. Where either grass or forb was present only then the cover of the absent growth form was arbitrarily assigned to 0.5
Ericoid cover	Sum of cover of *Calluna vulgaris, Erica cinerea* & *E. tetrali*x. Analyses carried out for plots located in Bog or Dwarf Shrub Heath broad habitats
C	Mean Grime Competitor score – see Carey *et al.* (2008)
S	Mean Grime Stress-tolerator score – see Carey *et al.* (2008)
R	Mean Grime Ruderal score – see Carey *et al.* (2008)
cC	Mean Grime cover-weighted Competitor score (Carey *et al.* 2008)
cS	Mean Grime cover-weighted Stress-tolerator score (Carey *et al.* 2008)
cR	Mean Grime cover-weighted Ruderal score – see Carey *et al.*(2008)
Ellenberg N	Mean Ellenberg fertility score
Ellenberg R	Mean Ellenberg substrate pH score
Ellenberg F	Mean Ellenberg wetness score
Ellenberg cN	Mean cover-weighted Ellenberg fertility score
Ellenberg cR	Mean cover-weighted Ellenberg substrate pH score
Ellenberg cF	Mean cover-weighted Ellenberg wetness score
Species richness	Species richness excluding bryophytes and lichens

4. Results

Most of the results described here are based on analyses of data gathered within the Monitoring of Higher Level Stewardship project. These analyses may be divided into five themes:

1. Analysis of the uptake frequency and coverage of options associated with grassland, heathland and moor (**Contextual information – how extensive are the options? Which are the most important options in enhancing the target habitats?**)
2. Evidence of effective targeting of HLS effort through comparison of options applied with the FEP habitat features and Priority Habitats identified during the field survey of agreements in their first year (relates to **Hypothesis 1: HLS agreements have been targeted to maximise the expected benefit from the agreement. Analysis of whether HLS has been well located; are options positioned where they might most protect and enhance the quality of the target habitats; how does option implementation match the priority habitats recorded in the baseline survey?**)
3. Feature condition and Indicators of Success of agreements in their first year (relates to **Hypothesis 2: Habitats and vegetation on agreement land selected for Higher Level Stewardship is of higher quality than equivalent habitats on land that was not under agreement. Qualitative analysis of the situation revealed by baseline survey, providing an informed prediction of the likely result of HLS management; how species-rich are the habitats; which plant communities are represented; in what condition are the target features; will the Indicators of Success be met?**)
4. Direct comparison of land under HLS with equivalent habitats within the wider countryside as indicated by the *Countryside Survey*. (**Hypotheses 2 and 3. Rigorous quantitative analysis of HLS against non-agreement land in the baseline survey – has HLS been well-located on high quality land and is there any early evidence of progress toward the desired outcomes. Together with Theme 5, this approach represents the core of the analyses relevant to the present report.**)
5. Assessment of progress toward desired outcomes as shown by HK, HL and HO options that had been applied for at least two years. (**Hypothesis 3: Feature condition and progress towards Indicators of Success are better on land that has been under agreement for some time than on land which is just entering agreement. NCA survey: are feature conditions and progress toward IoS better than in the baseline survey? The results of this survey were assessed using approaches comparable those followed for the baseline survey *i.e.* Themes 1-3**)

4.1 Theme 1. Analysis of the uptake frequency and coverage of options associated with grassland, heathland and moor

By the end of September 2012, over 5.5 million hectares of land in England had been included within Environmental Stewardship, although the area under HLS option was considerably less than this. The take-up of the key options for grasslands, moorland and rough grazing, and lowland heathland is summarised in Table 3, with a fuller summary in Appendix Table A1[6] detailing all other relevant Higher Level Stewardship, Entry Level Stewardship and organic variants.

Table 3 Key Environmental Stewardship Options for grassland, moorland and lowland heathland implemented in England (up to mid-September 2012); listing the number of agreements containing each option and the total area under management by each option.

HLS option	Agreements Containing Selected Options	Option Area (Ha)
All Options (ELS,OELS,HLS)	9,895	5,542,248.0
HK6 - Maintenance of species-rich, semi-natural grassland	2,442	26,450.34
HK7 - Restoration of species-rich, semi-natural grassland	3,836	49,292.96
HK8 - Creation of species-rich, semi-natural grassland	480	4,543.13
HL9 - Maintenance of moorland	249	100,078.89
HL10 - Restoration of moorland	840	296,990.86
HL11 - Creation of upland heathland	18	1,919.53
HO1 - Maintenance of lowland heathland	187	8,202.68
HO2 - Restoration of lowland heath	382	33,190.75
HO3 - Restoration of forestry areas to lowland heathland	87	1,661.62
HO4 - Creation of lowland heathland from arable or improved	25	212.59

These data give an indication of the relative effort devoted to different habitats, though it should be borne in mind that without detailed examination of each agreement, one cannot judge the degree of overlap *i.e.* the extent to which ELS and HLS options or HLS main options and HLS supplements had been applied to the same parcel of land. However, whilst noting this caveat, certain overall patterns may be inferred, which are discussed below. The analytical results (Themes 2-5) focus on these most important options in enhancing the target habitats.

[6] Tables and figures found in the Appendix are prefixed with the letter A.

4.2 Theme 2. Qualitative Analysis of Samples from the HLS Baseline Survey

Evidence of effective targeting of FEP features and HLS options

Fundamental to the implementation of HLS is the principle that options should be matched to the FEP features that are present on the ground. Thus habitat management options within the HK, HL and HO groups should be closely associated with specific grassland, moorland and heathland features recorded in the original Farm Environment Plan. The association between features and options helps to demonstrate whether agri-environment activity has been properly targeted and whether HLS and related schemes are likely to improve the ecological status of grassland, heathland and moorland.

HLS options also include specific approaches to the management of lowland heathland, as well as supplements for grassland and moorland situations that can overlay the main management options, and which often can only be used with specific options. There are 15,814 instances of HK management options for grassland being used in HLS agreements at the holding level (potential maximum coverage 223,615 ha). In addition, grassland supplements (HK18 and HK19) have been used on 1752 occasions, with a maximum extent of 16,196 ha. The equivalent totals for moorland and rough grazing options (HL) are 2,359 instances of main management options (potential maximum extent 437,255 ha) and 888 cases of supplements (up to 309,579 ha). Finally the five main management options for lowland heathland (HO) have been used on 685 occasions, with a potential maximum extent of 43,283 ha.

The key options for the maintenance, restoration and creation of grassland and moorland habitats are amongst the most extensively applied in Higher Level Stewardship. The grassland options HK6-HK8 have been employed on 6,758 occasions, with coverage of 80,286 ha. Of these options, HK7 restoration has been the most extensively applied to species-rich semi-natural grassland. Options for moorland HL9-HL11 have been implemented on fewer occasions (1107) but over a potential maximum area of 398,989 ha. Again it is the restorative option (HL10) that has been most extensively applied.

The usage of organic options is more restricted and, within HLS, confined to “more of the same” options (*i.e.* developments of the original OELS options). OELS options for grasslands (OK1-OK5) have been implemented on 748 instances up to the end of September 2012, potentially covering 17,040 ha, whilst the rough grazing equivalents (OL1-OL5) have only been applied on 160 occasions, with a potential maximum coverage of 5896 ha. Usage of OHLS options has been even more limited, with just 185 instances of grassland options OHK1-OHK5 (up to 3808 ha) and only 44 cases of rough grazing options OHL1-OHL5 (potential maximum extent 485 ha).

During the baseline survey for the HLS Monitoring project, maps were prepared recording Broad and Priority Habitats, as well as the full range of FEP point, linear and habitat features. Comparisons of grassland, upland and lowland heathland options with the FEP habitat types recorded are presented in Tables A2-A4. Under each HK, HL and HO option, the total area surveyed is subdivided into areas mapped by the survey as specific FEP habitat features. Numerous FEP codes were recorded during the baseline survey but where a particular habitat feature occupies <1.5% of the total area under that option, the FEP habitat feature is not itemised but instead included in a general category "Other FEP codes". Although the results tables include information for all HK, HL and HO options, discussion here focuses only on the key options listed in Table 3. The results presented in Tables A2-A4 are summarised in Table 4, indicating the proportions of land where options are a) properly targeted on BAP Habitat; b) properly targeted on other habitats; and c) where there is evidence that the option was located on an inappropriate habitat.

Table A2 presents the results for grassland options and supplements. The most extensive options recorded were for species-rich semi-natural grassland (HK6 and HK7) and grassland for target features (HK15 and HK16). Where HK6 (maintenance of species-rich semi-natural grassland) is practised, just over half the area under this option was mapped as BAP grassland type *i.e.* the main target features for this option. A further 22% was classified as semi-improved grassland. Most of the remaining HK6 area was mapped under diverse non-grassland habitats (*e.g.* small areas of woody, wetland and tall herb vegetation present within the same parcel as the target grassland). Results for HK7 (restoration of species-rich, semi-natural grassland) are broadly similar, although the area under BAP grassland types is only 37% and that under semi-improved grassland as much as 42%. Only 4,500 ha of HK8 (creation of species-rich, semi-natural grassland) have been implemented nationally (Table 1) of which just 20 ha were included in the baseline survey. Despite the early stage of these agreements, the broad composition of 13 ha had already developed into target grassland types.

Table A3 gives a corresponding summary for moorland and upland rough grazing options. The most extensively applied options are those intended to benefit existing unenclosed upland habitats (HL9 and HL10) *i.e.* two of the key options for the present study.

Table 4 Summary of habitats mapped during the baseline survey of HLS Grassland options, showing proportions under appropriate (BAP and other) and apparently inappropriate habitats.

	Total Area (ha)	Appropriate BAP habitats	Non-BAP Habitats (appropriate to option)	Habitats inappropriate to option
HK2 - Permanent grassland with low inputs	**29**	**1**	**28**	
HK3 - Permanent grassland with very low inputs	**97**		**97**	
HK6 - Maintenance of species-rich, semi-natural grassland	**579**	**293**	**283**	**3**
HK7 - Restoration of species-rich, semi-natural grassland	**649**	**242**	**391**	**16**
HK8 - Creation of species-rich, semi-natural grassland	**20**	**10**	**10**	
HK10 - Maintenance of wet grassland for wintering waders/wildfowl	**56**	**3**	**53**	
HK11 - Restoration of wet grassland for breeding waders	**49**	**4**	**45**	
HK13 - Creation of wet grassland for breeding waders	**10**		**10**	
HK14 - Creation of wet grassland for wintering waders/wildfowl	**2**		**2**	
HK15 - Maintenance of grassland for target features	**793**	**74**	**419**	**301**
HK16 - Restoration of grassland for target features	**476**	**322**	**154**	
HK17 - Creation of grassland for target features	**45**	**28**	**17**	
HK18 - Hay making supplement	**128**	**35**	**93**	
HK19 - Raised water levels supplement	**27**	**11**	**16**	
Total Areas of habitats mapped in grassland options (ha)	**2960**	**1023**	**1619**	**320**
% of this Total Area by appropriateness of targeting		**34.5%**	**54.7%**	**10.8%**
HL2 - Permanent grassland with low inputs	**5**		**5**	
HL3 - Permanent grassland with very low inputs	**36**		**35**	**1**
HL5 - Enclosed rough grazing	**12**	**7**	**2**	**3**
HL6 - Unenclosed moorland rough grazing	**32**		**32**	
HL7 - Maintenance of rough grazing for birds	**340**	**18**	**322**	
HL8 - Restoration of upland grazing for birds	**216**	**6**	**210**	
HL9 - Maintenance of moorland	**2527**	**2138**	**274**	**115**
HL10 - Restoration of moorland	**4091**	**2237**	**1832**	**22**
HL11 - Creation of upland heathland	**271**	**15**	**256**	
Total Areas of habitats mapped in upland options (ha)	**7530**	**4421**	**2968**	**141**
% of this Total Area by appropriateness of targeting		**58.7%**	**39.4%**	**1.9%**
HO1 - Maintenance of lowland heathland	**309**	**231**	**13**	**64**
HO2 - Restoration of lowland heathland on neglected sites	**147**	**85**	**47**	**15**
HO3 - Restoration of forestry areas to lowland heathland	**16**		**14**	**2**
HO4 - Creation of lowland heath from arable or improved grassland	**4**		**4**	
Total Areas of habitats mapped in heathland options (ha)	**476**	**316**	**78**	**81**
% of this Total Area by appropriateness of targeting		**66.4%**	**16.4%**	**17.0%**

Under HL9 (moorland maintenance), 79% was mapped as upland heathland during the baseline survey and most of the remaining 21% was allocated to other upland associated habitats *i.e.* M01 grass moorland and rough grazing, M02 fragmented heath, M06 blanket bog and M08 upland flushes *etc*. Very occasionally, native semi-natural woodland (5%) and bracken (4%) were recorded under HL9, both typical minor elements of the upland habitat mosaic. Where HL10 (moorland restoration) is applied, the habitats present are more mixed with just 18% assessed as upland heathland and 30% being grass moorland and rough grazing. Blanket bog appeared far more extensive under HL10 than under HL9, probably reflecting regional and local targets to protect and restore degraded blanket bog (and other habitats on deep peat soils) to reduce carbon losses. Less than 2000 ha of HL11 (creation of upland heathland) had been attempted in England, and of the 271 ha included in the baseline survey, greater than 75% was M01 grass moorland.

Lowland heathland (HO) options are presented in Table A4, where M03 lowland heathland was the main target. In the HO1 (maintenance of lowland heathland) option, 61% of the area was mapped as BAP lowland heath, with BAP lowland dry acid grassland also a significant habitat. Small areas of non-native plantation and landmark woodland were present within the heaths surveyed. Where restoration of heath was attempted on neglected sites (option HO2), only 50% of the area was identified as heath and much of the remainder reflected the history of neglect, being under various scrub and woodland types. According to the BAP definition this may still technically be heathland, albeit in unfavourable condition (e.g. >25% ericaceous species and 50% scrub).

Of the 1662 ha of HO3 (restoration of forestry areas to lowland heath) implemented thus far in England, only 16 ha were included within the baseline survey and, at this very early stage in the agreements, most of this was still non-native plantation or other woodland types. Only 213 ha of HO4 (creation of lowland heathland from arable or improved grassland) had been employed by the autumn of 2012, with only 4 ha included in the survey. The other heathland creation option for worked mineral sites (HO5) was not covered by the HLS Monitoring project since less than 16 ha had been implemented in the whole of England.

Overall, the locations of HLS options in grassland, upland and heathland are appropriate, with ≤5% certainly located in situations where the prescribed management would not achieve the desired outcomes (Table 4). About 52.5% of the mapped area was within BAP habitats whilst the remaining 42.5% lay within non-BAP habitats where some benefits should accrue from applying the HLS management. However, both the judgement of the field surveyors and appraisal by expert panels indicated that maintenance options were sometimes applied where a restorative approach was needed.

Table 5 Proportion of area mapped in each HLS option allocated by the baseline survey to Priority or non-Priority Habitat.

	% Priority Habitat	% Non-Priority Habitat
HK2 - Permanent grassland with low inputs		100
HK3 - Permanent grassland with very low inputs	6	94
HK6 - Maintenance of species-rich, semi-natural grassland	32	68
HK7 - Restoration of species-rich, semi-natural grassland	35	65
HK8 - Creation of species-rich, semi-natural grassland	22	78
HK9 - Maintenance of wet grassland for breeding waders	25	75
HK10 - Maintenance of wet grassland for wintering waders and wildfowl	40	60
HK11 - Restoration of wet grassland for breeding waders	28	72
HK12- Restoration of wet grassland for wintering waders and wildfowl		100
HK13 - Creation of wet grassland for breeding waders		100
HK14 - Creation of wet grassland for wintering waders and wildfowl	7	93
HK15 - Maintenance of grassland for target features	46	54
HK16 - Restoration of grassland for target features	35	65
HK17 - Creation of grassland for target features	3	97
HK18 - Hay making supplement	29	71
HK19 - Raised water levels supplement	2	98
% of Total Area	**35**	**65**
HL2 Permanent grassland with low inputs		100
HL3 Permanent grassland with v. low inputs	20	80
HL5 Enclosed rough grazing	59	41
HL6 Unenclosed moorland rough grazing	89	11
HL7 Maintenance of rough grazing for birds	9	91
HL8 Restoration of upland grazing for birds	12	88
HL9 Maintenance of moorland	70	30
HL10 Restoration of moorland	53	47
HL11 Creation of upland heathland	24	76
% of Total Area	55	45
HO1- Maintenance of lowland heathland	75	25
HO2 - Restoration of lowland heathland on neglected sites	69	31
HO3 - Restoration of forestry areas to lowland heathland	4	96
HO4 - Creation of lowland heath from arable or improved grassland	13	87
% of Total Area	70	30

4.2.1 Association between Priority Habitats and HLS Options

Similar comparisons to those made for FEP features in the last section can be made for mapped Priority Habitats and HLS options. The summaries and tables listed below give area covered by the baseline survey under each option, followed by the percentages either allocated to any Priority Habitat or to non-Priority habitat. As with the investigation of FEP habitat features, discussion here focuses mainly on the key habitats, although a summary is given of the overall proportions of Priority and non-Priority habitats mapped within all HK, HL and HO options during the baseline survey (Table 5).

4.2.1.1 Grassland

There were examples of most HK options in the baseline survey. 3220 ha were surveyed in total, 34% of which was allocated to one of 16 Priority Habitats (Table A5). Maintenance, restoration and creation options accounted for 2810 ha, of which 54% were maintenance, 43% restoration options and only 3% creation options. The options aimed at species-rich semi-natural grassland are most relevant to Priority Habitats, totalling 577 ha, 664 ha and 20 ha for maintenance, restoration and creation respectively (Table A5). The maintenance option (HK6) comprised 32% Priority Habitats and 68% non-priority habitat. The restoration option (HK7) comprised 35% Priority Habitats and 65% non-priority habitat. Finally, creation option (HK8) comprised just 22% Priority Habitats and 78% non-priority habitat.

4.2.1.2 Moorland and Upland Grazing

In total 7430 ha of these options were surveyed (Table A6), with 56% assigned to Priority Habitats (overwhelmingly Upland Heathland). Most of the non-Priority Habitat surveyed was identified as the Acid Grassland Broad Habitat, apparent when examining the Land Cover Map of 2007 (LCM). Acid Grassland was identified in 23% of the area surveyed and Rough Low Productivity Grassland (mostly acid grassland) in <1%. There is a big discrepancy between the areas identified as Blanket Bog by the surveyors (6%) and that identified by LCM (19%). Given the expertise of the field surveyors, their site-specific classification is more likely to be accurate whilst the LCM may confound other Ericoid-or Graminoid-dominated habitats with bog.

4.2.1.3 Lowland Heathland

Based on the digitised agreement maps of the surveyed land, four of the five lowland heathland options were used. A total of 476 ha from lowland heath options were surveyed in the baseline portion of the HLS Monitoring project, with 55% identified as Lowland Heathland Priority Habitat, 11% Lowland Dry Acid Grassland Priority Habitat and most of the rest as non-Priority habitat (Table A7).

4.2.2 Summary

This review of option targeting and the agreements mapped in the baseline survey indicated:

- HLS options for grassland (HK), upland (HL) and heathland (HO) may cover an area of land in excess of 700,000 ha, although some areas of land can be recorded under multiple options.
- The key options for maintenance and restoration of semi-natural habitats are the most frequently and extensively used, especially the restorative options for species-rich semi-natural grassland (HK7), moorland (HL10) and heathland (HO2).
- The baseline survey mapped the extent of FEP features (including BAP habitats) and Priority Habitats on the surveyed agreements. This assessment generally indicated appropriate matching of options to features, but with evidence of local "feature inflation" whereby maintenance options were applied to poorer quality features that would benefit from a restorative approach.
- Problems with misallocation of options to features were most apparent in grassland, less so in moorland and in heathland, where application of HLS options was mainly well-targeted.
- Due to effective targeting, habitats under Higher Level Stewardship should be of higher quality than those in the countryside as a whole. This apparent trend was tested more rigorously through Theme 4 (see section 4.4).
- With some local exceptions, the Farm Environment Plan (FEP) and its linked map provide a detailed and accurate description of HLS agreements at the time of implementation. This original description of FEP feature condition and distribution could also provide a qualitative baseline from which progress to the desired goals could be measured, but FEPs lack the quantitative information provided by vegetation quadrats etc that provide for a more robust baseline.

4.3 Theme 3. Feature condition and Indicators of Success of agreements in their first year

The baseline survey component of the Monitoring of Higher Level Stewardship project examined 103 different HLS options, recording vegetation quadrats and making assessments of feature condition, as well as Indicators of Success (IoS).

4.3.1 Species richness, community type and vegetation structure

Table 6 provides a summary of those HK, HL and HO options that occurred in a minimum of ten of the surveyed and assessed agreements. The most frequently assessed options focused on grasslands, especially species-rich, semi-natural grassland (HK6 and HK7), though management for target features (HK15 and HK16) was also common in the surveyed agreements.

Table 6 HLS options (HK, HL and HO) assessed during the baseline survey in ten or more agreements, recording the total of RLR parcels[7] (or habitat features in the uplands) surveyed and mean species-richness of the survey quadrats.

HLS Option Code	Number of Agreements*	Number of Surveys (RLR parcels *etc*)	Mean Species Richness	Standard Error
HK7	65	195	11.65	0.28
HK6	50	110	13.12	0.44
HK15	33	107	9.01	0.34
HL10	31	70	9.83	0.77
HK16	21	42	10.91	0.69
HK3	11	19	9.00	1.07
HO2	10	30	10.50	0.79

*Results arranged by frequency of assessment. Note that where a parcel contains more than one HLS option, it will contribute to the totals for all assessed options

Each quadrat was classified within the types of the NVC using the MAVIS software package. Table 7 gives a summary of these results indicating NVC types to which the quadrats of the baseline survey were most frequently allocated. Where other NVC types were well-represented (though less frequently) these too are indicated. The table distinguishes cases where particular sub-communities or communities were especially associated with individual HLS options from those where several (or many) NVC types were represented within the quadrats of the baseline survey.

[7] RLR parcel numbers are those set by the Rural Land Register as a central database for Defra and provide all fields and other land parcels with a unique number comprising a 6-digit national grid reference (designating a 1 km square) and a further 4 digits denoting the individual parcels.

Table 7 HLS options (HK, HL & HO) and types of the National Vegetation Classification (NVC) to which quadrats were most frequently allocated in the baseline survey.

HLS Option Code	NVC Community(s) most often recorded	Other NVC types frequently recorded
HK3	MG6	MG7
HK6	MG6 (especially MG6b), MG9, MG10a and U4b	Various semi-natural MG and CG types
HK7	MG6 (especially MG6b), MG10a and MG7 (especially MG7d)	Wide range of CG, M, MG and U types
HK9	MG11a	MG10a
HK10	MG10a	Other MG types
HK11	Various MG types	
HK15	MG6 (especially MG6b), MG7 (especially MG7a), MG10 (especially MG10a) & MG11 (especially MG11a)	
HK16	MG10a	MG6 and MG7
HK17	Various MG and OV types	
HL2	MG6 and MG7	
HL3	MG6	
HL7	MG6b	U4b
HL8	Various M, MG and U types	
HL10	Various H, M and U types	
HL15	Various H, M and U types	
HO1	U1	Various H types

HLS grassland options were clearly associated with specific *NVC* grassland communities, most often variants of MG6 *Lolium perenne-Cynosurus cristatus* grassland. MG6b *Anthoxanthum odoratum* sub-community prevailed where botanical quality was higher, though MG7 *Lolium perenne* grassland was often extensive despite HLS management. Where there were options for species-rich, semi-natural grassland (HK6 & HK7), quadrat data showed a wide range of *NVC* types including calcicolous grasslands (CG), acid grasslands (U) and fen meadows (M). Grasslands managed for target features were referable to varied *NVC* communities, though coarser types such as MG10a (typical *Holcus lanatus-Juncus effusus* rush-pasture) are especially common. Where HLS management options targeted waders and wildfowl (*e.g*. options HK9 and HK10), moister mesotrophic grasslands were found *e.g.* MG10a and MG11a

(the *Lolium perenne* sub-community of *Festuca rubra-Agrostis stolonifera-Potentilla anserina* grassland).

Moorland and upland rough grazing options (HL) were classified in two groups. Rough grazing options were mainly associated with MG6 *Lolium perenne-Cynosurus cristatus* grassland, whilst moorland options that represent the focus of the present project included a wide variety of heath, mire and acid grassland communities. Lowland heathland options (HO) had quadrats referable to a similar range of *NVC* types, together with woodland communities where heath was being restored on previously neglected sites (option HO2).

Field data for unenclosed upland vegetation were also summarised by vegetation height and other structural aspects, with direct comparison of HL9 moorland maintenance and HL10 moorland restoration. Table 8 describes the differences in cover of total dwarf shrubs and heather (*Calluna vulgaris*) between HL9 and HL10, as well as mean heights of heather and any graminoid (*Trichophorum, Eriophorum* and *Juncus* species) sward. Results are presented by both HLS option and survey protocol, though the five protocols used (dry heath, mixed dry/wet heath, mixed mire/wet heath, mires and grass moorland) used identical recording methods for structural variables (Mountford *et al.* 2011; 2013).

Dwarf shrub cover and that of *Calluna* alone were always higher in HL9 than in HL10 for upland heath and mire. Dwarf shrub cover was highest in heath vegetation and <5% on grass moor regardless of option. Heather height showed a similar pattern, with a mean height of *ca.* 31 cm on heath and mire under HL9, but only *ca.* 23 cm where HL10 was applied. However, where *Calluna* does occur on grass moorland, the growth appears to be taller under HL10 than under HL9. Finally examination of the graminoid sward height revealed that on all moorland types the vegetation was considerably coarser under HL10. Where graminoids occurred within a dwarf shrub dominated heath or on grass moorland, the mean sward height was *ca.* 7.5 cm under HL9 and *ca.* 12.5 cm in land managed within HL10. Graminoids have higher cover on upland mires than on heaths, and sward heights are correspondingly much higher, but the differential between HL9 and HL10 remained, with the maintenance option (HL9) having a mean height of *ca.* 16 cm, whilst mires under HL10 have a mean sward height of almost 40 cm.

Detailed analysis of lowland heathland condition was not possible due to insufficient sample size.

Table 8 HLS survey of unenclosed upland habitats under options HL9 and HL10: Summary data for vegetation structure. Note: in a very few cases, the heather height data were not recorded and hence neither standard deviation nor standard error could be calculated.

Survey Type	HLS Code	Mean Dwarf Shrub Cover		Mean Heather Cover		Mean Heather Height (cm)		Mean Sward Height (cm)	
		Mean %	S.E.	Mean %	S.E.	Mean height (cm)	S.E.	Mean height (cm)	S.E.
Dry Heath	HL9	69.54	6.91	47.69	4.70	34.81	1.49	8.4	1.43
	HL10	36.69	7.62	28.91	7.86	24.68	3.69	13.2	4.37
Dry/Wet Heath (Mosaic)	HL9	65.29	4.72	43.58	5.14	34.35	2.82	6.6	0.77
	HL10	40.49	5.94	24.47	6.43	25.28	3.38	14.2	1.87
Grass Moorland	HL9	3.58	2.23	2.55	1.73	12.50	1.77	7.8	2.74
	HL10	3.51	1.93	3.13	2.21	21.67	n/a	10.2	1.59
Mire/Wet Heath (Mosaic)	HL10	21.04	10.54	18.52	11.28	18.75	3.39	16.4	6.32
Mires	HL9	26.22	16.13	32.15	16.63	23.38	6.45	15.9	6.43
	HL10	14.88	6.94	8.91	8.70	18.63	n/a	39.4	0.31

4.3.2 Condition of FEP features

1200 assessments of FEP features (mainly habitats, but also historic and landscape) were conducted during the baseline survey. The survey methodology focussed principally on HLS options addressing the main habitats within the RLR parcels, rather than either the field boundaries (feature code F) or scrub, bracken and other tall vegetation (feature code V). Table 9 summarises the condition assessments for those grassland and heath/moor FEP features gauged on at least 10 occasions.

Table 9 FEP features and condition assessed by the HLS baseline survey of 2009-11*.

FEP Features	**FEP feature condition**				
	A	**A/B**	**B**	**B/C**	**C**
G01 Improved grassland	10		73		17
G02 Semi-improved grassland	21	1	44	2	32
G03 Species-rich grassland	21		42	3	34
The following six FEP features are types of BAP grassland					
G04 Lowland Calcareous	20	17	17	6	41
G05 Lowland Acid	12		41		47
G06 Lowland meadow	21		32	3	44
G07 Purple moor-grass & rush	21	2	48	4	25
G08 Upland calcareous	38	19	24	9.5	9.5
G09 Upland hay meadow	11		32	11	47
The following two FEP features are habitats for breeding waders					
G12 Lowland wader habitat	20		50		30
G14 Upland wader habitat	31		31		38
G15 BAP grazing marsh	47		41		12
M01 Grass moorland & rough grazing	18	18	18		45
M03 BAP lowland heath	14	7	21	7	52
M04 BAP upland heath	24	5	46	8	16
M06 BAP blanket bog	5	10	43	19	24
M08 BAP upland flushes *etc*	33	6	44		17
ALL FEATURES	26	4	38	4	27

*Notes: Results refer to the percentage of assessments in each condition category; results are presented for features assessed in ≥10 locations; features assessed more than once in an agreement (*i.e.* in separate parcels *etc*) are counted as distinct locations.

Condition assessment follows the standard approach described in the FEP features manual (Natural England 2010), allocating condition to one of three possible assessment categories: A, B or C, but allowing for the possibility of transitional categories (A/B and B/C) where the condition was indeed intermediate. Within the FEP procedure, each feature that requires a condition assessment has a series of condition criteria associated with it (usually four criteria per feature type). If the feature achieves all these criteria, then the condition assessment category is A (good) and the HLS option selected will be for maintenance. If one criterion is not achieved, the condition is classified as B (moderate) and the HLS management option should be to either maintain or restore the feature. Finally, where two or more criteria are not met, the condition is C (poor), and restorative HLS options will certainly be required.

Overall, 27.6% of FEP features were in condition A, 42.2% in condition B and the remaining 30.2% in condition C. Some feature types (especially amongst the most frequently assessed) had condition scores distributed fairly evenly over the categories *e.g.* G02 semi-improved grassland, G03 species-rich grassland and grasslands for breeding waders (G12 and G14). Few features were consistently in good condition, although some BAP habitats (G08 upland calcareous grassland and G15 grazing marsh) were frequently scored as A. Amongst feature types most often scored in condition B were G07 purple moor-grass and rush pastures and moorland habitats (M04, M06 and M08).

Amongst the grassland, heathland and moorland habitats, only BAP lowland heaths (M03) had more than half the samples in condition C. However, most BAP grasslands and the broader categories of semi-improved and species-rich grasslands, as well as M01 grass moorland had a large proportion (30-50%) of features classified as in poor condition.

4.3.3 RAG assessment of Indicators of Success (IoS)

All measurable Indicators of Success (IoS) were given a "RAG assessment"[8] by the field teams. Assessment was based upon a field assessment at each agreement of what was observed for a particular IoS for a specific option. Many options had several IoS and particular options were often applied to more than one parcel on a holding. Hence the number of individual RAG assessments, made for each option-parcel combination, resulted in several thousand IoS

[8] **G** = **Green**. The IoS has already been achieved or it is (almost) certain that it will be achieved within the duration of the HLS agreement. There is no (or minimal) risk that the desired outcomes will not be met.

A = **Amber**. Some doubt that the IoS will be achieved and a moderate risk that the desired outcomes will not be met. The management prescriptions may appear appropriate but they may be ambitious or require rigorous implementation.

R = **Red**. High risk that the IoS will not be achieved within duration of agreement. Site conditions may be such that the IoS is impossible to meet practically or HLS management prescriptions require complete revision to meet desired outcomes.

assessments being made. If results for parcels on the same holding are combined, this reduces to 714 assessments of distinct agreement-option combinations. For each option in each agreement, a range of RAG scores might be given, varying between IoS and between RLR parcels.

Table 10 summarises results of these assessments through three categories (Mountford *et al.* 2013). Where individual options were assessed less frequently, results are pooled by option group. Although not all indicators are necessarily of equal importance, the general rates of success are indicative of overall progress with HLS agreements and their component options. The results in Table 10 suggest that 56% of options had achieved all their IoS by the time of survey or were judged by the field teams as certain to achieve these indicators within the span of the agreement. For a further 20.6% of options, one indicator had been given a Red (very likely or certain not to achieve the indicator) assessment. In 23.6% of options, more than one IoS received a Red assessment.

Table 10 RAG assessments of Indicators of Success (IoS) for HLS options made during the HLS baseline survey of 2009-2011 (Results are presented for those individual HLS options assessed in 10 or more agreements – results for other options are summarised at the level of the HLS option group).

HLS option	**Results of RAG assessment of measurable IoS**		
	All Green	**One Red**	**>1 Red**
HK less frequent options	33	7	4
HK6	24	14	16
HK7	33	16	18
HK9	5	3	2
HK15	15	7	10
HK16	15	7	1
HL less frequent options	17	2	6
HL8	8	1	2
HL10	40	13	18
HL15	9		1
HO less frequent options		3	3
HO2	4	2	5

4.4 Theme 4. Direct Comparison of land under HLS (Baseline Survey) with equivalent habitats in the wider countryside (Countryside Survey)

The effectiveness of targeting with HLS was investigated through comparison of species composition and richness of HLS samples *vs.* the wider English countryside, the latter represented by vegetation samples drawn from the Countryside Survey (CS) 2007 database (Carey *et al.* 2008). To achieve this, one must derive ecologically equivalent samples *i.e.* the same kinds of vegetation are being contrasted

Species-compositional equivalence was ensured by using the Broad Habitat assignment for each plot as the common unit. Only data for English CEH land classes (Bunce *et al.* 1996; Carey *et al.* 2008 – see Table 11) represented in both HLS and CS were analysed and adjustments made where necessary to ensure an even representation of upland and lowland locations in both datasets.

The overall approach is derived and adapted from that used by Carey *et al.* (2002) to compare the ecological quality of land in Countryside Stewardship Scheme (CSS) with that in the wider countryside and also builds on the methods applied to the last Countryside Survey (Carey *et al.* 2008). Fundamentally this assessment of HLS tests whether land selected for the implementation of HLS is of a higher environmental quality than otherwise ecologically equivalent land (habitats and vegetation) in the wider countryside.

Results presented make a rigorous comparison of a range of response variables derived from the vegetation composition of quadrats gathered during the HLS baseline survey with the same array of variables obtained from quadrats collected during the fieldwork for Countryside Survey 2007. A full summary of the results by broad habitat is included within an Appendix to this report: a) Improved grassland (Table A8 and Figure A1); b) Neutral grassland (Tables A9-A10 and Figure A2); c) Acid grassland (Table A11 and Figure A3); and d) Dwarf shrub heath (Table A12 and Figure A4).

Table 11 Summary names for CEH land classes used to make comparisons between CS and HLS data. All land classes are for England (suffix e) except 5w which is described for Wales but also occurs in England (the Marches).

Land Class Code	**Summary name of Land-class**
1e	Flood plains/shallow valleys, S England
2e	Low calcareous hills/variable lowlands, S England
3e	Flat/gently undulating plains, E Anglia/S England
4e	Flat coastal plains, E Anglia/S England
5e[1]/5w[2]	Shallow slopes/flood plains, [1]S-W England, [2]Wales
6e	Complex valley systems/table lands, S-W England
7e	Sea cliffs/hard coast, England
8e	Estuarine/soft coast/tidal rivers, England
9e	Almost flat plains, N Midlands, NE England
10e	Gently rolling/almost flat plains, NE England/N Midlands
11e	Flat plains/small river floodplains, E Midlands
12e	Large river floodplains, flat plains, margins, E Anglia
13e	Coastal plains/gently rolling low hills, NW England
15e	Flat river valleys/lower hill slopes, NW England
16e	Gently rolling low hills/flat river valleys, NW England
17e	Upland valleys/rounded hill sides, England
18e	Upland valley sides/low mountains, N England
19e	Upland valleys/plateaux, N England
22e	Intermediate mountain tops/broad ridges, N England
25e	Flat/gently undulating river valleys, N England

4.4.1 Comparison of HLS plots against CS X plots

In the following section we break down the results of the comparisons between HLS and CS X plots by Broad Habitat. For each Broad Habitat the results tables (Tables A8-A12) present the following information:

a) the response variables
b) the number of plots in the analysis
c) the F statistic
d) probability P
e) if the difference between CS and HLS plots is significant and the direction of the significance.

The tables of results are complemented by bar-charts showing the percentage of plots in each Broad Habitat (numbered) from the HLS survey and CS X plots.

4.4.1.1 Improved Grassland

Results show quite unequivocally that, compared to the wider English countryside, HLS has targeted Improved Grassland habitats with higher relative cover of forbs to grasses, a higher relative contribution of stress-tolerant species, and a lower contribution of ruderals and more competitive plants (*sensu* Grime *et al.* (1995)). In addition the mean Ellenberg fertility score was lower in the HLS sample and species richness was higher (Table A8 and Figure A1).

4.4.1.2 Neutral Grassland

The same pattern of differences was seen in Neutral as in Improved Grassland, indicating effective targeting of vegetation. Thus the HLS sample had lower mean Ellenberg fertility scores (both presence-only and cover-weighted), and a higher contribution from more stress-tolerant species (Table A9). The profile of differences between HLS and CS samples was largely similar irrespective of whether HLS plots were assigned to the Broad Habitat in the field or probabilistically based on NVC matching. The only major difference between Improved Grassland and Neutral Grassland plots was that species richness was not significantly different between CS and HLS plots assigned probabilistically to Neutral Grassland (Table A10 and Figure A2).

4.4.1.3 Acid Grassland

Acid Grasslands in the wider countryside sample had a significantly higher relative contribution from stress-tolerant species and lower contributions from weedy and more competitive species (*sensu* Grime *et al.* 1995) than the HLS sample. Mean Ellenberg fertility score was also lower in the wider countryside (CS) sample (Table A11 and Figure A3).

4.4.1.4 Dwarf Shrub Heath

Countryside Survey contains a large number of upland heathland samples, but a low number of samples from lowland heathlands. The pattern of differences in response variable does not clearly discriminate between the wider English countryside and HLS samples. The wider countryside had a significantly lower relative contribution from more competitive species (*sensu* Grime *et al.* 1995) when based on presence only, yet a higher contribution when cover-weighted (Table A12 & Figure A4). However all 3 cover-weighted Grime indices were higher in CS than HLS, presumably reflecting greater recording of vegetation layers in CS.

4.5 Assessment of progress toward desired outcomes as shown by HK, HL and HO options that had been applied for at least two years

4.5.1 Option frequency, species frequency and vegetation structure

The survey of NCAs covered 56 different HLS options. Table 12 summarises those options that were surveyed and assessed on at least 5 agreements. As with the baseline survey, options for species-rich, semi-natural grassland (HK6 and HK7) were most frequently assessed options, with maintenance of grassland for target features (HK15) also widespread in the agreements surveyed.

Most of the other options that were well represented in the baseline survey were also frequent in the 6 NCAs *e.g.* HK18 (haymaking supplement). HK8 (creation of species-rich, semi-natural grassland) was relatively more common in the assessments of these 6 NCAs than in the main body of the baseline survey.

As had been the case in the baseline survey, there was little evidence of trends in species richness when comparing paired maintenance and restoration options, although HK6 (maintenance of species-rich, semi-natural grassland) was somewhat richer than HK7 (restoration of species-rich, semi-natural grassland). However, comparison of the results in Table 12 with the equivalent information for the baseline survey presented in Table A6 showed that the quadrats in agreements that had been under HLS options for at least two years were usually more species-rich than those from the baseline survey.

For many options that were frequently assessed in both surveys, the allocations to NVC type were also generally similar *e.g.* HK7, HK10, HK15 and HK18 (Table 13). Within the grassland options, for HK3 options the NCA samples were closer to MG7b *Lolium perenne-Poa trivialis* leys than to the MG6 *Lolium perenne-Cynosurus cristatus* sward that was prevalent in the baseline survey. Although species-rich semi-natural fields under the HK6 maintenance option showed a wide variety of NVC types in both surveys, the MG5b *Cynosurus cristatus-Centaurea nigra* grassland (*Galium verum* sub-community) was notably commoner in the longer established agreements. Finally, the HK10 option for the maintenance of wet grassland for wintering waders and wildfowl appeared to cover a larger range of MG types in the 6 NCAs than in the baseline survey.

Table 12 HLS options assessed during the survey of 6 NCAs, recording the number of individual RLR parcels surveyed and the mean species-richness (number of species per quadrat) of the quadrats recorded as part of the survey.

HLS Option Code*	Number of Agreements	Number of Surveys (RLR parcels)	Mean Species Richness
HK3	7	19	10.23
HK6	24	52	17.31
HK7	27	59	15.21
HK8	7	10	13.14
HK15	12	24	11.71
HK16	6	18	12.52
HK18	9	18	15.43

*Only options which occur in 5 or more agreements. No HL or HO option was assessed on more than 5 occasions

Table 13 HLS options and the types of the *National Vegetation Classification* (*NVC*) most frequently recorded in quadrats of the survey of 6 NCAs.

HLS Option Code	*NVC* Community(s) most often recorded	Other *NVC* types frequently recorded
HK3	MG7 (especially MG7b)	MG6
HK6	MG5b and MG6b	Various CG and MG types
HK7	MG6 (especially MG6b)	Various MG (and CG) types
HK8	Various MG and OV types	
HK10	MG10	
HK13	Various MG types	
HK15	MG6 and MG10a	Other MG types
HK16	Various MG types	
HK18	MG6b	Other MG types
HK19	MG6a	Other MG types
HL10	U2 (especially U2b)	
HL15	U2	

Some HLS options were better represented in the NCA survey than in the baseline samples. Quadrats under HK8 were classified in a variety of MG and OV NVC vegetation types reflecting the dynamic nature of the species assemblages in the early years of this creation option. The results for the wet grassland creation option HK13 were also varied, though mainly within the mesotrophic grassland (MG) group. Fields within the HK19 raised water-level supplement similarly were allocated to a range of MG types.

Moorland options HL10 and HL15 had contained many different NVC types drawn from heath, mire and acid grasslands in the baseline survey, but in the NCA survey there was a marked association for U2 *Deschampsia flexuosa* grassland, probably reflecting the smaller sample size and inherent geographical bias present in the NCA survey where only 6 limited areas of England were included in the study.

4.5.2 The distribution and extent of priority habitats in selected NCAs

The results of the habitat mapping within the NCA study are presented in Tables 14 and 15. Overall, within the six NCAs (Table 14), 37% of the land within surveyed HLS agreements was Priority Habitat. In addition to the habitats listed in Table 14, there were also very small areas of Lowland Dry Acid Grassland, Purple Moor Grass and Rush Pastures, Upland Flushes and Swamps, and Upland Heathland. Within the NCA survey, the most extensive Priority Habitat was Coastal Saltmarsh (irrelevant to the present study), followed by Blanket Bog, Arable Field Margins (also not relevant to this study), Lowland Meadows and Lowland Calcareous Grassland.

Table 14 Total Areas of Priority Habitats (grassland, heathland & upland) within the sample of 62 agreements in 6 NCAs.

Priority Habitat	**Area (ha)**	**% of Area**
Blanket Bog	264	6
Coastal and Floodplain Grazing Marsh	60	1
Lowland Calcareous Grassland	137	3
Lowland Heathland	85	2
Lowland Meadows	139	3
Other Priority Habitat (arable, woods etc)	892	23
No Priority Habitat	2510	62
Total	**4160**	**100**

Table 15 Total (ha) and percentage area of surveyed land mapped to Priority Habitats in the six selected NCA studies. A total of 62 agreements were surveyed within the six NCAs.

Priority Habitat	Dorset Downs & Cranborne Chase	Dunsmore & Feldon	High Weald	Southern Pennines	The Fens	Upper Thames Clay Vales
Blanket Bog				264 (33%)		
Coastal and Floodplain Grazing Marsh					60 (5%)	
Lowland Calcareous Grassland	134 (17%)	2 (<1%)				2 (<1%)
Lowland Dry Acid Grassland	2 (<1%)	0 (0%)				
Lowland Heathland			83 (14%)	2 (<1%)		
Lowland Meadows	54 (7%)	2 (1%)	55 (9%)	8 (<1%)		20 (5%)
Purple Moor Grass and Rush Pastures			3 (1%)	1 (<1%)		
Upland Flushes and Swamps				4 (<1%)		
Upland Heathland				4 (<1%)		
Other Priority Habitats	144 (18%)	63 (12%)	30 (4%)	15 (1%)	687 (61%)	8 (3%)
No Priority Habitat	457 (58%)	415 (86%)	408 (70%)	502 (63%)	376 (33%)	352 (92%)
Total Area	**790**	**483**	**580**	**801**	**1123**	**382**

The 6 NCAs were carefully selected to ensure each NCA had its own distinctive mixture of Priority Habitats. Table 15 provides a detailed breakdown of the areas of Priority Habitats recorded in the six NCAs, together with the percentages of the area mapped during the survey.

The highest proportion of Priority Habitat on HLS land surveyed in 2011 was within the Fens NCA but most of this was Coastal Saltmarsh (covering more than half the surveyed area) and the most important grassland habitat was Coastal and Floodplain Grazing Marsh. Mapped agreements in the Dorset Downs and Cranborne Chase NCA had greater than 40% cover by Priority Habitat, with grassland habitats (notably Lowland Calcareous Grassland and Lowland Meadow) important as well as Arable Field Margins and semi-natural woodlands. The extent of Priority Habitat in the High Weald and Southern Pennines NCAs was *ca.* 30-35% of the holdings included in the survey, with Lowland Heath and Lowland Meadow important in the Weald whilst Blanket Bog was much the most extensive Priority Habitat in the uplands of the Southern Pennines.

Priority Habitats appeared least extensive in the Dunsmore & Feldon, and the Upper Thames Clay Vales NCAs. In the former, only 51 hectares (14%) of the HLS area covered by the survey was Priority Habitat, and only 4 hectares (1%) of this was grassland. The Upper Thames Clay Vales had important areas of Lowland Meadows, but overall just 30 hectares (8%) of the surveyed area was Priority Habitat in that NCA.

4.5.3 The condition of FEP features in NCAs

FEP features identified within the survey of NCAs were assessed in the same way as described for the baseline survey and 313 distinct feature assessments were undertaken. Table 16 presents the results of these condition assessments for any FEP features where condition was measured at five or more locations. The second part of the table shows how these feature condition scores were distributed through the six NCAs included in the survey. The condition of FEP features within the 6 NCAs is also summarised in Table 16. In HLS agreements that had been established 2-4 years before the survey, the FEP feature condition appeared somewhat improved when compared to the results of the baseline survey (Table 17). In Table 17, intermediate condition categories (A/B and B/C) were allocated to both relevant main categories e.g. if 10 features were assessed as condition A/B, 10 were added to the totals for both categories A and B.

Table 16 FEP features and their condition as assessed within the 2011 survey of 6 NCAs. Results presented for grassland, heathland and upland features assessed on ≥5 occasions. Features assessed more than once in an agreement (i.e. in separate parcels) are counted as distinct locations. Results in the second part of the table are summarised by individual NCA.

FEP Feature	**FEP feature condition**				
	A	**A/B**	**B**	**B/C**	**C**
G02 Semi-improved grassland	31	6	21	1	8
G04 BAP Lowland calcareous grassland	7	7	5	4	5
G05 BAP Lowland dry acid grassland					10
G06 BAP Lowland meadows	4	6	10	5	21
G11 Habitat for invertebrates	7	2	2		
G12 Habitat for breeding waders (lowland)	12		2		
G13 Habitat for wintering waders/wildfowl	3		2		
G15 BAP Coastal/floodplain grazing marsh	1		4		
National Character Area (NCA)	**FEP feature condition**				
	A	**A/B**	**B**	**B/C**	**C**
Dorset Downs and Cranborne Chase	27	14	12	4	3
Dunsmore and Feldon	6	1	22		12
The Fens	21	2	14	5	3
High Weald	40	12	11	1	11
South Pennines	1	2	9	1	21
Upper Thames Clay Vales	10	2	29	4	16

Table 17 Comparison of FEP feature condition for Baseline Survey and NCA Survey. Figures indicate percentages of features allocated to condition categories A, B & C.

FEP feature condition	***Baseline survey***	**Survey of 6 NCAs**
A	27.6	38.8
B	42.2	38.3
C	30.2	22.8

Some habitats were most frequently in good (A) condition *e.g.* G02 semi-improved grassland and grasslands for invertebrates and waders (G11, G12 and G13). Other habitat features were most often in moderate (B) condition *i.e.* G04 BAP lowland calcareous grassland and G15 grazing marsh (though only assessed on five occasions). Two particular BAP grassland habitats (G05 lowland dry acid grassland and G06 lowland meadows) were often in poor (C) condition. There was variation between the six NCAs in the general condition of FEP features. Within the Dorset Downs and Cranborne Chase NCA and the Fens and the High Weald NCA, 50-60% of features were scored in the highest condition, and only 8-15% in the poorest category. Both Dunsmore & Feldon NCA and the Upper Thames Clay Vales NCA had the highest proportion of their features scored in the intermediate (B) category. In contrast, the South Pennines NCA had almost two thirds of its assessed features in poor (C) condition. Such variation in feature condition appeared to stem primarily from the habitats that predominated in the particular NCA, and indeed moorland and upland bog (typical of the South Pennines) were consistently scored in poorer condition than the main habitats of the mainly arable and grassland NCAs further south.

Comparison of these results with those of the baseline survey not only suggests that FEP features were generally in better condition two years or more after inclusion in HLS, but also that the condition of certain specific features was better once HLS options had been applied e.g. G02 semi-improved grassland. The proportion of most grassland habitats in poor condition appeared generally reduced in the NCA study. A more quantitative assessment of change in FEP feature condition between the first year and Years 2-4 of the agreement is desirable.

As a preliminary approach, the results of condition assessments for the baseline survey were summarised, calculating the proportion (possible values ranging from 0.0 to 1.0) for each feature of scores in the five condition categories (A, A/B, B. B/C and C). The process was repeated for the FEP feature condition assessments made during the NCA survey of 62 agreements. The value for each category from the baseline survey was subtracted from the corresponding value for the NCA survey to provide an index of changing feature condition (Table 18).

Table 18 The difference between the NCA study proportion and the baseline survey proportion of selected FEP features in the NCAs. Only features appearing 10 times or more in both datasets are shown. The table is ordered based on the number of features present in the baseline dataset.

FEP Habitat Feature	FEP Feature Condition				
	A	A/B	B	B/C	C
G02 Semi-improved grassland	0.25	0.08	-0.23	-0.01	-0.13
G06 BAP Lowland meadow	-0.12	0.13	-0.10	0.08	0.01
G04 BAP Lowland calcareous grassland	0.05	0.08	-0.02	0.09	-0.20
G05 BAP Lowland dry acid grassland	-0.12	0.00	-0.41	0.00	0.53
G12 Habitat for breeding waders (lowland)	0.66	0.00	-0.36	-0.20	-0.30

Positive values in Table 18 indicate that the proportion of a particular condition score for a given feature was higher in the NCA study, whilst negative values indicated the proportion was lower in the NCA work. Some trends in individual habitat features can be inferred, although it must be remembered that the condition assessments were gathered from different sets of agreements in the two surveys, that there are numerous site-specific factors influencing the feature condition for any given agreement, and that the trend results have not been subject to rigorous statistical testing. Where features have positive values for condition categories A and A/B, one may surmise that a greater proportion of the habitat was in very good condition where HLS management had been applied for at least two years. This trend was found in semi-improved grassland, lowland calcareous grassland and habitat for breeding waders. These same features generally show negative values for condition category C *i.e.* indicating that a smaller proportion of the features are in poor condition. One may cautiously conclude that features showing these trends have benefitted from the application of HLS management.

For those features with negative values for conditions A and A/B, the results imply that the feature was in poorer condition where HLS management had been applied for some time than where the option had only just been introduced. There is a suggestion that this might be the case for lowland dry acid grassland and lowland meadows (at least with regard to the highest condition A), but lowland meadows had a positive index for the A/B category (although that category was less consistently employed than A, B and C). Greater concern might arise from the positive value for condition category C for dry acid grassland, meaning that a greater proportion of that habitat was in poor condition on land under HLS management options for 2 or

more years than where HLS had only just been introduced. However, as with all these comparisons, it should not necessarily be inferred that the difference in condition arose as a result of management under HLS since the features in the NCA agreements could well have been in poorer condition at the inception of the HLS agreement than those in the baseline study.

Almost all features that occur at least 10 times in both datasets showed a negative index for category condition B, meaning that a much greater proportion of most habitats had been allocated to that category in the baseline survey than in the NCA survey. Taken together with the trends for condition A and C, there seems to be evidence of an overall improvement in feature condition for most of the frequently assessed habitats, although concerns raised with some BAP grassland types (notably lowland meadows and lowland dry acid grassland) are substantiated by this examination.

4.5.4 Indicators of Success

Indicators of Success (IoS) for HLS options which were measurable during the NCA survey were given a RAG assessment and the results presented as earlier for the baseline survey. There were 214 assessments of distinct agreement-option combinations, and results are given in Table 19 for HLS options which were examined on at least 5 occasions (results for less frequently assessed options are pooled within option groups). The second part of Table 19 shows how these RAG assessments for IoS were distributed through the six surveyed NCAs.

As with the baseline survey, it is possible to classify the results from the RAG assessments in three groups: a) all measurable IoS were achieved or judged very likely to be achieved in the future; b) one IoS had failed or 2-5 indicators seemed likely to fail; and c) where there was clear failure for two or more indicators.

Despite the rather better condition of the FEP features after 2 or more years of HLS management, Tables 19 and 20 suggest that a higher proportion of indicators were assessed as Red in the study of agreements in their 2nd to 4th year than in the baseline survey. It would appear that, after a period of management, assessments of success or failure can be made with greater certainty.

Table 19 RAG assessments of Indicators of Success (IoS) for HLS options (HK, HL and HO) within the 2011 survey of 6 NCAs.

HLS option	**Results of RAG assessment of measurable IoS**		
	Passed all	**Failed one**	**Failed >1**
HK less frequent options	11	7	1
HK3	2	2	1
HK6	9	9	6
HK7	8	5	11
HK8	1	2	2
HK15	6	4	2
HK16	3	1	1
HK18	3	2	
HL less frequent options	3		3
HL10	1	3	7
HO options	2	1	
National Character Area (NCA)	**Results of RAG assessment of measurable IoS**		
	Passed all	**Failed one**	**Failed >1**
Dorset Downs & Cranborne Chase	22	10	3
Dunsmore and Feldon	12	9	8
The Fens	18	12	6
High Weald	25	12	1
South Pennines	13	11	20
Upper Thames Clay Vales	9	8	15

Table 20 Overall RAG assessments of Indicators of Success (IoS) for HLS options (HK, HL and HO) as recorded in the Baseline Survey and NCA Survey. Figures indicate percentages of features allocated to condition categories Red, Amber and Green.

RAG assessment	***Baseline survey***	**Survey of 6 NCAs**
Green – appearing certain to be achieved within span of agreement	56.0%	43.6%
Amber – one indicator very likely or certain to fail	20.6%	39.0%
Red - >1 indicator very likely or certain to fail	23.6%	24.8%

Three categories of trend were again identified between options and the IoS:

I. Pass all their IoS more frequently than is typical *e.g*. less frequent HK options HK15 and HK16 (though the latter was only rarely assessed).
II. Fail one IoS more frequently than is the norm in the survey *e.g*. HK6.
III. Fail >1 IoS more often than is typical for surveyed agreements *e.g.* HK7 and HL10. HK8 also appeared to show this trend, but this option was only assessed occasionally.

The results for individual options and option groups were similar to those described for the baseline survey, with more ambitious options (restoration or creation of species-rich semi-natural grassland and moorland) judged especially likely to fail. Direct comparison of the RAG results from the baseline survey with those from agreements 2 or more years into implementation might suggest that there was evidence that the likelihood of meeting the desired outcomes had actually declined in some aspects. However, making RAG assessments in the first few months of an agreement (*i.e.* during the **baseline survey**) clearly has more uncertainty than doing so well into the agreement when progress toward desired outcomes should be more discernible. Hence, it is possible that surveyors have given agreements in the baseline survey "the benefit of any doubt", meaning that some IoS might have received an Amber appraisal rather than Red. Once an agreement had been in place for over two years, some of the IoS could receive absolute judgements, confounding the trends for RAG assessments in the two modules of the project.

Trends that are very similar to those described for FEP feature condition can be discerned in the six NCAs. Again HLS options in the Dorset Downs and Cranborne Chase (63%), High Weald (66%) and, to a lesser extent, the Fens (50%) usually passed all their IoS, with only 2.6-8.5% in the poorest category (16.7% in the Fens). Options in the Dunsmore & Feldon NCA showed a trend toward failing one or more of the IoS. The Upper Thames Clay Vales and South Pennines NCAs had the highest rate of likely failure with 45-50% of options judged as failing more than one IoS.

5. Discussion

The fundamental hypothesis to be tested by this study was that Environmental Stewardship has provided enhancement in ecological condition. However, the great majority of available data on Higher Level Stewardship (HLS) are for agreements in their first year. Consequently, demonstration of progress has to rely on more circumscribed studies such as that focussing on 6 National Character Areas (NCAs), where assessment of enhancement can but be tentative. Natural England and Defra commissioned a related major study (Mountford *et al* 2013) whose central purpose was to create a quantitative baseline from which to assess enhancement.

About 5.5 million hectares of land is under Environmental Stewardship. The focus of the present study is HLS and particularly the key options relating to the maintenance, restoration and creation of species-rich grassland, moorland and lowland heathland. The project comprised a baseline survey of agreements, the majority of which were in their first year. In addition a smaller number of agreements were surveyed that had begun 2-4 years previously. These were drawn from just 6 NCAs selected to represent contrasting landscape types rather than being representative of the entire HLS scheme.

The first stage of HLS implementation is the Farm Environment Plan (FEP). FEP maps and documents were found to be generally very effective in matching management options to the correct features. FEPs constitute a detailed and rigorous description of each holding at the start of an agreement, with condition assessments of features and maps of their distribution. However, they do not include quantitative information on the species composition of the habitats.

The baseline field survey showed that samples in maintenance options were generally more species-rich than those under restoration options. The vegetation under maintenance options reflected a wider range of plant communities, including semi-natural types, than did restoration options where semi-improved grasslands were prevalent, especially in HK grassland and HL upland options. In moorlands, maintenance options were found to have a greater dwarf shrub cover and lower incidence of coarse graminoids than land under restoration. The FEP feature conditions and occurrence of both BAP and Priority Habitats recorded during the baseline survey were in the main appropriate to the HLS options implemented, although some BAP grassland and lowland heathland types showed poorer quality than would be desirable.

The Indicators of Success (IoS) also indicated that most options would deliver their desired outcomes, although a sizeable minority of options (ca. 24%) failed on more than one IoS, suggesting either that remedial management was necessary or that the option had been implemented in an inappropriate location.

These assessments of the survey data strongly suggest that most HLS options have been well located on features that merit such agri-environmental management. This contention was further tested through a direct comparison of the quantitative survey data from the baseline survey (vegetation quadrats) with equivalent data for the same habitats and CEH Land Classes drawn from the most recent Countryside Survey (CS2007). The objective was to ascertain whether land under HLS was of higher biodiversity quality than the wider countryside.

The results of this direct comparative analysis showed that a) Improved grasslands under HLS were more forb- and species-rich, with more stress-tolerators, fewer ruderals and a species composition reflecting lower fertility; b) Neutral grassland under HLS showed a very similar pattern, except that the results for species richness were less consistent; c) In contrast acid grasslands in HLS had fewer stress-tolerant species, and appeared to reflect more fertile conditions than in the wider countryside (CS2007) sample; whilst d) Dwarf Shrub Heath under HLS was less distinct from the CS2007 sample in its attributes. However, overall these analyses indicate that the HLS options have been located in higher quality habitats that merit the maintenance or restorative management.

The smaller survey of 2-4 year old agreements from 6 NCAs provided some insight into early progress toward the goals of HLS. However, the limited number of NCAs surveyed was reflected in the distribution of Priority Habitats. Analyses of FEP feature condition and Indicators of Success (IoS) gave a somewhat mixed impression. As would be hoped and expected, FEP features were generally in better condition where they had been under HLS management for more than two years than in newly created agreements. Although a higher proportion of options failed more than one IoS than in the baseline survey, this may simply reflect the greater confidence with which an assessment of likely success could be made. Most options were judged as certain to meet their desired outcomes and these early and preliminary assessments of HLS produce a generally positive picture of the success of the scheme.

In conclusion, the data available for analysis was not derived from agreements that had been monitored, or in place for long enough to show significant habitat change. As a result, these analyses do not as yet demonstrate unequivocally that Higher Level Stewardship is progressing in a positive direction, enhancing the habitats and species of England. However, these results do show that the majority of agreements in this agri-environment scheme have been applied to the correct areas and features, that the management appears suitable and predicts that most HLS options/agreements will contribute to the conservation and enhancement of biodiversity, as well as landscape, historic environment, resource protection and amenity (Mountford *et al.* 2013).

6. References

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Appendix: Supporting Material

The use of MAVIS in vegetation analysis

Modular Analysis of Vegetation Information System (MAVIS)

MAVIS is a programme for analysing vegetation data using different types of classifications developed for Great Britain. These include the Countryside Vegetation System (CVS) and other measures, such as fertility and competitor scores, as used in Countryside Survey 2000. MAVIS also includes classification programmes for the National Vegetation Classification (NVC).

What Does MAVIS Do?

Data on plant species collected from sample areas constitute the basic information used by ecologists, vegetation scientists and nature reserve managers to answer a range of questions about vegetation. These questions are often answered by classifying the field data in different ways. Various classifications have been developed, which all attempt to explain or describe the distribution of plant species at different scales.

MAVIS enables links to be made between botanical field data and a number of widely used classifications of plant species. The result is a standard description of the entered data in terms of each classification. Because the classifications remain static and only the field data changes, many different sorts of plant community can all be expressed in the same standard language. This permits site to site, region to region, and biogeographic zone to biogeographic zone comparisons to be made. The classification systems available are as follows:

- Ellenberg scores for Light, Fertility, Wetness and pH.
- Preston and Hill's (1997) classification of the British Flora into biogeographic elements.
- Grime's (1979) triangular CSR model classifying British vegetation in terms of three established strategies; Competitors, Stress-tolerators and Ruderal species.
- The wider countryside classification of ITE Countryside Survey data for 1978 and 1990 known as the Countryside Vegetation System (CVS).
- The National Vegetation Classification (NVC) developed at the Unit of Vegetation Science, Lancaster University.

The program accepts data in the form of single species lists, with or without abundance codes. It also handles frequency (sometimes called constancy) tables. These are species lists in which each taxon is coded in terms of its frequency of occurrence within a group of individual samples, recorded in stands of (usually) floristically similar vegetation.

Table A1 Environmental Stewardship Options implemented in England (to mid-September 2012) in addition to the key options detailed in **Table 3**, listing the number of agreements containing each option and the total area under management by each option.

a. Higher Level Stewardship options

HLS option	Agreements Containing Selected Options	Option Area (Ha)
All Options (ELS,OELS,HLS)	9,895	5,542,248.0
HK1 - Take field corners out of management	88	47.91
HK2 - Permanent grassland with low inputs	345	4,703.51
HK3 - Permanent grassland with very low inputs	665	5,930.94
HK4 - Management of rush pastures	33	104.22
HK5 - Mixed stocking	150	5,562.51
HK9 - Maintenance of wet grassland for breeding waders	586	13,797.33
HK10 - Maintenance of wet grassland for wintering waders and wildfowl	885	17,372.36
HK11 - Restoration of wet grassland for breeding waders	364	6,448.88
HK12 - Restoration of wet grassland for wintering waders and wildfowl	266	3,837.67
HK13 - Creation of wet grassland for breeding waders	233	3,760.35
HK14 - Creation of wet grassland for wintering waders and wildfowl	150	1,483.31
HK15 - Maintenance of grassland for target features	3,083	49,388.04
HK16 - Restoration of grassland for target features	1,304	21,244.55
HK17 - Creation of grassland for target features	904	9,648.50
HK18 - Supplement for haymaking	1,543	12,164.92
HK19 - Raised water levels supplement	209	4,031.06
HL1 - Take field corners out of management in SDAs	8	7.15
HL2 - Permanent grassland with low inputs in SDAs	69	759.48
HL3 - Permanent grassland with very low inputs in SDAs	252	1,890.50
HL4 - Management of rush pastures in SDAs	27	220.62
HL5 - Enclosed rough grazing	22	126.38
HL6 - Unenclosed moorland rough grazing	10	493.77
HL7 - Maintenance of rough grazing for birds	452	19,817.66
HL8 - Restoration of rough grazing for birds	412	14,949.96
HL12 - Management of heather, gorse and grass	197	103,578.10
HL13 - Moorland re-wetting supplement	62	6,532.68
HL15 - Seasonal livestock exclusion supplement	463	123,302.18
HL16 - Shepherding supplement	166	76,165.59
HO5 - Creation of lowland heathland on worked mineral sites	4	15.65

b. Entry Level Stewardship options

ELS option	Agreements with Selected Options	Option Area (Ha)
EK1 - Take field corners out of management: outside SDA & ML	149	70.76
EK2 - Permanent grassland with low inputs: outside SDA & ML	3,007	49,422.18
EK3 - Permanent grassland with very low inputs: outside SDA & ML	3,395	36,266.72
EK4 - Manage rush pastures: outside SDA & ML	118	563.93
EK5 - Mixed stocking	916	58,316.15
EL1 - Field corner management: SDA land	48	28.79
EL2 - Permanent in-bye grassland with low inputs: SDA land	1,208	35,997.18
EL3 - In-bye pasture & meadows with very low inputs: SDA land	1,190	18,760.99
EL4 - Manage rush pastures: SDA land & ML parcels under 15 ha	337	5,478.63
EL5 - Enclosed rough grazing: SDA land & ML parcels under 15 ha	420	6,163.38
EL6 - Moorland and rough grazing: ML land only	516	306,268.01

c. Organic options – subdivided into OHLS and OELS

Organic option	Agreements with Selected Options	Option Area (Ha)
Organic HLS options		
OHK1 - Take field corners out of management	12	8.04
OHK2 - Permanent grassland with low inputs	36	469.48
OHK3 - Permanent grassland with very low inputs	96	1,435.40
OHK4 - Management of rush pastures	5	16.15
OHK5 - Mixed stocking	36	1,879.18
OHL1 - Take field corners out of management in SDAs	1	0.50
OHL2 - Permanent grassland with low inputs in SDAs	4	46.84
OHL3 - Permanent grassland with very low inputs in SDAs	34	403.53
OHL4 - Management of rush pastures in SDAs	2	25.61
OHL5 - Enclosed rough grazing	3	8.91
Organic ELS options		
OK1 - Take field corners out of management: outside SDA & ML	6	3.20
OK2 - Permanent grassland with low inputs: outside SDA & ML	275	4,967.02
OK3 - Permanent grassland with very low inputs: outside SDA & ML	357	5,491.01
OK4 - Manage rush pastures: outside SDA & ML	11	74.45
OK5 - Mixed stocking	99	6,504.11
OL1 - Field corner management: SDA land	1	0.47
OL2 - Permanent in-bye grassland with low inputs: SDA land	58	1,998.24
OL3 - In-bye pasture & meadows with very low inputs: SDA land	72	3,501.56
OL4 - Manage rush pastures: SDA land & ML parcels under 15 ha	21	236.06
OL5 - Enclosed rough grazing: SDA land & ML parcels under 15 ha	8	159.39

Table A2 FEP Codes recorded during the baseline survey of HLS Grassland options.

	Total Area (ha)	Improved grassland	Semi-improved grassland	Lowland Calcareous Grassland	Lowland Dry Acid Grassland	Lowland Meadows	Purple Moor Grass and Rush Pastures	Upland Calcareous Grassland	Grass moorland and rough grazing	Upland Heathland	Fens	Other FEP codes
HK2 - Permanent grassland with low inputs	**29**	**14**	**13**								**1**	**1**
HK3 - Permanent grassland with very low inputs	**97**	**57**	**20**									**20**
HK6 - Maintenance of species-rich, semi-natural grassland	**578**	**15**	**127**	**122**	**123**	**45**	**1**	**2**	**12**	**0**	**3**	**129**
HK7 - Restoration of species-rich, semi-natural grassland	**648**	**26**	**270**	**158**	**20**	**34**	**23**	**7**	**0**		**16**	**95**
HK8 - Creation of species-rich, semi-natural grassland	**20**		**3**	**10**								**7**
HK9 - Maintenance of wet grassland for breeding waders	**0**											**0**
HK10 - Maintenance of wet grassland for wintering waders and wildfowl	**56**	**42**	**3**				**2**				**1**	**8**
HK11 - Restoration of wet grassland for breeding waders	**49**	**29**	**14**			**1**					**3**	**1**
HK13 - Creation of wet grassland for breeding waders	**10**		**10**									**0**

	Total Area (ha)	Improved grassland	Semi-improved grassland	Lowland Calcareous Grassland	Lowland Dry Acid Grassland	Lowland Meadows	Purple Moor Grass and Rush Pastures	Upland Calcareous Grassland	Grass moorland and rough grazing	Upland Heathland	Fens	Other FEP codes
HK14 - Creation of wet grassland for wintering waders and wildfowl	**2**		**2**									**1**
HK15 - Maintenance of grassland for target features	**793**	**113**	**221**		**11**	**0**		**0**	**63**	**292**	**9**	**85**
HK16 - Restoration of grassland for target features	**476**	**41**	**43**	**127**		**6**	**6**	**183**	**10**		**0**	**60**
HK17 - Creation of grassland for target features	**46**		**5**			**28**						**12**
HK18 - Hay making supplement	**128**	**9**	**72**	**1**		**6**			**17**		**11**	**12**
HK19 - Raised water levels supplement	**27**	**13**	**1**				**11**					**2**
Total Area (ha)	**2960**	**360**	**804**	**418**	**153**	**121**	**43**	**191**	**103**	**292**	**45**	**433**
% of Total Area		**12**	**27**	**14**	**5**	**4**	**1**	**6**	**3**	**10**	**2**	**15**

Table A3 FEP Codes recorded during the baseline survey of HLS Upland options.

		G01	G02	G08	M01	M02	M04	M06	M08	T08	V02	
	Total Area (ha)	Improved grassland	Semi-improved grassland	Upland Calcareous Grassland	Grass moorland and rough grazing	Fragmented heath	Upland Heathland	Blanket Bog	Upland Flushes, Fens and Swamps	Native semi-natural woodland	Bracken	Other FEP codes
HL2 - Permanent grassland with low inputs	5	3										2
HL3 - Permanent grassland with very low inputs	36	13	16		5					1	0	1
HL5 - Enclosed rough grazing	12				1		7			3	0	1
HL6 - Unenclosed moorland rough grazing	32				12		0		0		19	0
HL7 - Maintenance of rough grazing for birds	340	60	38	1	175			9	9	0	44	4
HL8 - Restoration of upland grazing for birds	216	3	55		150			1	5			2
HL9 - Maintenance of moorland	2527	2	20		58	12	2007	75	104	115	90	42
HL10 - Restoration of moorland	4091	3	26	157	1226	229	743	1159	178	22	295	55
HL11 - Creation of upland heathland	271	3	5		206			9	6		43	0
Total Area (ha)	**7530**	**88**	**161**	**157**	**1832**	**241**	**2757**	**1254**	**302**	**141**	**491**	**106**
% of Total Area		**1**	**2**	**2**	**24**	**3**	**37**	**17**	**4**	**2**	**7**	**1**

Table A4 FEP Codes recorded during the baseline survey of HLS Lowland Heathland options.

		A01	G05	M03	T05	T07	T08	V04	
	Total Area (ha)	Arable	Lowland Dry Acid Grassland	Lowland Heath	Non-native plantation	Landmark woodland	Native semi-natural woodland	Scrub	Other FEP codes
HO1 - Maintenance of lowland heathland	**309**	**39**	**42**	**189**	**10**	**12**	**3**	**4**	**9**
HO2 - Restoration of lowland heathland on neglected sites	**147**		**11**	**73**	**5**		**15**	**14**	**27**
HO3 - Restoration of forestry areas to lowland heathland	**16**		**1**		**12**		**2**	**1**	**1**
HO4 - Creation of lowland heathland from arable or improved grassland	**4**			**0**				**1**	**3**
Total Area (ha)	**476**	**39**	**54**	**263**	**28**	**12**	**20**	**20**	**37**
% of Total Area		**8**	**11**	**55**	**6**	**3**	**4**	**4**	**7**

Table A5 The percentage of the area of each of the Grassland Options of HLS that were identified as Priority Habitat by surveyors.

	Total Area (ha)	Arable Field Margins	Coastal & Floodplain Grazing Marsh	Inland Rock Outcrop and Scree	Lowland Calcareous Grassland	Lowland Dry Acid Grassland	Lowland Fen	Lowland Meadows	Lowland Mixed Deciduous	Ponds	Purple Moor Grass and Rush Pastures	Upland Calcareous Grassland	Upland Hay Meadows	Upland Heathland	Wet Woodland	No Priority Habitat
HK2 - Permanent grassland with low inputs	29															100
HK3 - Permanent grassland with very low inputs	97		5							1						94
HK6 - Maintenance of species-rich, semi-natural grassland	577	0	3		4	11	1	5	1	1	1	0	0		3	68
HK7 - Restoration of species-rich, semi-natural grassland	664	0	0		22	0	4	4	1	0	0	0	2		2	65
HK8 - Creation of species-rich, semi-natural grassland	20	0			20			1							2	78
HK9 - Maintenance of wet grassland for breeding waders	104		9				10	4		0	0				2	75
HK10 - Maintenance of wet grassland for wintering waders and wildfowl	56		26				11				3					60
HK11 - Restoration of wet grassland for breeding waders	52						18	10								72
HK12- Restoration of wet grassland for wintering waders and wildfowl	5															100

	Total Area (ha)	Arable Field Margins	Coastal & Floodplain Grazing Marsh	Inland Rock Outcrop and Scree	Lowland Calcareous Grassland	Lowland Dry Acid Grassland	Lowland Fen	Lowland Meadows	Lowland Mixed Deciduous	Ponds	Purple Moor Grass and Rush Pastures	Upland Calcareous Grassland	Upland Hay Meadows	Upland Heathland	Wet Woodland	No Priority Habitat
HK13 - Creation of wet grassland for breeding waders	10															100
HK14 - Creation of wet grassland for wintering waders and wildfowl	2	7														93
HK15 - Maintenance of grassland for target features	793		15			1	0	0	0	0		0		17	12	54
HK16 - Restoration of grassland for target features	481	1	0	12	10		2	1	0		0	5	1		0	65
HK17 - Creation of grassland for target features	46							3								97
HK18 - Hay making supplement	138				2		20	2				1	3		1	71
HK19 - Raised water levels supplement	27										2					98
Total Area (ha)	**3101**															
% of Total Area		**0**	**5**	**2**	**7**	**2**	**3**	**2**	**0**	**0**	**0**	**1**	**1**	**4**	**4**	**65**

Table A6 The percentage of the area of each of the moorland and Upland Grazing Options of HLS that were identified as Priority Habitat by surveyors.

	Total Area (ha)	Blanket Bog	Calaminarian Grassland	Inland Rock Outcrop and Scree	Limestone Pavements	Lowland Fen	Lowland Heathland	Lowland Meadows	Lowland Mixed Deciduous Woodland	Ponds	Purple Moor Grass and Rush Pastures	Upland Birchwoods	Upland Calcareous Grassland	Upland Flushes Fens and Swamps	Upland Heathland	Upland Oakwoods	Wet Woodland	No Priority Habitat
HL2 Permanent grassland with low inputs	5						0	0	0	0							0	100
HL3 Permanent grassland with v. low inputs	36					20	0	0	0	0							0	80
HL5 Enclosed rough grazing	12						0	0	0	0					59		0	41
HL6 Unenclosed moorland rough grazing	32			51			0	0	0	0				38	1		0	11
HL7 Maintenance of rough grazing for birds	340	3					0	0	0	0		0	0	7			0	91
HL8 Restoration of upland grazing for birds	216						0	0	0	0				12			0	88
HL9 Maintenance of moorland	2526	0		0			0	0	0	0		0		1	69	0	0	30
HL10 Restoration of moorland	4091	9	1	3	1		0	0	1	0	1		3	9	24	0	0	47
HL11 Creation of upland heathland	271	8					0	0	0	0				17			0	76
Total Area (ha)	**7529**																	
% of Total Area		**5**	**1**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**2**	**7**	**36**	**0**	**0**	**45**

Table A7 The percentage of the area of each of the Lowland Heathland options of HLS that were identified as Priority Habitat by surveyors

	Total Area (ha)	Lowland Dry Acid Grassland	Lowland Fen	Lowland Heathland	Lowland Mixed Deciduous Woodland	Ponds	Wet Woodland	No Priority Habitat
HO1- Maintenance of lowland heathland	309	14	0	61				25
HO2 - Restoration of lowland heathland on neglected sites	147	8	3	51	0	0	7	31
HO3 - Restoration of forestry areas to lowland heathland	16	4						96
HO4 - Creation of lowland heath from arable or improved grassland	4			5		8		87
Total Area (ha)	**476**							
% of Total Area		**11**	**1**	**55**	**0**	**0**	**2**	**30**

Table A8 Response variables for plots in Improved Grassland – the response variables are defined in Table 1.2. N represents the number of plots, together with the F statistic and the P (probability). Where the difference is significant, the final column shows whether the value for the response variable was higher or lower in Countryside Survey plots.

Response	N plots	F	P	Difference if significant
Grass:forb ratio	693	28.48	<.0001	CS higher
C	689	0.20	0.6574	
S	689	20.20	<.0001	CS lower
R	689	11.80	0.0006	CS higher
cC	689	4.90	0.0272	CS higher
cS	689	0.76	0.3849	
AcR	689	17.34	<.0001	CS higher
Ellenberg N	693	29.66	<.0001	CS higher
Ellenberg R	693	10.02	0.0016	CS higher
Ellenberg F	693	5.72	0.0170	CS lower
Ellenberg cN	693	59.82	<.0001	CS higher
Ellenberg cR	693	51.82	<.0001	CS higher
Ellenberg cF	693	31.74	<.0001	CS higher
Species richness	693	40.24	<.0001	CS lower

Table A9 Response variables for plots in Neutral Grassland (Habitat assigned by field surveyors) – other legend as for Table A8.

Response	N plots	F	P	Difference if significant
Grass:forb ratio	1239	17.53	<.0001	CS higher
C	1242	2.63	0.1049	
S	1242	23.37	<.0001	CS lower
R	1242	0.25	0.6174	
cC	1242	22.97	<.0001	CS higher
cS	1242	0.03	0.8741	
cR	1242	13.80	0.0002	CS higher
Ellenberg N	1243	21.93	<.0001	CS higher
Ellenberg R	1243	0.58	0.4448	
Ellenberg F	1243	1.66	0.1982	
Ellenberg cN	1243	48.26	<.0001	CS higher
Ellenberg cR	1243	27.00	<.0001	CS higher
Ellenberg cF	1243	33.13	<.0001	CS higher
Species richness	1244	34.66	<.0001	CS lower

Table A10 Response variables for plots in Neutral Grassland. (Habitat assigned probabilistically using NVC allocations) – other legend as for Table A8.

Response	N plots	F	P	Difference if significant
Grass:forb ratio	2881	18.31	<.0001	CS higher
C	2914	0.54	0.4627	
S	2914	23.62	<.0001	CS lower
R	2914	27.77	<.0001	CS higher
cC	2914	17.72	<.0001	CS higher
cS	2914	1.13	0.2887	
cR	2914	46.57	<.0001	CS higher
Ellenberg N	2915	18.63	<.0001	CS higher
Ellenberg R	2915	2.29	0.1302	
Ellenberg F	2915	7.54	0.0061	CS lower
Ellenberg cN	2915	39.51	<.0001	CS higher
Ellenberg cR	2915	25.75	<.0001	CS higher
Ellenberg cF	2915	4.01	0.0454	CS higher
Species richness	2916	2.72	0.1004	

Table A11 Response variables for plots in Acid Grassland– other legend as for Table A8.

Response	N plots	F	P	Difference if significant
Grass:forb ratio	437	0.19	0.6630	
C	442	19.14	<.0001	CS lower
S	442	19.25	<.0001	CS higher
R	442	6.00	0.0147	CS lower
cC	442	0.14	0.7060	
cS	442	15.93	<.0001	CS higher
cR	442	1.34	0.2483	
Ellenberg N	442	4.48	0.0349	CS lower
Ellenberg R	442	7.94	0.0050	CS lower
Ellenberg F	442	0.10	0.7576	
Ellenberg cN	442	0.51	0.4757	
Ellenberg cR	442	0.22	0.6396	
Ellenberg cF	442	3.83	0.0510	
Species richness	442	0.00	0.9497	

Table A12 Response variables for plots in Dwarf Shrub Heath.

Response	N plots	F	P	Difference if significant
Grass:forb ratio	124	0.80	0.3720	
Ericoid cover	141	4.78	0.0304	CS higher
C	141	4.36	0.0386	CS lower
S	141	2.94	0.0884	
R	141	0.02	0.8939	
cC	141	20.34	<.0001	CS higher
cS	141	26.63	<.0001	CS higher
cR	141	10.03	0.0019	CS higher
Ellenberg N	141	3.89	0.0504	
Ellenberg R	141	9.22	0.0029	CS lower
Ellenberg F	141	0.07	0.7898	
Ellenberg cN	141	1.33	0.2508	
Ellenberg cR	141	0.88	0.3506	
Ellenberg cF	141	20.67	<.0001	CS higher
Species richness	141	0.15	0.6962	

Figure A1 Improved Grassland: percentage of plots in HLS survey (light grey) and CS (dark grey) within each ITE land class (see Table 9 for interpretation of land class codes).

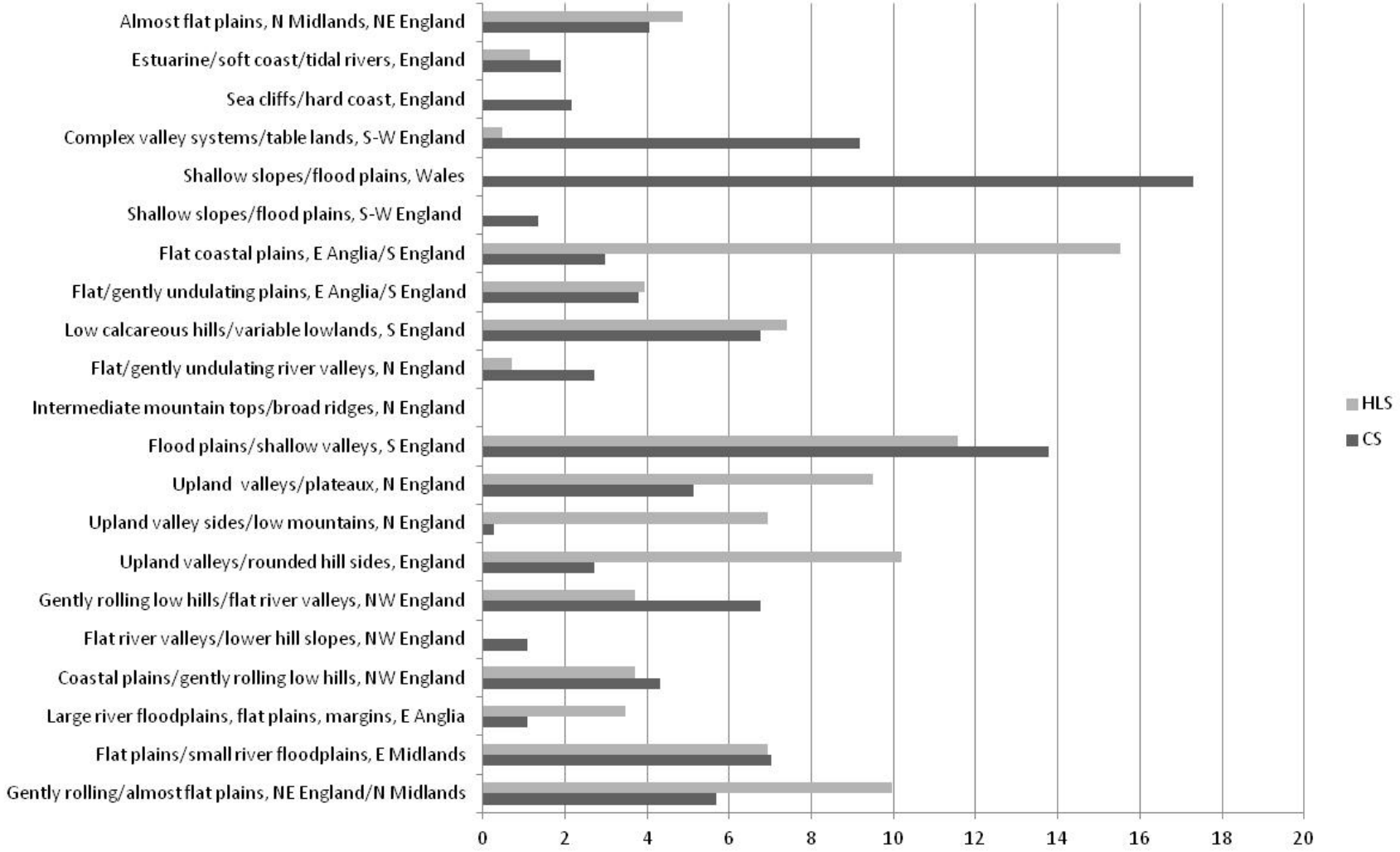

Figure A2 Neutral Grassland: percentage of plots in each survey by land class – other legend as Figure A1.

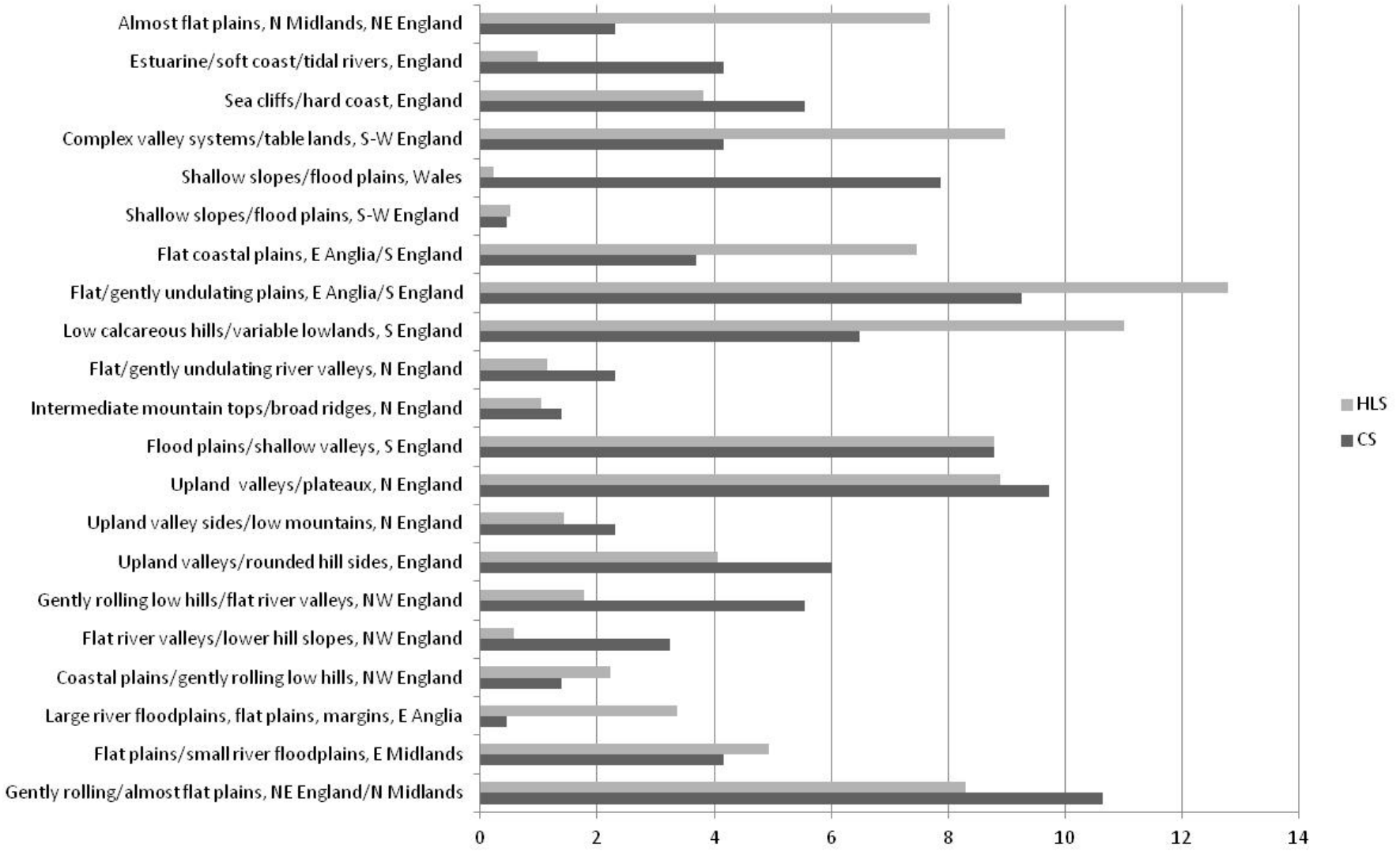

Figure A3 Acid Grassland: percentage of plots in each survey by land class – other legend as Figure A1.

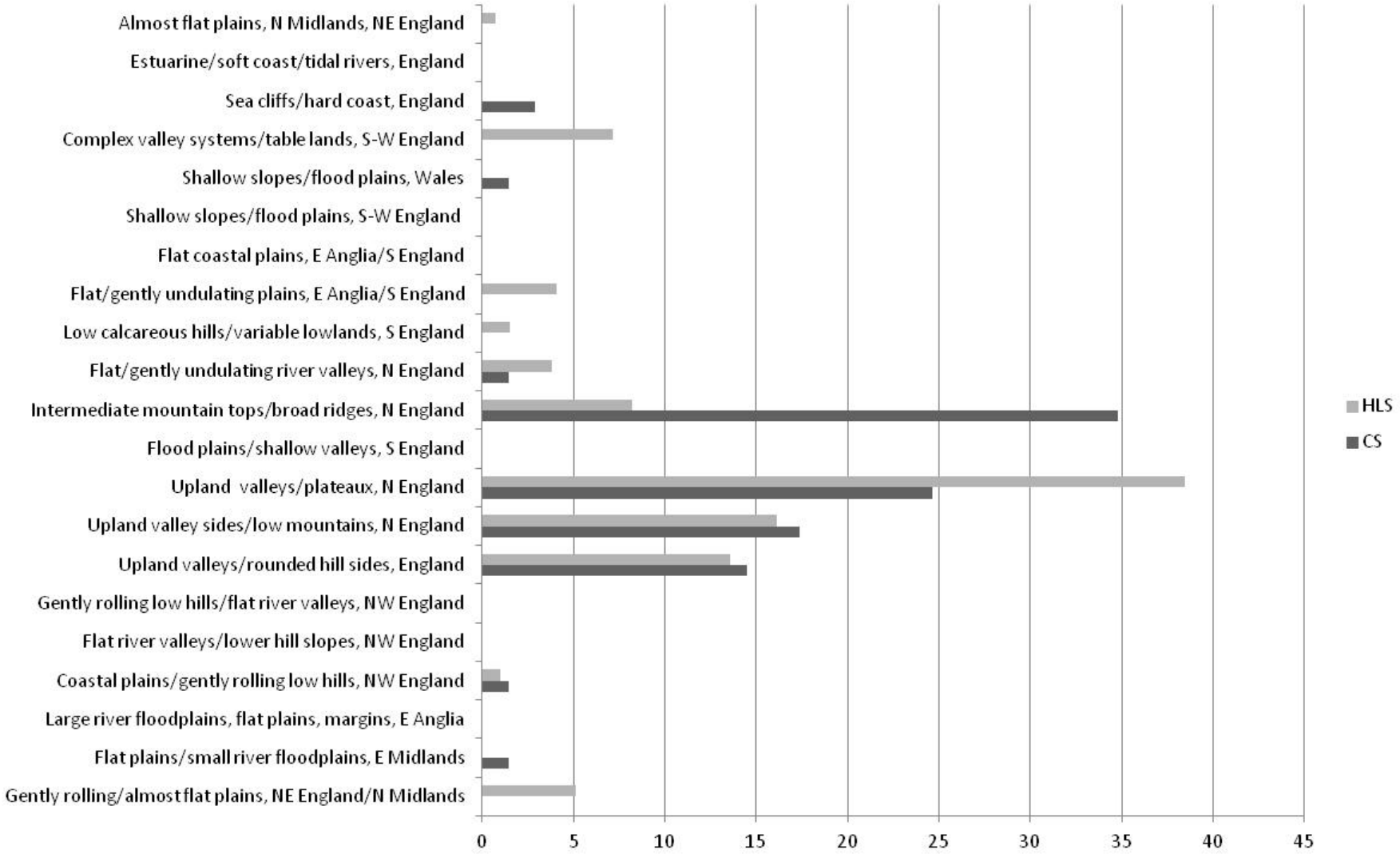

Figure A4 Dwarf Shrub Heath: percentage of plots in each survey by land class – other legend as Figure A1.