A field survey to evaluate the outcome of Higher Level Stewardship options on lowland heathland

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Executive summary

1. Lowland Heathland is a priority habitat for conservation in the UK, and the one with the largest number of priority species associated with it, many of which need bare ground and early stages of succession to thrive. Since 2006, the Higher Level Stewardship (HLS) scheme has been the main funding source for heathland management and restoration in England. Now the HLS is ending, the new Countryside Stewardship (CS) will play this role in the future.
2. The objective of this project was to assess the effectiveness of the heathland options HO1 and HO2 in the HLS agri-environment scheme in meeting favourable condition on lowland heathland in England. HO1 is for the maintenance of lowland heathland and HO2 for the restoration of lowland heathland from neglected sites.
3. Two samples were drawn from Sites of Special Scientific Interest (SSSI) and non-SSSI, both including dry and wet heathlands. A total of 165 sites were visited and 143 sites containing 155 stands were surveyed between 11th May and 7th October 2016.
4. The non-SSSI sample had baseline data from a previous survey carried out in 2006. There was no SSSI baseline, as it was not possible to obtain detailed condition assessments from the selected sites from about ten years ago.
5. The SSSI stands were mapped as all areas in the HO1/HO2 option category which supported heath. Large areas of non-heath (eg stands of dense bracken or scrub) were excluded, although smaller areas of scrub and bracken were included in the stand where they were in a fine mosaic. Non-SSSI stand boundaries followed those from the 2005/06 baseline survey. They included areas of actual heathland, plus any areas of heathland believed to have at least some restoration potential back then. Wet and dry heaths were generally sampled separately where they could be clearly distinguished in the field.
6. Common Standards for Monitoring (CSM) methodology was used but, contrary to the CSM guidance, this project did not include tailoring targets for each attribute in order to reflect natural geographical diversity. Surveyors also noted signs of management, and other habitat features, including south-facing slopes, microtopographic features, signs of ground-nesting invertebrates, edge habitats and veteran trees and deadwood in the field.
7. There is clear evidence that HLS HO1 and HO2 options brought in more positive management for many heathland sites, which has resulted in some detectable changes in the vegetation, and increased levels of bare ground. It is possible that other vegetation changes may be too slow or small to detect (and some agreements had been in place for only one or two years when surveyed).
8. Some changes were seen in the non-SSSI heathlands over the ten year period from 2005/06. Stands both within and without HO1/HO2 options improved in terms of gorse *Ulex* spp. cover and richness of positive indicator species, but deteriorated with regard to bracken *Pteridium aquilinum* and tree/scrub cover. Only stands in HO1/HO2 showed improvements over time in terms of graminoid diversity, lichens and bryophyte cover, dwarf-shrub richness and overall bare-ground. Pass-rates were lowest for dwarf-shrub structure and undisturbed bare ground, which are the features of most value for heathland priority species. Slightly more stands improved in condition (ie passed more targets) in the HO1/HO2 stands compared to the stands outside of these options, although the difference was not statistically significant, and 38% of stands currently in HO1/HO2 declined in condition over time.
9. All SSSI stands surveyed failed at least one generic CSM attribute target. Pass-rates were again lowest for dwarf-shrub structure and undisturbed bare ground, as well as positive indicator species diversity. HO1/HO2 stands were generally in better condition than non-HO1/HO2 stands, in terms of dwarf-shrub and graminoid species richness, negative species, bramble *Rubus* spp., and had a greater cover of bare ground (both disturbed and undisturbed). However, they also had more scrub and bracken, and more dense acrocarpous mosses, and a lower diversity of positive indicator species.

10. SSSI stands were generally in better condition than non-SSSI stands.
11. Stand pass-rates (against the generic CSM attribute targets), stand-level attribute means, and stop-level attributes were analysed by survey date and/or HO1/HO2 status, using a combination of unpaired and paired t-tests, and Chi-squared analyses as appropriate, and following necessary data transformation. A large number of statistical tests were carried out increasing the chance of generating false-positive results when comparing between groups, and this should be born in mind when interpreting the results.
12. Conservation bodies (mostly county Wildlife Trusts, the National Trust, Natural England and a range of other organisations with the primary management aim of countryside conservation) owned or managed the majority of sites surveyed. However, privately owned heaths were significantly more likely to be outside HO1/HO2 options.
13. Each landowner/manager was contacted and asked a series of questions about the management of their site. This was done informally by email, telephone, returned form, or in person conversation, and was not a structured questionnaire. 70% of the land managers that responded were satisfied with their current management, and a greater proportion happy with caveats. However, if sites are not meeting all the targets, there may be a need for further advice or training.
14. Heathland stands that were grazed had more attributes that passed their targets. Grazing had a positive influence on meeting the targets for diversity of dwarf-shrubs, graminoids and positive indicator species, and for trees/scrub cover. On the other hand, there was little obvious impact of grazing on vegetation structure in either sample.
15. The project found inconsistencies in the way that the heathland options have been implemented or targeted in HLS agreements: for example, in some cases the agreement area included non-heathland habitats; sites originally in unfavourable condition were put under management options; or the Indicators of Success were not appropriate for the site. Many sites did not have a condition baseline to allow the evaluation of the outcomes.

1 Introduction

Background

1.1 Lowland Heathland is a priority habitat for conservation in the UK. Its current extent in England (about 51,000 ha) is not large when compared with upland heathland (>1.5 million ha) or even grasslands (about 89,000 ha), but lowland heathland is the habitat with the largest number of associated priority species (133) (Webb and others 2010). Therefore, achieving Favourable Condition on most heathland sites will ensure that, not only the habitat is maintained in an appropriate status to meet national (Defra 2011) and international commitments (eg Favourable Conservation Status under the Habitats Directive), but also that the many rare species associated with it will benefit.

1.2 Except for those found in extreme conditions, such as high altitude or coastal areas, heathlands generally require active management to be maintained as an open habitat. Most of its priority species (53%) require the presence of bare ground and early stages of succession (Webb and others 2010). The mechanisms by which this required management can be facilitated are varied, including funding from charities, landowners and bodies such as the Forestry Commission and the Ministry of Defence, but agri-environment schemes have played a major role. In 2006 the Countryside Stewardship Scheme (CSS) was superseded by Environmental Stewardship (ES); within that, the Higher Level Stewardship (HLS) has been the main funding source for heathland restoration and management in England in recent years. Now that the HLS has ended, the new Countryside Stewardship (CS) will play a role in the future of heathland management.

1.3 The heathland options that were on offer through HLS are shown in Table 1. There have been 657 HLS agreements that included Lowland Heathland options affecting the management of nearly 47,000 ha, with a total expenditure in the last 10 years of over £57M, excluding additional supplements and capital works. These HLS options, plus the range of capital items available, have also been the primary means of delivering the Government's Biodiversity 2020 targets for other habitats and species notified as interest features on Sites of Special Scientific Interest (SSSIs).

Table 1 The number, area and value of HLS agreements for heathlands (as of February 2017). Source: GenRep.

Option	Number of agreements including this option	Area under this option (ha)	Lifetime value of this option (£)
HO1 - Maintenance of lowland heathland	227	8,770.7	13.6M
HO2 - Restoration of lowland heath	523	36,023.4	40.5M
HO3 - Restoration of forestry areas to lowland heathland	106	1,697.6	2.4M
HO4 - Creation of lowland heathland from arable or improved grassland	27	239.8	928.6k
HO5 - Creation of lowland heathland on worked mineral sites	4	15.7	21.4k
Total	**657**	**46,747.2**	**57.4M**

Note: the total number of agreements is less than the sum of the individual entries for each option, because some agreements include more than one of the heathland options.

1.4 The Common Standards for Monitoring (CSM) is guidance published by the Joint Nature Conservation Committee (JNCC) to inform the monitoring and assessment of features on protected sites. It specifies the attributes to monitor and provides generic targets to achieve favourable condition. These are then tailored on English SSSIs in site specific Favourable Condition Tables. Table 2 shows the attributes and generic targets for Lowland Heathlands

(JNCC 2009).

Table 2 Attributes and broad targets of the CSM for lowland heathlands (JNCC 2009).

Attributes common to all heaths	**Broad targets that need to be tailored to each site**
Extent	No un-consented loss of area
Bare ground	1-10%
Vegetation Structure	Dwarf shrubs vs. grasses; Heather growth phases
Vegetation composition	Frequency of shrubs, grasses, forbs, lichens & mosses
Indicators of negative trends	% Scrub, invasive species, signs of disturbance
Indicators of local distinctiveness	Presence of local species, special features (ponds...)

1.5 Up to 90% of the lowland heathlands by area (based on the current inventory figures) is now under a relevant HLS option (but see 2.5). Nearly two thirds of lowland heathland are in Unfavourable Recovering Condition, though only 34% in Favourable Condition, compared with 45% and 32% respectively in 2006 (Alonso 2015).

1.6 A survey undertaken approximately ten years ago in 2005/06 (Hewins and others 2007) covered 104 lowland heathland sites, all of which were outside of SSSI designations, and aimed to investigate the condition of land within the Lowland Heathland Inventory. It covered both actual heathlands, and areas which had heathland restoration potential. That project did not specifically seek to investigate the effect of agri-environment schemes in any detail, but simply compared sites within a scheme boundary and those without. The current project includes a sub-sample of these non-SSSI heathlands and a set of SSSI heathland sites that were not covered within the 2005/6 survey.

Project aims

1.7 The main aim of this project was to assess the effectiveness of the lowland heathland options in the Higher Level Stewardship (HLS) agri-environment scheme in England. The work aimed to answer, as far as possible, the following questions:

- Is there evidence that HLS has delivered positive effects for lowland heathland, especially with regard to heathland vegetation structure and the provision of bare ground and pioneer heath?
- What are the detectable impacts of grazing?
- Have the heathland options been implemented appropriately and effectively? (However, the Project Steering Group later agreed that this last aim was secondary, being covered by more comprehensive studies such as Mountford and others (2013)).

1.8 Focus was specifically on the HO1 (maintenance of lowland heathland) and HO2 (restoration of lowland heathland from neglect) options, which account for the large majority of total agreements with a heathland option (Table 1).

1.9 The first phase of work (September 2015 to March 2016) was to collate and analyse GIS data sources to understand the extent, agreement and SSSI status of current heathland; devise a sampling framework by which sites could be selected for survey; select a sample of sites in preparation for the following field season, and create and populate a database for these selected sites. Fieldwork and further data collection from landowners and managers took place in the second phase of the project, followed by data analysis and reporting (March 2016 to March 2017).

2 Methods

Sample selection

2.1 A statistician was tasked with designing a sampling strategy for the project, beginning with a review of relevant datasets.

2.2 HLS agreements: Sampling required knowledge of which areas of heathland were within the target (HO1 and HO2) options, and which were not. Unfortunately the boundaries of individual options were not available electronically. Therefore, GIS datasets for current (2015) agreements were downloaded from the government 'DataShare' website, though, critically, these only covered the boundaries of whole agreements, attributed with the HLS options they contained in a single data-field. The whole agreement polygons were separated into those containing and not containing a heathland option.

2.3 Heathland inventories: The original 2005/06 survey sites were primarily selected from a sub-set of the 2005 digital (GIS) Lowland Heathland Inventory. At that time, this covered a total area of 94,139 ha, in largely low-resolution polygons. (Note, because of a 'SW Pilot' inventory updating project which included splitting polygons, there may have been a bias towards the south-west of England in terms of the number of polygons in the 2005/06 sample). The 2005/06 population was also supplemented by the RSPB's (2005) Heathland Extent And Potential (HEAP) GIS database. This GIS layer was based on aerial photograph interpretation, combined with soil data.

2.4 The current Priority Habitat Inventory (v2014) is quite different, containing many very small fragments of lowland heathland, due to differences in digitising rules and standards, and mapping to higher resolution, as well as real changes in heathland extent. This was particularly problematic when trying to use it to devise a sampling strategy to extend the 2005-06 non-SSSI sample to SSSI sites.

2.5 The HLS agreement boundaries were used to split the 2014 inventory into polygons which might have a heathland option, and those which definitely did not. This found that 32,744 ha[1] (64% by area) of heathlands lay within agreements which had heathland options applied somewhere within them, whereas 18,231 ha (36%) did not.

2.6 SSSI datasets: SSSI Unit boundaries were also downloaded from the 'DataShare' website. Natural England then provided a spreadsheet showing SSSI Units that have lowland heathland as a notified feature, and whether there was believed to be a CSM condition assessment survey dated 2006-2009 (possibly therefore providing baseline data for SSSIs from around the time of the 2005/06 survey of non-SSSI stands). It was found that:

- 360 SSSIs (c.9%), and 1,194 SSSI Units had lowland heathland as a notified feature.
- The majority (78%) of these SSSI Units had a condition assessment carried out in the period 2006-2009.
- 16% of these Units had more than one entry in the spreadsheet because they either had more than one interest feature (eg heath and broadleaved woodland) or both wet and dry heath. For these the condition assessment was for the Unit as a whole and did not distinguish between habitats.
- It was later discovered that available CSM data was very variable and sparse, negating its use as SSSI baseline data.

2.7 When the 2014 heathland inventory was split by SSSI boundaries, it was found that 78% (by area) of the known heathland inventory resource lay within a SSSI.

2.8 The project budget allowed for a total of 167 sites to be visited. It was determined that in order to avoid difficulties in replicating the sampling approach taken in 2005 due to

[1] Note that this figure does not match that obtained from GenRep (Table 1), as some agreements did include non-heathland areas.

differences in resolution in the 2005 and 2014 heathland inventories, there would be two concurrent but separate samples:

- 2005/06 stands that are currently (as of 2015) managed under HO1/HO2 options, with an equal number of control (non-option) stands, selected randomly from the 2005/06 sample.
- Randomly drawn SSSI Units with heathland as a recorded feature, filtered by those which were believed to have CSM data from the period 2006-2009, again with approximately equal numbers within and outside of HLS agreements with heathland options listed.

2.9 Approximately 20% of SSSI Units were rejected due to lack of a suitably dated CSM. However, the use of baseline CSM data from 2006-09 was later dropped due to lack of availability of data, meaning that baseline comparison for SSSI sites was not possible.

2.10 Ideally, digital option boundaries would have been available to sample simply on the basis of actual HO1/HO2 status for any parcel of land. However, this was not possible, as the digital data was only available at the whole agreement boundary level, with options and supplements for the agreement listed in a single data-field. The HO1/HO2 sample was drawn from those with options somewhere in the overlying agreement, with sufficient reserves to allow for rejections where the option was found not to occur on the selected site. The control sites were therefore drawn from areas definitely lacking HO1-HO5, regardless of other HLS agreements and options which may be in place. This was done because simply selecting from heathland outside of all HLS agreements would bias the sample away from heath that had been, for whatever reason, kept out of a heathland option. [eg non-HLS heaths may have had other funding mechanisms which may be influencing them positively].

2.11 The potential heathland SSSI Units were first split by the agreement boundaries with/without HO1-HO2 applied. The resulting polygons were then 'cleaned' in GIS by removing:

- Any polygons <0.5 ha in area (thus avoiding slivers)
- Any polygons with <95% area remaining after splitting by HLS boundary (thus avoiding Units with large splits between HLS and non-HLS). This was to facilitate better comparison with any whole-Unit monitoring data (although this later proved unavailable).

2.12 This formed two potential 'populations': those with and those without HO1/HO2 options, from which to draw the sample. Then, a random number generator was used to sort the two 'populations' of SSSI Units and the first 60 and 70 in each population selected, respectively, to form the proposed sample, including enough reserves in case of later rejections.

2.13 The non-SSSI sample was all of the 2005/06 survey sites predominantly covered by HO1/HO2 option (n=31), with a randomly selected similar number of control sites, again with reserve sites in case of later site rejection.

2.14 To ascertain for certain whether a particular site (ie 2005/06 stand or SSSI Unit) in the proposed sample was actually in a HO1/HO2 option, individual agreement documents and maps were sought from Natural England's Genesis database. Where information gaps remained, a request was made for additional GIS layers for specific agreements. Any sites which had been selected as possibly in a heathland option, but were found not to be, were rejected from the sample at this stage.

2.15 Unfortunately a relatively low proportion (31 out of 101) of the total population of 2005/06 stands were in one of the target options, making the non-SSSI HO1/HO2 sample smaller than the c.50 initially hoped for.

2.16 The supplied HLS documents (Farm Environment Plans (FEPs), FEP maps, capital works documents, and miscellaneous correspondence, file notes and any existing surveys) also provided other information, including additional options and supplements, Indicators of Success (IoS) and capital works. However, in some cases this information was lacking or unclear (for example, some PDF agreement maps did not show the boundaries between different options).

2.17 While most missing HLS data issues were eventually resolved, some key information could not be obtained:

- Two agreements where the maps didn't allow options to be distinguished
- Two agreements lacked the Part 3 document (management prescriptions and IoS)
- One agreement where the supplied Part 3 document was corrupt and incomplete
- One agreement where no documents were supplied

2.18 Table 3 shows the final proposed field sample, including reserves, after rejections for lack of target options. Rejections made during the survey phase are reported in Table 6.

Table 3 The final proposed field sample, including reserves, after early rejection for lack of target option, landowner or access issues or known definitely lack of heathland.

	SSSI	Non-SSSI	TOTAL
HO1/HO2	58	32	90
Non-HO1/HO2	58	40	98
TOTAL	116	72	188

Field methodology

2.19 Surveyors underwent a day's training and were provided with site dossiers and a methods handbook prior to survey. The site dossiers included:

- 1:10,000 scale map to locate sites
- Large-scale aerial photograph for stand mapping (showing either the 2005/6 stand boundary with locations of photos, target notes and route of structured walk, or SSSI Unit boundary)
- Photos from 2005/06 survey, where applicable
- Field forms
- Summary of site information collated in database
- Blank management 'questionnaire'
- Any returned survey permission forms

2.20 The electronic dossiers (where available) contained:

- Part 3 of the HLS agreement, which contained IoS and Management Prescriptions
- HLS options maps
- FEP and FEP map
- SSSI condition assessment monitoring data
- Any other information

2.21 The Methods handbook consisted of:

- Bio-security guidance
- Guidance on stand selection
- Attribute definitions

2.22 Landowners or tenants/managers were identified using a combination of HLS agri-environment agreement records, information from Natural England officers, information from 2005/06 surveys, results of internet searches, contact with nearby landowners and cold-calling. Those identified prior to fieldwork were sent a standard email or letter with return form, and stamped return envelope if applicable (copies of these letters can be found in Appendix 1). For those contacted during fieldwork background information was supplied verbally, with additional information provided on request. In order to secure as many access

permissions as possible, landowners/managers were assured that the name and exact location of the sites would be kept confidential and results reported only in an aggregate form. Participating landowners/managers were sent a final letter of thanks, and a brief summary of the results.

2.23 Each landowner/manager was asked a series of questions about the management of their site; because of Defra restrictions on structured public surveys this was done informally by email, telephone, returned form or in person conversation. The information sought included:

- Current and past heathland management (for example: grazing, stock type, grazing density, grazing season, scrub clearance, habitat creation, targeted species management, etc).
- How any grazing is facilitated, and if the site is not grazed, would they like it to be, and why.
- Whether any work was funded by the HLS agreement, or similar.
- What are the barriers to desired management.

And with regard to agri-environment schemes:

- Agreement scheme history.
- Whether there was any change in management due to HLS.
- Comments from the site owner/manager on appropriateness of HLS objectives, options, IoS and prescribed management.

2.24 Surveys were carried out between 11th May and 7th October 2016.

2.25 Once in the field, the boundary of the sample stand was mapped, and the structured walk route planned, using the guidance summarised below. In SSSIs, additional stands were sometimes recorded, separating wet and dry heath.

2.26 SSSIs:

- The stand comprised all areas within the selected SSSI Unit which fall within the selected HO1/HO2 or non-HO1/HO2 group, and which currently support heath or which are close to the heathland definition (BRIG 2008). Large areas of non-heath (eg stands of dense bracken or scrub) were excluded, although small areas of scrub and bracken were included in the stand where they were in a fine mosaic within it.
- Where SSSI Units were very large, or highly fragmented (for example in the New Forest), it was acceptable to only survey part, selected at random.
- The structured walk aimed to cover all of the mapped heathland stand, with stops at random locations across it.

2.27 Non-SSSIs:

- The 2005/06 stand boundary was followed. This included areas of actual heathland, plus any areas of heathland believed to have at least some restoration potential in 2005/06. Note, stands tend to match the boundaries of the 2005 heathland inventory and/or 2005 HEAP database, and may exclude some heath outside of this. The 2005/06 structured walk route was followed as far as possible.
- The survey tried to match the old survey as far as possible, but noting which stops fell within differing HLS options or habitat types.
- In some cases it was not possible to re-survey all stops, eg due to loss of habitat or access restrictions.

2.28 Valley mire habitat, while legitimately included in an HO1 or HO2 option was not included in the sample for two principal reasons: it would not be appropriately assessed by the wet/dry heath condition assessment methodology; and occurrence was expected to be low and would therefore dilute the sample, reducing the strength of any later analyses on wet and dry heaths.

2.29 Where burnt patches were encountered, care was taken not to over-sample these areas.

2.30 The whole stand was assessed using standard CSM condition assessment methodology (JNCC 2009). Following stand mapping, a description was written. This included observations on visible signs of management (eg grazing, burning, mowing, scrub and weed control, and tree removal), and influencing factors (such as agriculture, conservation, recreation, military activities, forestry, mineral extraction). Digital photographs were taken to aid description of each site (original photograph points from 2005/06 sites were replicated where possible). Target notes were added to the field map as required.

2.31 Mapping was onto paper copies of aerial photographs in the field, with additional use of a hand-held GPS to mark target notes or stop-locations where required.

2.32 Once the stand had been defined, a structured walk was undertaken and twenty stops recorded at approximately regular, randomly selected intervals. At each stop, the attributes required by JNCC (2009) were recorded (see Table 4).

2.33 Observations on other habitat features (particularly relating to invertebrates and/or reptiles) were made on the suitability of each site for invertebrates, including:

- Presence of south-facing slopes
- Presence of (micro)topographic features
- Presence of individual significant bare ground patches of >1m^2 distributed over the site (additional to CSM bare ground recording)
- Evidence of ground nesting invertebrates, ie burrows
- Presence of edge habitat
- Presence of old or veteran trees and deadwood

2.34 However, it was not always easy for surveyors to assess these to any great detail in the time available. Incidental records of notable species and features where made where time allowed.

2.35 The following appropriately attributed GIS layers were produced in MapInfo:

- Selected site - equating to either the whole SSSI Unit boundary, or the 2005/06 stand boundary
- Surveyed stand
- Condition assessment stop locations
- Target notes
- Photograph locations
- Some additional broad habitat polygons – where additional mapping was done to assist the survey

Analysis

2.36 All surveyed stands were broadly categorised as follows:

- True dwarf-shrub heath - where the mean stop cover of dwarf-shrubs exceeded 25% (ie meeting the strictest definition of heathland)
- 'Near' heath - where the cover of dwarf-shrubs was between 10-25% overall
- Non-heath (NH) – where dwarf-shrubs were rare or absent, or <10% cover.

2.37 These were further divided into:

- Dry (including humid, chalk and dune) heath
- Wet heath

2.38 The assessment targets for dune and chalk heath were identical to dry heath, albeit with a modified list of positive indicator species.

2.39 Stands were classified as predominantly HO1, HO2 or non-HO1/HO2. The 2016 stop data were also individually categorised by option, when in a small number of cases a stand might not be entirely within one option. Where possible, the non-heathland HLS options in place were identified.

2.40 Stands were categorised by the presence of one or more the following broad management activities (ie receiving at least some management), based on field observations and information from landowners/managers:

- Livestock grazing
- Prescribed burning
- Weed control
- Scrub control
- Bracken management
- Heather cutting/mowing
- Bare ground creation

2.41 More detailed analysis of management activity is presented in Section 5.

2.42 Stands were also categorised by other factors, including:

- Ownership types (council, conservation organisation, private and commercial forestry)
- Size classes (Small <5 ha; Medium 5-20 ha; and Large >20 ha)
- Geographic region

2.43 For the purposes of this project, the generic CSM targets (JNCC 2009) have been used in order to be able to compare all sites in the survey equally. These are summarised in Table 4.

2.44 Bare ground was divided into 'disturbed' (where the soil was broken by vehicles, livestock, rabbits, spoil heaps, intensive management activities, and paths), and 'undisturbed' where bare ground was present without signs of obvious disturbance within the vegetation. Not all of this 'disturbed' ground is negative in terms of heathland condition and conservation interest, and this should be born in mind when interpreting the results of the study.

2.45 A number of approaches were taken for analysing the vegetation data:

- Number of attribute targets passed by each site (out of the relevant maximum)
- Analysis of stand level pass-rates (the proportion of stands passing any particular attribute target), by predominant HO1/HO2 status or survey date (analysis by date was only possible for the non-SSSI sample).
- Analysis of stand level mean raw attribute values, by HO1/HO2 status, and/or 2005/06 or 2016 survey data (analysis by date was only possible for the non-SSSI sample).
- Analysis of individual stop data (not grouped by individual site), by actual stop option in 2016, and by predominant stop option in analyses with 2005/06 data (it was not possible to map individual 2005/06 stops accurately enough to separate out the few stops where a stand is not entirely within a single option group. However it is not thought that this impacts very significantly on the outcome of the analyses).
- Analysis of individual stop data to compare the vegetation of stands with and without known grazing, the most important widespread management activity at the whole stand level, whose importance was a specific project objective.

Table 4 Generic Condition assessment attribute target thresholds applied to the heathlands in this sample. See JNCC (2009) for more information and definitions. A species glossary is provided in Appendix 3.

Attribute	DRY HEATH	WET HEATH
Bare ground	'Undisturbed' 1-10%; 'disturbed' <1%; Signs of disturbance; erosion <1% (including on *Sphagnum*)	
TOTAL % cover shrubs	Cover of dwarf-shrubs: 25-90%	
Dwarf-shrub structure	(pseudo-)Pioneer 10-40%; Building/Mature 20-80%; Degenerate <30%; Dead <10%	Presence of heather in all stages of growth. No one growth form should be dominant.
Ulex **spp. cover**	<50%	
dwarf-shrub frequency	At least 2 species at least frequent *Arctostaphylos uva-ursi, Calluna vulgaris, Empetrum nigrum, Erica ciliaris, E. cinerea, E. tetralix, E. vagans, Genista anglica, Ulex minor, Vaccinium myrtillus, V. vitis-idaea.*	At least 2 species at least frequent *Calluna vulgaris, Empetrum nigrum, Erica ciliaris, E. cinerea, E. tetralix, E. vagans, Myrica gale, Salix repens*, *Ulex gallii, U. minor, Vaccinium* spp.
Graminoids	At least 1 species at least frequent and 2 species at least occasional throughout the sward (except *, which should be not more than occasional & <25% cover, and ! which should be <30%) *Agrostis* spp.*, Ammophila arenaria, Carex* spp., *Danthonia decumbens, Deschampsia flexuosa*, Festuca* spp.*, Molinia caerulea!, Nardus stricta*, Trichophorum cespitosum* (now *T. germanicum* and *T. cespitosum).*	At least 1 species at least frequent and 2 species at least occasional throughout the sward (except *, which should be <60%, and !, which should be >20% when naturally present) *Carex panicea, C. pulicaris, Eleocharis* spp.*, Eriophorum angustifolium, Juncus acutiflorus, J. articulatus, Molinia caerulea*, Rhynchospora alba, Schoenus nigricans!, Trichophorum cespitosum* (now *T. germanicum* and *T. cespitosum)*.
Positive species (desirable forbs)	At least 2 species at least occasional *Armeria maritima, Galium saxatile, Hypochaeris radicata, Lotus corniculatus, Plantago lanceolata, Plantago maritima, Polygala serpyllifolia, Potentilla erecta, Rumex acetosella, Scilla verna, Serratula tinctoria, Thymus praecox* (now *T. polytrichus), Viola riviniana.* Chalk/Limestone heath only*: Filipendula vulgaris, Galium verum, Helianthemum nummularium, Sanguisorba minor* (now *Poterium sanguisorba)* Dune heath only: *Aira praecox, Corynephorus canescens, Phleum arenarium, Erodium cicutarium, Filago minima, Sedum acre, Peltigera*	At least 2 species at least occasional *Anagallis tenella, Drosera* spp.*, Galium saxatile, Narthecium ossifragum, Pinguicula* spp., *Polygala serpyllifolia, Potentilla erecta, Serratula tinctoria, Succisa pratensis.*
Bryophytes and lichens	No generic target. Cover excluding *Sphagnum* spp. and dense acrocarpous mosses maintained or increased where naturally present)	When naturally present: >10% cover of Sphagna and >5% of lichens
Artificial drainage		Artificial drainage channels adversely affecting hydrology are absent. No signs of silt or leachate.
Exotics spp	<1%	
Negative species	< 1 % in clumps. *Cirsium spp. Digitalis purpurea, Epilobium spp. (excl. E. palustre), Chamerion angustifolium, Juncus effusus, J. squarrosus, Ranunculus* spp.*, Senecio* spp.*, Rumex obtusifolius, Urtica dioica,* "coarse grasses"*.*	<1% undesirable herbaceous/forb spp. *Apium nodiflorum, Cirsium arvense, Digitalis purpurea, Epilobium* spp. (excl. *E. palustre), Glyceria fluitans, Juncus effusus, J. squarrosus, Oenanthe crocata, Phragmites spp., Ranunculus repens, Rumex obtusifolius, Senecio jacobaea, Typha* spp., *Urtica* spp
Trees and scrub	< 15% trees, tree seedlings or other species of scrub. <1% *Rubus* spp.	<10% trees, tree seedlings or other species of scrub.
Pteridium aquilinum	< 10% in dense canopy	<5%
Ulex europaeus	<25%	<10%
Acrocarpous moss	Dense acrocarpous mosses < occasional	

2.46 The SSSI and non-SSSI vegetation samples were analysed separately because the samples were drawn, and the stands selected, using different criteria. The 2005/06 stand boundaries followed the existing Inventory/HEAP polygon as far as possible, and included some non-heath areas with, sometimes low, potential for heathland restoration. In the SSSI sample, the stand boundary followed that of existing (near) heathland, or that with high-restoration potential, albeit with smaller areas of non-heath in fine mosaic within it.

2.47 Note that in the non-SSSI sample, the raw attribute analyses included both the 57 dry heaths, plus the two wet heath stands together (they were separated in analysis of pass-rates). In the SSSI sample, the wet and dry heaths were separated in analysis of pass-rates and stand level attributes, but grouped for stop data analyses.

2.48 A full list of vegetation variables may be found in Appendix 2. The key variables analysed were:

- Pass-rates for groups of stands against individual generic CSM attribute targets
- Number/percentage of targets passed by each stand (out a maximum 19 for dry heaths, and 15 wet heaths) – excluding the three targets which only apply where lichens, *Schoenus nigricans* or *Sphagnum* spp. are naturally present)
- Mean attribute values for individual stands
- Attribute values for individual stops

2.49 In addition to the attributes used in one or more condition assessments, some additional attributes were derived, namely:

- Dwarf-shrub species richness
- Positive species richness
- Graminoid species richness
- Dwarf-shrubs at least frequent – number of species at least frequent in the stand
- Positive species at least occasional– number of species at least occasional in the stand
- Graminoid species at least occasional – number of species at least occasional in the stand
- Frequency (ie stop count out of 20) for key attributes

2.50 While all of these attributes were used for whole-stand level analyses, only a sub-set were applied at the stop level (eg it was not possible to calculate a frequency at a single stop). Additionally, only variables recorded in 2005/06 could be included in analysis focused on survey year (no baseline data were available for SSSIs).

2.51 The proportion of dwarf-shrub age classes was calculated as a proportion of the total area of dwarf-shrub, ie weighting towards stops with higher cover of dwarf-shrub overall, but totalling 100% per stand.

2.52 At stop level, the dwarf-shrub age-structure was used to calculate the overall proportion for the whole treatment group (rather than an individual stand). This was then presented graphically, although no statistical analyses could be applied.

2.53 Table 5 shows the issues that arose with regard to the attributes and targets in the 2005/06 and 2016 datasets and how they were resolved.

Table 5 Issues with the attributes and targets, and solution applied.

Issue	Solution
2005/06 dry heath dwarf-shrub diversity target included *Ulex gallii.*	2005/06 data reassessed against 2016 targets
No *Molinia caerulea* target applied to dry heaths in 2005/06.	
Wet heath targets for Sphagna, lichens and *Schoenus nigricans* only applicable where naturally present.	Targets only used and analysed where this species/species group occurred in at least one stop within the stand

2.54 Statistically significant differences in pass-rates and management activities were tested by Chi-squared two-way contingency analysis with Yates' Correction applied where there were low degrees of freedom.

2.55 Differences in attributes between groups (including option and presence of grazing) were tested by unpaired, two way, unequal variance t-tests. Prior to analysis, variables with a skewness value of >3 (in any group or overall) were transformed, either by ln(x+1) of 1/(x+1), and the applied transformation is shown in tables where relevant. In a few cases transformation was not sufficient (eg where there were very few non-zero values in the datasets), and this is also noted in the tables. Back-transformed values are shown within the context of this report.

2.56 Differences in non-SSSI stand-level attributes between 2005/06 and 2016 were tested by means of two-tailed paired t-tests and Chi-squared two-way contingency analysis with Yates' Correction applied where there were low degrees of freedom. Unpaired t-tests were used to compare 2005/06 and 2016 stop level attributes. Samples sizes are shown in each table.

2.57 The large number of statistical tests carried out increased the chance of generating false-positive results, and this needs to be born in mind when interpreting the results.

2.58 Of the 188 selected possible sites (for which HO1 or HO2 had been confirmed present where relevant), some were rejected prior to survey, and some during (or after) survey.

2.59 Table 6 outlines which sites in the sample were rejected and the reason for rejection. A total of 165 sites were visited, and heathland on 143 sites containing a total of 155 stands were fully surveyed and analysed. Figure 1 shows the location of these sites.

2.60 A major reason for SSSI in-field rejection, was the lack of lowland heathland within Units, even though they had lowland heathland as a notified feature (n=18). When this was investigated further, it was found that the following habitats occurred in these Units:

- Mire (n=2)
- Dense bracken (n=2)
- Culm grassland (n=5)
- Conifer plantation (n=2)
- Scarp woodland/acid grassland/calcareous grassland (n=2)
- Stunted cliff-top *Ulex europaeus* (n=4)
- Bare ground (scraped for heathland restoration purposes (n=1)

Table 6 Site rejections and final stands recorded

	SSSI		**non-SSSI**		
	HO1/HO2	**non-HO1/HO2**	**HO1/HO2**	**non-HO1/HO2**	**ALL**
Rejected pre-survey	2 Large and fragmented Unit – rejected for reasons of practicality(1); rejected by NE officer – already has survey (1)	12 Access refused (2), rejected by NE officer – landowner issue (5); Rejected by NE officer – definitely no suitable habitat (5)	1 rejected by NE officer – landowner issue (1)	8 Access refused (5); No response from landowner (3)	23
Reject in field	1 No heath (1)	17 No heath (16) Site recently scraped for heathland restoration so full survey not possible (1)	0	4 Impenetrable dense *Ulex europaeus* (1) chalk heath lost, and sample outlier (1); wrong landowner contacted and site gated (1) Multiple issues (part destroyed, part inaccessible and part woodland) (1)	22
Full survey undertaken	55	29	31	28	143
Second stand	11	1	0	0	12
TOTAL NUMBER OF SURVEYED STANDS IN SAMPLE	**65**	**30**	**31**	**28**	**155**

Figure 1 The Location of the surveyed sites in the sample.

2.61 Three non-SSSI stands were also rejected in the field. One was the only limestone heath in the sample, which, having had a low cover of dwarf-shrubs in 2005/06, had no dwarf-shrubs in 2016 and was being managed by a conservation body as chalk grassland. The rejection of this site appears valid as it would have been a significant outlier. Another was a dense and impenetrable stand overwhelmingly dominated by common gorse *Ulex europaeus*. It was not clear whether it had changed much since 2005/06, although the gorse may have become more mature and dense. Some time was spent crawling beneath the gorse, and only one

straggly remnant of *Calluna vulgaris* was found. Finally a non-SSSI non-HO1/HO2 stand was rejected as there was an error in the 2005/06 mapping data, causing the wrong area to be surveyed.

2.62 In four cases, following discussions with Natural England staff, an adjacent area of land was surveyed in lieu of a selected SSSI Unit; in one case this was non-SSSI land, and was excluded from the analyses.

2.63 Table 7 shows further issues encountered while sampling in the field and analysing the vegetation, and the solution applied in each case.

Table 7 Assessment issues encountered, and the solutions applied

Issue	**Solution/comment for whole site analyses**
non-SSSI sites	
One stand assessed as dry heath in 2005/06, but assessed as dune heath in 2016	2005/06 data reassessed against dune heath targets (relevant only to positive indicator species)
Three stands classified as wet in 2005/06, but assessed as dry heath in 2016. Examination of raw data suggests that this down to difference in classification approach between the two survey years	2005/06 data reassessed against dry heath targets
One 2005/06 stand since designated as part of an SSSI	Kept within the non-HLS sample for vegetation analysis purposes, but SSSI designation considered under management section
2005/06 sites part destroyed for new road (remainder in HO2)	Remaining areas surveyed (10 stops)
Only very small part HO1	Whole 2005/06 site surveyed and moved to non-agreement sample
2005/06 only 12 HO2 stops re-surveyed (rest non-agreement and no access permission, but similar in appearance). Cannot separate out correct 2005/06 stops, but raw 2005/06 data suggests both areas similar character at time of baseline	Kept in sample (average of 12 rather than 20 stops in 2016)
A few stops in a dry heath stand fell with wet heath but assessed as dry heath in 2005/06	Included all stops and kept within the dry heath sample
HO1 stand. All but two stops resurveyed (different owner and agreement, but similar vegetation). Not possible to identify the correct two stops to remove from 2005/06 dataset	Kept in sample (average of 18 rather than 20 stops in 2016)
HO1 stand. Three stops fell within long-standing woodland. Due to a 2005/06 mapping error (site known to surveyor)	Kept in sample (three erroneous stops removed, and average of 17 rather than 20 stops in 2016)
Mainly HO2, but five stops fell outside this option, and one or two other stops possibly within HO3 (map not clear)	Included all stops and kept within the HO2 heath sample. Option correct for individual stop analyses
Walk consisting of <20 stops for practical reasons	Use means based on correct number of stops

Issue	**Solution/comment for whole site analyses**
SSSI sites	
Stands with small fragments (<5%) wrong side of HO1/HO2 boundary	Placed in correct predominant HO1/HO2 group. Option correct for individual stop analyses
Six stands with <20 stops for practical reasons, for example for very small Units or when doing second stands	Average for correct number of stops
Eleven large SSSI Units supporting a fine mosaic of wet and dry heath, which could not be practically separated during survey	Assessed heath type based on combination of surveyor advice, and examination of raw attribute data (pass-rates of wet vs dry, and cover of *Sphagnum* spp.).
Two stands include smaller amounts of wet heath within a wider dry heath stand the stand	Included in the dry heath sample
Four stands surveyed with <10% dwarf-shrubs, but still heathy in character	Kept in sample
Classic Lizard heathland – a mosaic of 'tall' heath and 'short-heath'	Assessed as dry heath

3 Results - preliminary analyses – testing assumptions

3.1 Because of differences in how samples were drawn and in stand mapping and stop sampling between the SSSI and non-SSSI sample, the vegetation of the two samples have been analysed separately. However, a Chi-square analysis was performed to examine the differences in condition in dry heaths between the two groups of stands (**Figure 1**Figure 2). This confirms that that in general the SSSI stands appear to be in slightly better condition than those outside of SSSIs, with statistically significant better pass-rates for dwarf-shrub cover and diversity, tree/scrub cover and *Rubus* spp. cover. However, SSSIs had a significant lower pass-rate for dense acrocarpous mosses.

3.2 The non-SSSI baseline data from 2005/06 were used to look for differences in 'starting point' for dry heath stands that were eventually placed in an HO1/HO2 option (n=29), and those that were not (n=28), hence testing the assumption that any resulting differences between the two groups in 2016 could be attributed directly to the HLS heathland options rather than a different 'starting-point'. No significant difference in 2005/06 dry heath pass-rates were found between the two groups. The biggest difference (p=0.08) was in dwarf-shrub diversity pass-rate, with 55% of stands which went into HO1/HO2, compared to 29% which didn't (Figure 4). However, significant differences were found in some raw attribute values (Table 8), with *Molinia caerulea* frequency at higher levels in 2005/06 in the stands which went into HO1/HO2 compared with those that didn't, at stand level.

3.3 At the more sensitive stop level analysis, more attributes showed a significant difference between the groups (Table 8), with stands destined for HO1 and HO2 having greater dwarf-shrub cover, increased dwarf-shrub richness, greater cover of dwarf Ulex spp. and more *Sphagnum* spp. And, on the other hand, fewer negative species, less dense acrocarpous moss, less undisturbed bare ground and a lower cover of lichens.

3.4 Table 8 also indicates where significant differences existed in 2005/06 between the HO1 and HO2 destined groups. In general, this suggests that sites with lower cover of scrub, *Rubus* spp. *Pteridium aquilinum* and *Ulex europaeus*, and higher dwarf-shrub cover (but lower dwarf Ulex spp. cover) were more likely to end up in an HO1 rather than an HO2 option. However, the HO2 destined stands had a bigger range of graminoid indicator species than the HO1 destined ones.

3.5 Figure 3 shows the differences in 2005/06 dwarf-shrub age-structure in stands destined for each option group, calculated using stop data. This shows some very slight suggestion of an older age-structure in non-HO1/HO2 stands than in those destined for HO1/HO2 options. However, this has not been tested statistically, and in all groups the proportion of young pioneer dwarf-shrubs was low.

3.6 Overall, there were therefore differences in the vegetation of the two groups in 2005/06, but these were not generally significant to affect the overall pass-rates at that time.

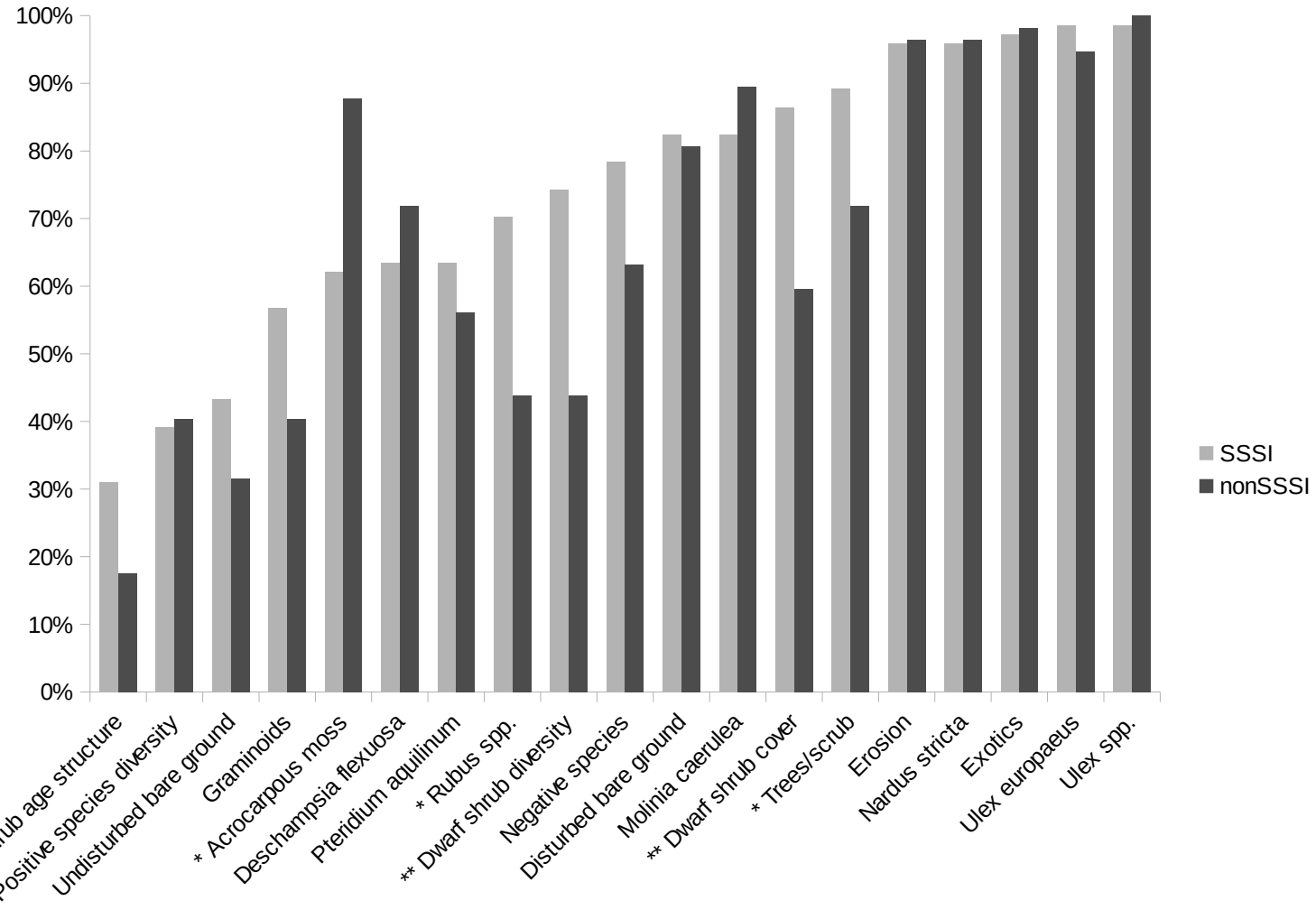

Figure 2 Pass-rates of targets in dry heaths in SSSI (n=74) and outside (n=57) SSSI, showing statistically significant differences as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005)

Table 8 2005/06 raw attribute values in the stops destined for HO1 (n=180) and HO2 (n=417) options, or no such option (n=580) by the year 2016. Only shows significant results: *=p<0.05, **=p<0.005

Basis Transfor-mation	**2005/06 attribute**	**destined 2016 predominant HO1/HO2 status**											
		non		**HO1/O2**		**HO1/HO2 vs non**		**HO1**		**HO2**		**HO1 vs HO2**	
		mean	*SE*	*mean*	*SE*	*p.*	*sig.*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
Stand	*Molinia caerulea* frequency	4.82	1.27	8.84	1.48	0.04	*						
ln(x+1)	Bare ground – undisturbed	3.65	0.49	2.01	0.37	0.00	**						
ln(x+1)	Bryophyte cover							12.69	1.97	3.88	0.39	0.02	*
1/(x+1) weak	Dense acrocarpous moss	1.05	0.31	0.83	0.31	0.00	**	2.66	1.07	0.12	0.06	0.01	*
	Dwarf-shrub cover	32.03	1.46	40.86	1.49	0.00	**	51.76	3.15	36.57	1.63	0.00	**
	Dwarf-shrub richness	1.13	0.04	1.56	0.04	0.00	**						
	Graminoid species richness							1.11	0.07	1.37	0.04	0.00	**
1/(x+1) weak	Lichen cover	1.95	0.46	0.04	0.01	0.00	**						
	Molinia caerulea cover							3.17	0.96	12.97	1.27	0.00	**
ln(x+1)	Negative species cover	3.98	0.50	1.29	0.26	0.00	**						
ln(x+1)	*Pteridium aquilinum* cover							2.68	0.93	5.96	0.83	0.02	*
1/(x+1)	*Rubus* spp. cover							0.37	0.17	1.93	0.33	0.00	**
ln(x+1)	Trees/scrub cover							1.07	0.48	5.99	0.71	0.00	**
ln(x+1)	*Ulex europaeus* cover							7.75	1.49	3.20	0.60	0.00	**
	Ulex spp. cover	9.78	1.09	18.80	1.35	0.00	**	11.28	1.84	21.76	1.72	0.00	**

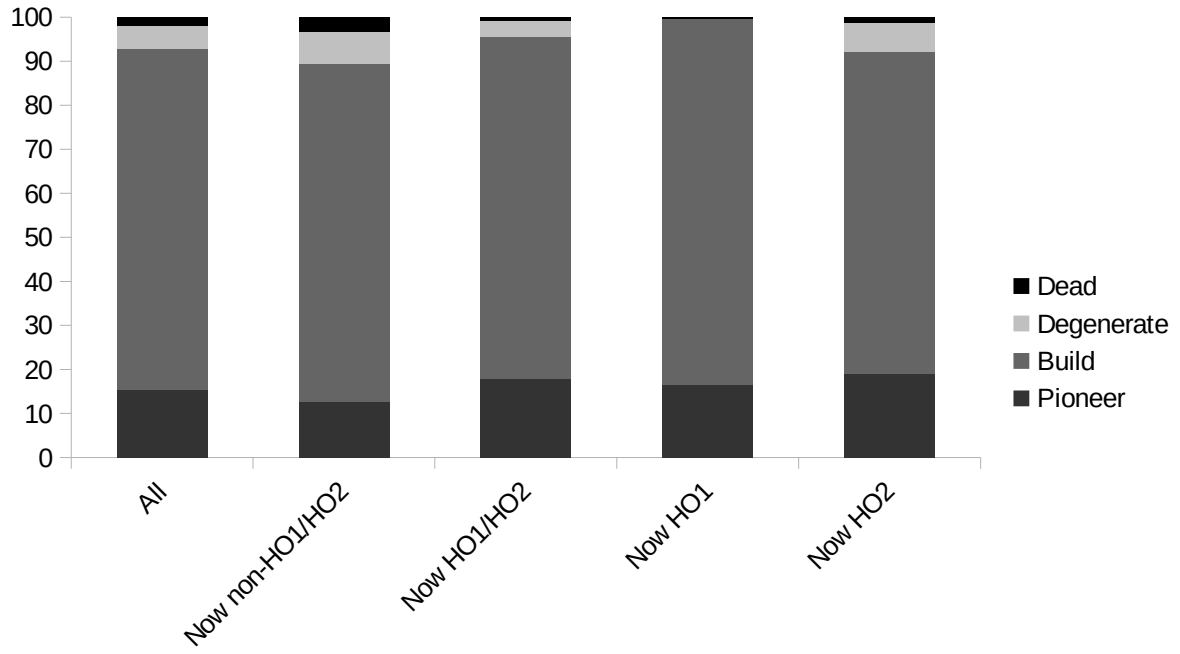

Figure 3 Dwarf-shrub age-structure of the 2005/06 vegetation destined for predominantly HO1 (n=180 stops), HO2 (n=457 stops) or no such (n=580 stops) option. Based on stop-level data. NB: Targets for dry-heath are 10-40% pioneer, 20-80% building, <30% degenerate, <10% dead.

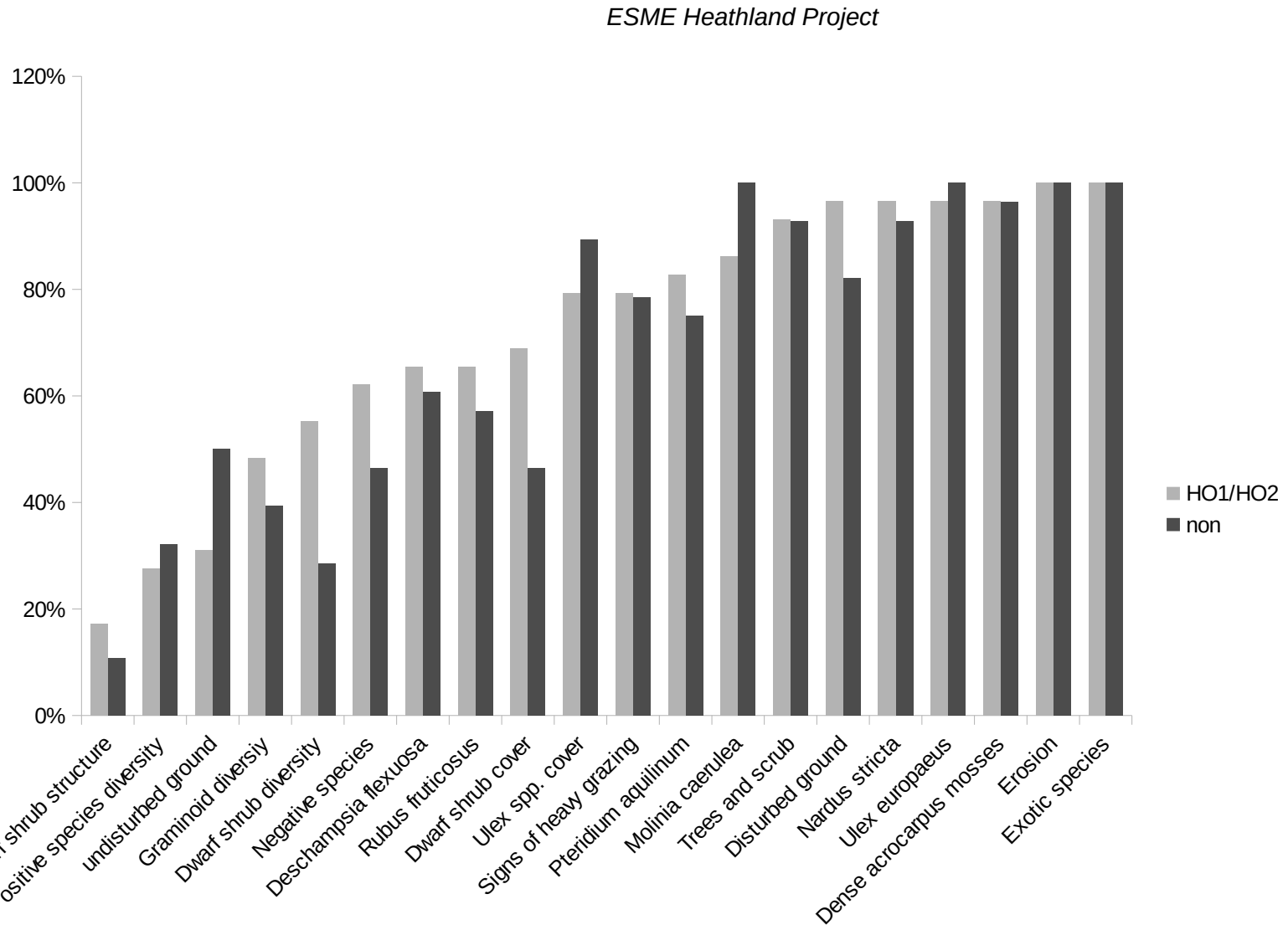

Figure 4 Differences in 2005/06 baseline pass-rates for dry heath stands destined to be within (n=29) and outside (n=28) HO1/HO2 options by 2016. No differences were statistically significant, as tested by individual Chi-square tests, with Yates' correction applied.

4 Results: the vegetation

The non-SSSI sample

4.1 Table 9 below shows the details of the non-SSSI stands. The sample is predominantly dry heath, with only two wet stands, both under an HO2 option. There were more stands with <10% dwarf-shrub cover in the non-HO1/HO2 sample than those within these options, though heaths with 10-25% dwarf-shrub cover were approximately twice as likely to fall within HO1/HO2 than outside HO1/HO2.

Table 9 Details of the non-SSSI sample.

	HO1/HO2			non-HO1/HO2	ALL
Assessed as	**dry**	**wet**	**total**	**all dry**	
Number of stands	29	2	31	28	59
Mean dwarf-shrub cover					
>25%	18	1	19	17	36
10-25%	8	1	9	4	13
<10%	3	0	3	7	10
Natural England Area Team					
1. Northumbria				2	2
2. Cumbria	1		1		1
3. Yorkshire & North Lincolnshire				1	1
4. Cheshire, Greater Manchester, Merseyside & Lancashire				2	2
5. East Midlands				1	1
6. North Mercia	2		2	1	3
7. South Mercia	2		2	2	4
8. Essex, Hertfordshire, Bedfordshire, Cambridgeshire & Northamptonshire				1	1
9. Norfolk & Suffolk	2		2	5	7
10. Thames	5		5	4	9
11. Somerset, Avon & Wiltshire	1		1		1
12. Devon, Cornwall & Isles of Scilly	8		8	7	15
13. Dorset, Hampshire & Isle of Wight	4	2	6	2	8
14. Sussex & Kent	4		4		4
Current predominant heath option					
HO1	9		9		9
HO2	20	2	22		22
Within an non-HO1/HO2 HLS agreement	-	-	-	1	1
Years in current HO1/HO2 option to 1st September 2016					
Min	1.37	7.26	1.37	-	
Max	8.83	7.99	8.83	-	
Mean	4.86	7.62	4.94	-	
Stand size (ha)					
Min	0.51	1.10	0.51	0.13	0.13
Max	23.51	12.43	23.51	20.52	23.51
Mean	7.06	6.77	7.04	3.22	5.23
Size class					
Small <5ha	13	1	14	5	19
Medium 5-20ha	14	1	15	22	37
Large >20ha	2	0	2	1	3

4.2 Figure 5 show the number of attributes passed (out of 19) in the non-SSSI dry heath sample in 2016. Every stand failed at least one generic CSM attribute target. In general, stands within a current HO1/HO2 option pass slightly more targets (average 71%) than those without these options (average 65%) (n=29 and 28 respectively).

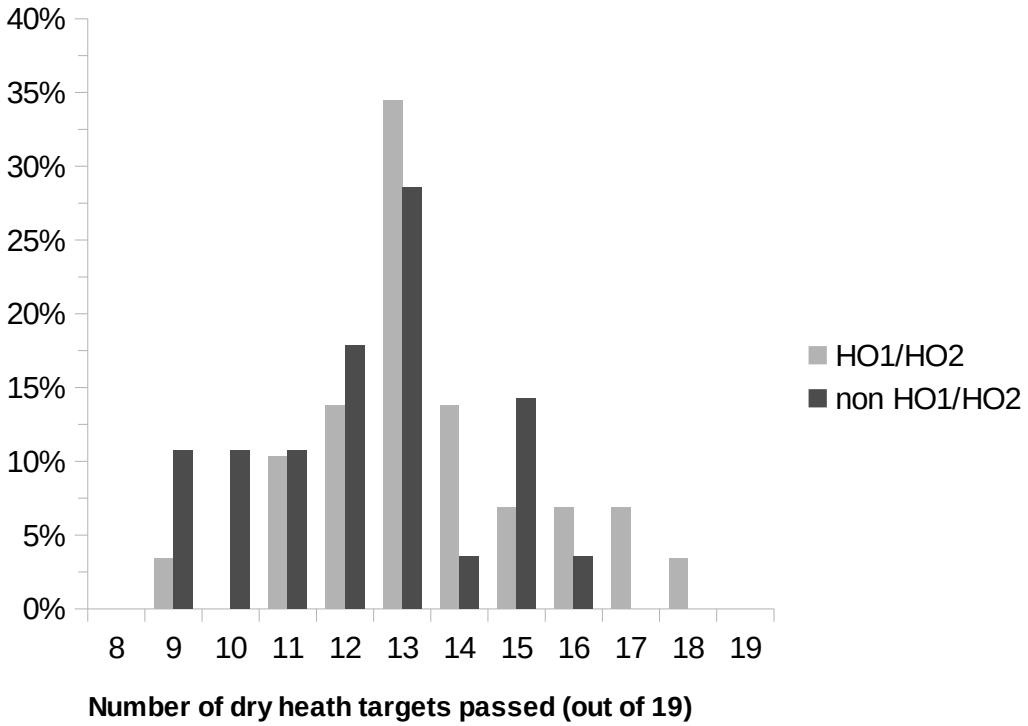

Figure 5 Percentage of stands by number of targets passed out of a possible 19 by the non-SSSI dry heath stands within (n=29) and outside (n=28) HO1/HO2 options.

4.3 The two wet heaths, not included in figure 5, had pass-rates of 10 and 9 attributes out of 15 (average 63%).

4.4 The condition assessment pass rates for individual attributes were also examined, and the results presented in Figure 6. This shows that HO1/HO2 stands had significantly higher pass rates for graminoid and dwarf-shrub diversity than non-HO1/HO2 stands. Other attributes also appeared to show slightly higher pass-rates in the HO1/HO2 stands, though these differences were not significant.

4.5 In both groups, pass-rates were among the lowest for dwarf-shrub age-structure and undisturbed bare ground, while graminoid diversity, dwarf-shrub diversity and cover of *Rubus* spp. had particularly low pass-rates in the non-HO1/HO2 group.

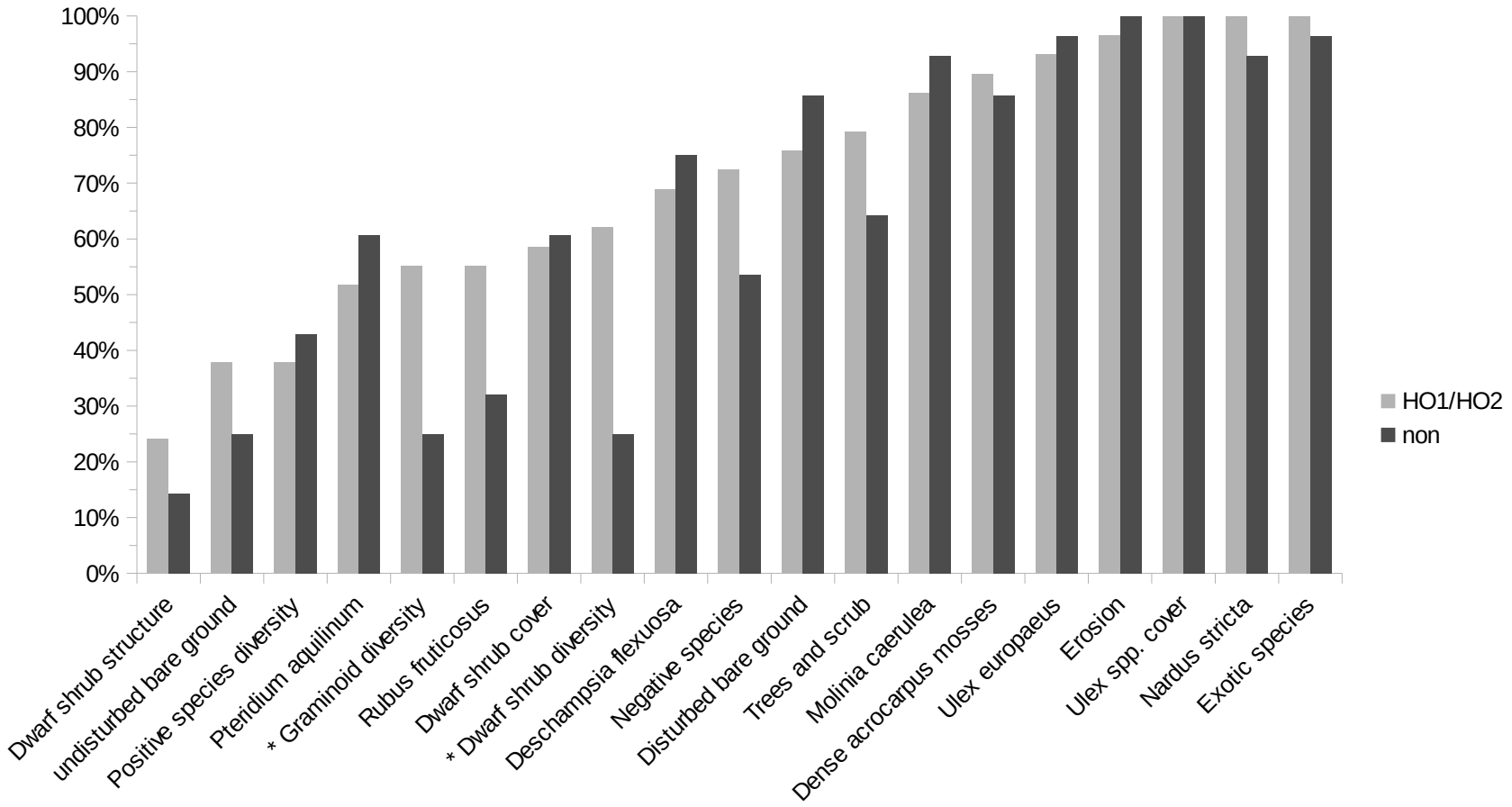

Figure 6 Pass-rates in 2016 for individual attribute targets in the non-SSSI dry heath sample, for stands predominantly within (n=29) and outside (n=28) HO1/HO2 options. Significant results. *=p<0.05, **=p<0.005 as tested by individual Chi-square tests, with Yates' correction applied.

4.6 Changes in pass-rates since 2005/06: Figure 7 shows the change in number of targets passed in the non-SSSI dry heath sample, showing those within and outside of HO1/HO2 options. This shows that slightly more stands improved in condition in the HO1/HO2 group, and that fewer stands declined in condition, although the differences were not statistically significant (Chi-squared p=0.6060).

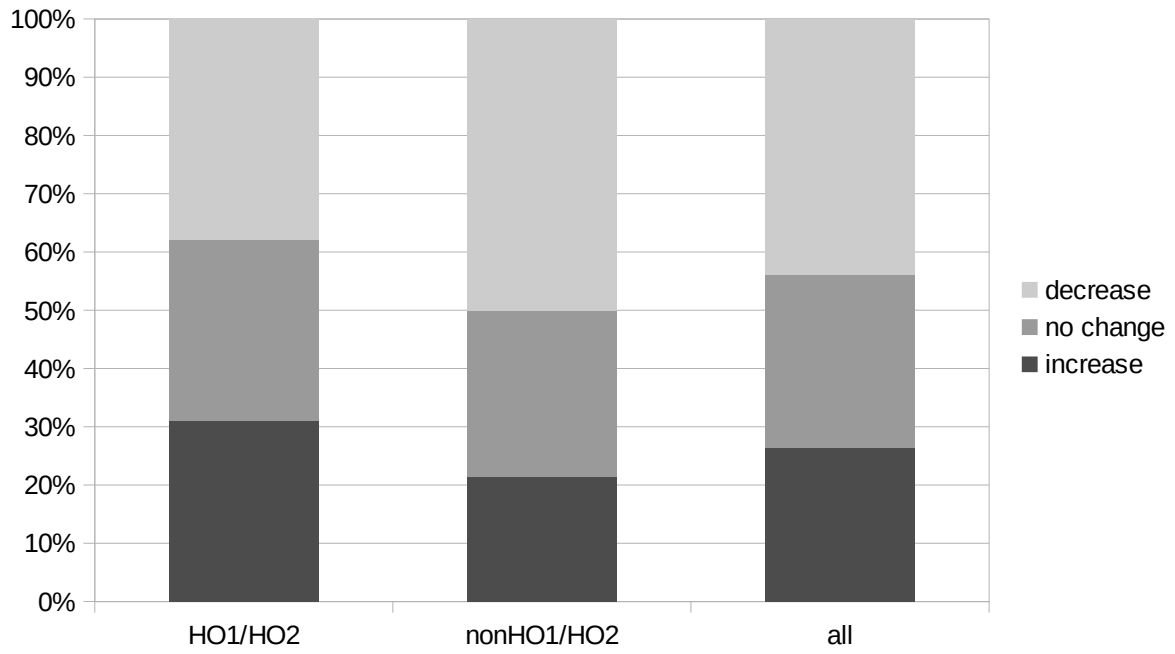

Figure 7 The relative change in number of attribute targets passed by non-SSSI dry heath stands in the period 2005/06 to 2016, for stands predominantly within (n=29) and outside of (n=28) current HO1/HO2 option.

4.7 Figure 8 compares pass-rates for stands predominantly in and out of HO1/HO2 options, whereas Figure 9 compares pass-rates for individual attribute targets between survey years. Though there were differences between the two survey dates, only a small number of these were statistically significant, and neither group improved consistently across all targets. In HO1/HO2 stands, there was a significant increase in pass-rate for the target for <50% Ulex spp. cover, but a decrease in passes against the <10% *Pteridium aquilinum* target over the ten year period. Outside of HO1/HO2 options, there was also a significant increase in pass-rate for the target for <50% Ulex spp. cover, but a decrease in passes for <15% trees/scrub. Other differences existed, but were not statistically significant.

4.8 In both groups, the targets for a varied dwarf-shrub age-structure and undisturbed bare ground were the least often met. In the case of undisturbed bare ground, while the pass-rate for the >1%[2] undisturbed bare ground target of the HO1/HO2 group increased slightly (by 7%), it decreased (by 25%) outside of these options. Conversely, a near significant (p=0.0569) difference was found in disturbed bare ground pass-rate, which decreased by 25% in the HO1/HO2 stands, but changed less (10% increase) in the non-HO1/HO2 stands. This implies that useful, undisturbed bare ground increased, whereas disturbed bare ground decreased in stands with HO1/HO2 options over the ten year period, while the opposite was true outside of HLS. However, these differences were not statistically significant at the stand-pass level.

4.9 The other attribute target pass-rate in which the direction of change differed between the two groups was dwarf-shrub cover: in the HO1/HO2 group the dwarf-shrub cover pass-rate decreased (by 10%), while in the non-HO1/HO2 stand it increased (by 14%), although these changes were also not statistically significant.

[2] Target is 1-10% undisturbed bare ground; only one non-HO1/HO2 stand failed due to exceedance of the upper limit.

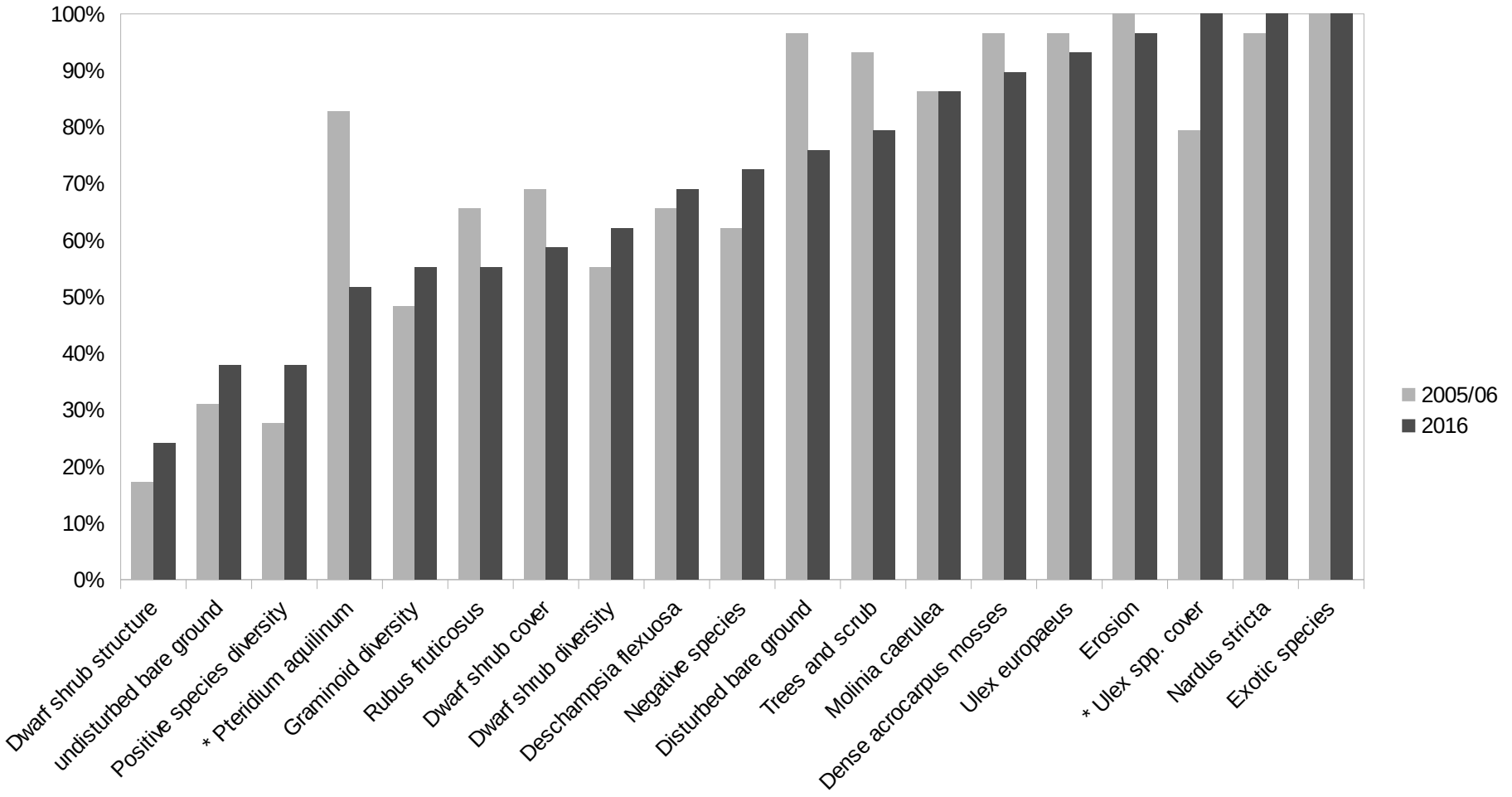

Figure 8 Change in pass-rates for individual non-SSSI dry heath targets for stands in HO1/HO2 options in 2016 (n=29). Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005).

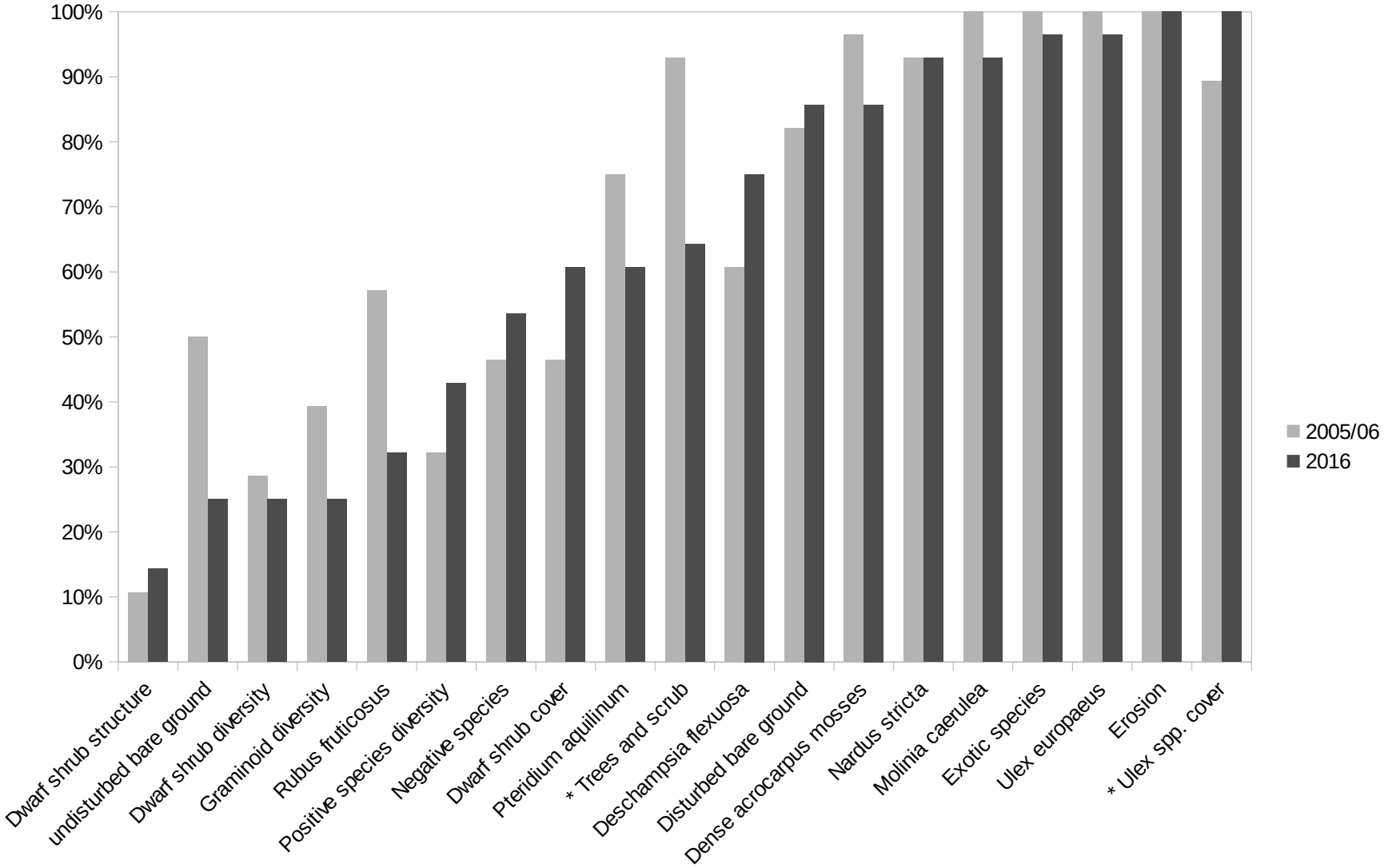

Figure 9 Change in pass-rates for individual non-SSSI dry heath targets for stands outside of HO1/HO2 options in 2016 (n=2015/2016 (n=28). Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005).

4.10 Analyses were also performed on the raw attribute values for all sites (including the two wet heaths), both as site averages, and individual stop attributes. Statistically significant differences were tested by unpaired or paired two-tailed t-tests as appropriate. Table 10 and Table 11 show the average attribute values where there were significant difference between the HO1/HO2 groups (Table 10), or survey years (Table 11) respectively. Full data, including the non-significant results, may be found in Appendix 4 and 5.

4.11 Table 10 shows that in 2016, stands within HO1/HO2 options had a greater diversity and frequency of dwarf-shrubs; greater graminoid diversity; a greater cover of bryophytes and lichens; more positive indicator species richness, but also more disturbed bare ground and higher cover of *Molinia caerulea* and litter, than those outside of these options.

4.12 Conversely stands within HO1/HO2 had lower cover of trees and scrub; lower cover of negative species, *Rubus* spp and dense acrocarpous mosses.

4.13 Using stop data to look for differences between the two individual options found that in 2016, HO1 stands tended to have a greater cover and diversity of dwarf-shrubs, but more dense acrocarpous mosses and more *Ulex europaeus*. However, they also had lower cover of lichen, dwarf *Ulex* spp, and *Molinia caerulea* than those in HO2.

4.14 Table 11 shows that both HO1/HO2 and non-HO1/HO2 stands increased in cover of *Pteridium aquilinum*, *Rubus* spp. and tree/scrub cover, but also positive indicator species richness over time (though the increase was bigger in the HO1/HO2 group). The frequency of dwarf-shrub decreased slightly overall in both groups.

4.15 The HO1/HO2 stands saw the increase of total graminoid richness; lichens and bryophytes (both cover and frequency); richness of species at least frequent in the stand; disturbed bare ground. In those stands the cover (but increased in frequency) of dense acrocarpous mosses decreased, as did, slightly, the total dwarf-shrub (and *Ulex* spp. cover) cover and frequency.

4.16 On the other hand, stands without agreements had lower total dwarf-shrub species richness; richness of graminoid species at least occasional in the stand; cover and frequency of *Deschampsia flexuosa* and undisturbed bare ground cover. The cover of dense acrocarpous mosses and exotic species increased over time.

4.17 Figure 10 shows the dwarf-shrub age-structure in the HLS groups, using stop data. This suggests a slightly younger age-structure occurring in stands within HO1/HO2 options, compared to those without, though this has not been tested statistically.

4.18 Figure 11 shows the dwarf-shrub age-structure in each option group between the two survey dates. This shows that the proportion of pioneer dwarf-shrub increased slightly more in the HO1/HO2 option stands, than those outside of these options, and the proportion of dead/degenerate dwarf-shrubs decreased in the non-HO1/HO2 stands. However the differences are not large and the statistical significance is not known.

Table 10 Raw 2016 attribute values, for non-SSSI stands within and outside HO1/H2 options, and also by actual HLS option in 2016. Based either on site averages (n=31 and 28 respectively) or individual stop data (HO1 (n=160) and HO2 (n=436) options, or no such option (n=559). Site-level analyses use predominant option for stand; stop based analyses use stop-specific option status. Only shows attributes with significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005. Full data found in Appendix 4.

Basis	**Transforma-tion**	**Attribute**	**HO1/HO2**		**non-HO1/HO2**		**HO1/HO2 vs non**		**HO1**		**HO2**		**HO1 vs HO2**	
			mean	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	p.	sig
stand		Dwarf-shrub species at least frequent	2.65	*0.17*	1.39	*0.17*	0.00	**						
		Dwarf-shrub species richness	3.26	*0.15*	2.00	*0.17*	0.00	**						
		Graminoid species at least occasional	2.77	*0.22*	1.89	*0.20*	0.00	**						
		Graminoid species richness	3.65	*0.20*	2.64	*0.24*	0.00	**						
		Tree/scrub cover	7.14	*1.39*	15.45	*3.75*	0.04	*						
Stop	1/(x+1) weak	Bare ground – disturbed	1.45	0.36	0.42	0.20	0.04	*						
		Bryophyte cover	14.73	1.20	7.87	0.90	0.00	**						
	1/(x+1)	Dense acrocarpous moss	0.55	0.14	1.49	0.29	0.02	*	1.74	0.49	0.12	0.05	0.00	**
	ln(x+1)	*Deschampsia flexuosa* cover	2.94	0.43	2.22	0.42	0.01	*						
		Dwarf-shrub cover							47.14	3.42	33.66	1.71	0.00	*
		Dwarf-shrub richness	1.53	0.05	0.98	0.04	0.00	*	1.71	0.10	1.46	0.06	0.03	*
		Graminoid species richness	1.61	0.05	1.20	0.04	0.00	*						
	1/(x+1) weak	Lichen cover							0.18	0.05	0.21	0.12	0.01	*
	ln(x+1)	Litter cover	7.86	0.76	4.10	0.53	0.00	**						
		Molinia caerulea cover	12.49	0.96	7.60	0.88	0.00	**	4.18	0.97	15.54	1.24	0.00	*
	ln(x+1)	Negative species cover	1.75	0.31	5.99	0.78	0.00	**						
		Positive species richness	1.18	0.07	0.71	0.05	0.00	**						
	ln(x+1)	*Rubus* agg. cover	2.76	0.41	6.57	0.78	0.00	**						
	ln(x+1)	Trees/scrub cover	6.59	0.71	15.83	1.29	0.00	**						
	ln(x+1)	*Ulex europaeus* cover							10.03	1.67	2.94	0.58	0.00	**
		Ulex spp. cover							4.50	0.84	8.90	0.96	0.00	**

Table 11 Raw 2005/06 and 2016 attribute values, for non-SSSI stands within and outside HO1/H2 options. Based either on site averages (n=31 and 28 respectively) or individual stop data. All analyses use predominant option for stand. Only shows attributes with significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005. Full data found in Appendix 5.

Basis	Transforma-tion	Attribute	non-HO1/HO2 2005/06		non-HO1/HO2 2016		2005/06 vs 2016		HO1/HO2 2005/06		HO1/HO2 2016		2005/06 vs 2016		All 2005/06		All 2016		2005/06 vs 2016	
			mean	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*
stand		Bare ground - disturbed cover							0.06	0.04	1.44	0.51	0.01	*						
		Bryophyte cover							6.11	1.90	14.83	4.66	0.04	*						
		Bryophyte frequency							6.81	1.19	10.39	1.35	0.01	*						
	1/(x+1)	Dense acrocarpous moss frequency							0.68	0.46	2.23	0.76	0.01	*	0.92	0.30	2.49	0.66	0.01	*
	ln(x+1)	*Deschampsia flexuosa* cover	6.80	2.52	1.51	0.59	0.00	**							6.37	1.62	2.53	0.78	0.00	**
		Deschampsia flexuosa frequency	5.71	1.33	3.50	1.09	0.01	*												
		Dwarf-shrub frequency	14.86	0.96	11.96	1.22	0.00	**	16.58	0.63	14.86	0.71	0.00	**	15.42	0.63	13.44	0.70	0.00	**
		Dwarf-shrub species at least frequent							1.94	0.19	2.65	0.17	0.00	**	1.69	0.10	2.05	0.11	0.02	*
		Dwarf-shrub species richness	2.64	0.23	2.00	0.17	0.00	*							3.08	0.11	2.66	0.11	0.00	*
	ln(x+1)	Exotic species frequent	0.00	0.00	0.39	0.20	0.03	*												
		Graminoid species occasional	2.29	0.19	1.89	0.20	0.02	*												
		Lichen frequency							0.90	0.24	1.69	0.45	0.04	*						
		Positive species occasional							0.87	0.21	1.35	0.27	0.01	*	0.98	0.12	1.27	0.13	0.05	*
		Positive species richness	1.89	0.33	2.54	0.36	0.05	*	1.74	0.27	3.00	0.31	0.00	**	1.81	0.16	2.78	0.18	0.00	**
		Pteridium aquilinum cover	5.28	1.47	13.36	3.28	0.01	*	5.25	1.78	12.77	2.52	0.01	*	5.20	1.17	13.26	2.02	0.00	**
		Pteridium aquilinum frequency													5.78	0.73	6.79	0.81	0.04	*
	ln(x+1)	*Rubus* spp. cover	2.08	0.47	6.55	2.03	0.03	*							1.91	0.44	4.53	1.07	0.02	*
		Tree/scrub cover	4.91	1.45	15.45	3.75	0.01	**							4.81	1.06	11.32	1.99	0.00	**
Stop	1/(x+1) weak	Bare ground – disturbed							0.06	0.03	1.47	0.35	0.00	**	1.02	0.26	0.95	0.21	0.01	*
	ln(x+1)	Bare ground – undisturbed	3.65	0.49	2.03	0.40	0.00	*							2.79	0.30	1.79	0.25	0.00	**
		Bryophyte cover							6.37	0.64	14.83	1.19	0.00	**	6.12	0.42	11.41	0.76	0.00	**
	1/(x+1) weak	Dense acrocarpous moss cover	1.05	0.31	1.51	0.30	0.00	*	0.83	0.31	0.55	0.14	0.00	**	0.94	0.22	1.01	0.16	0.00	**
		Dwarf-shrub cover							40.86	1.49	36.44	1.54	0.04	*						
		Dwarf-shrub richness	1.13	0.04	1.00	0.04	0.02	*							1.36	0.03	1.26	0.03	0.03	*
		Graminoid species richness							1.30	0.03	1.63	0.05	0.00	**	1.28	0.03	1.41	0.03	0.00	**
	1/(x+1) weak	Lichen cover							0.04	0.01	0.19	0.08	0.00	**						
		Positive species richness	0.28	0.03	0.71	0.05	0.00	*	0.30	0.03	1.18	0.07	0.00	**	0.29	0.02	0.96	0.04	0.00	**
	ln(x+1)	*Pteridium aquilinum* cover	5.49	0.70	13.60	1.25	0.00	*	5.04	0.66	12.58	1.09	0.00	**	5.25	0.48	13.07	0.83	0.00	**
	ln(x+1)	*Rubus* spp. cover	1.74	0.28	6.67	0.79	0.00	*	1.49	0.24	2.73	0.41	0.00	**	1.61	0.18	4.60	0.44	0.00	**
	ln(x+1)	Trees/scrub cover	5.04	0.60	15.21	1.28	0.00	*	4.60	0.53	7.29	0.77	0.00	**	4.81	0.40	11.06	0.74	0.00	**
		Ulex spp. cover							18.80	1.35	8.02	0.75	0.00	**	14.50	0.89	7.65	0.55	0.00	**
		n (stops)	*580*		*550*				*637*		*605*				*1217*		*1155*			

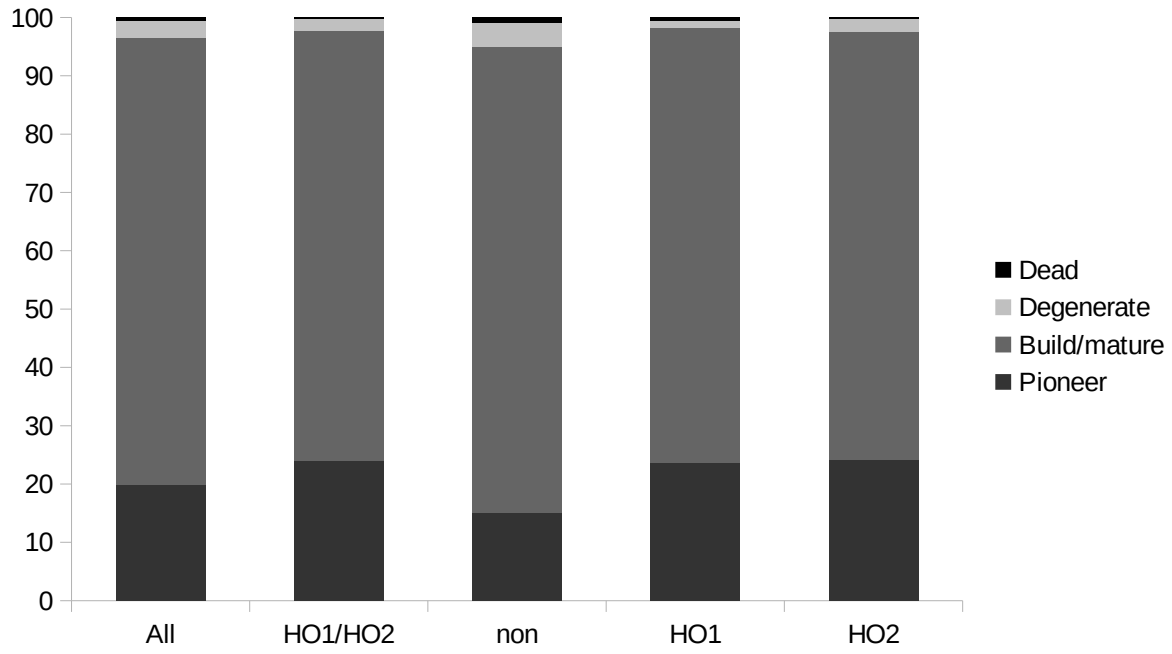

Figure 10 Dwarf-shrub age-structure of the 2016 vegetation within HO1 (n=160 stops), HO2 (n=436 stops) or no option (n=559 stops). Based on stop-level data. NB: Targets for dry-heath are 10-40% pioneer, 20-80% building, <30% degenerate, <10% dead.

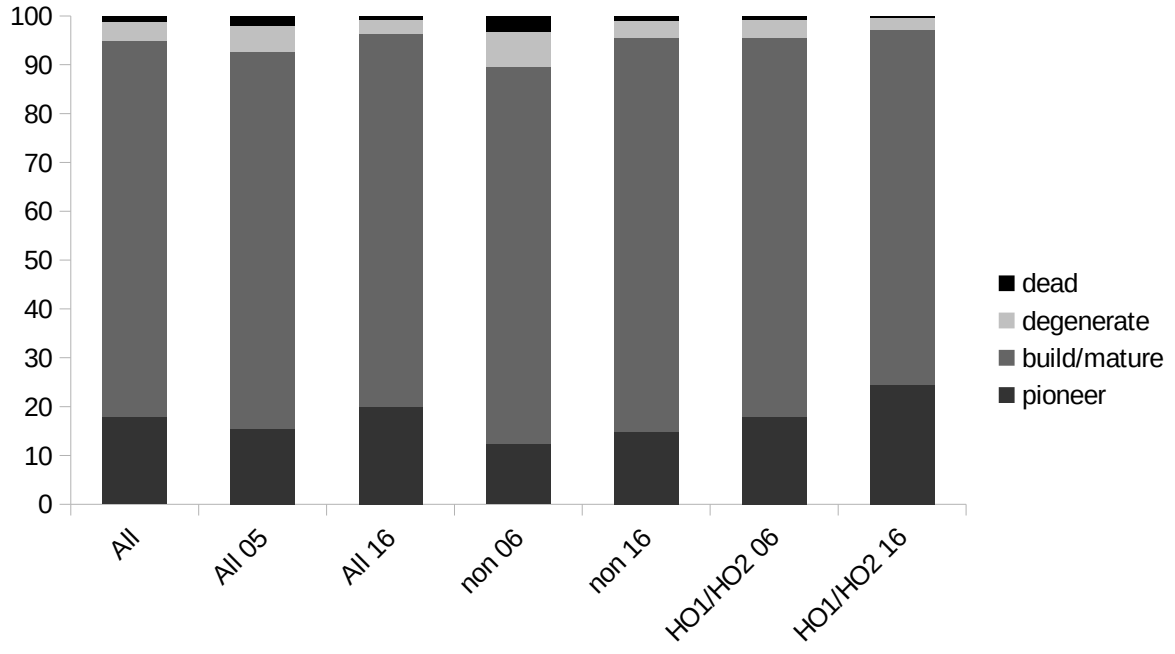

Figure 11 Dwarf-shrub age-structure of the stands in the two survey dates, in the different predominant option groups. Based on stop-level data. Non-HO1/HO2 2005/06 (n=580 stops), non-HO1/HO2 2016 (n=550 stops), HO1/HO2 2005/06 (n=637 stops), HO1/HO2 2016 (n=605 stops). NB: Targets for dry-heath are 10-40% pioneer, 20-80% building, <30% degenerate, <10% dead.

4.19 Figure 12 shows the pass-rates for targets in stands with and without grazing. This shows that grazing had few significant relationships with pass-rates, with the exception of graminoid species diversity, which was greatest in grazed stands.

4.20 Relationships between key attribute values and livestock grazing were examined with stop-level data, and differences tested by means of an unpaired two-tailed t-test. The results are shown in Table 12. Grazed stands had lower cover of dwarf-shrubs, trees/scrub, *Rubus* spp, and *Pteridium aquilinum*, lichens and dense acrocarpous mosses, but they had a greater diversity of dwarf-shrubs species, graminoid species, positive indicator species and higher cover of *Molinia caerulea*.

4.21 Figure 13 shows dwarf age-structure of grazed and ungrazed stands. There appears to be little impact of grazing on age-structure overall (and although grazed stands had a slighter greater pass-rate for this target than ungrazed stands, the difference was not statistically significant).

Table 12 Raw 2016 attribute values, for non-SSSI stands with and without livestock grazing. Based on individual stop data (non grazed (n=647) and grazed (n=508). Results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005.

Transforma-tion	**attribute**	**Not grazed**		**Grazed**		**Grazed vs Not grazed**	
		mean	*SE*	*mean*	*SE*	*p.*	*sig.*
1/(x+1) weak	Dense acrocarpous moss	1.70	0.28	0.12	0.04	0.00	**
	Dwarf-shrub cover	39.16	1.58	31.27	1.60	0.00	**
	Dwarf-shrub richness	1.16	0.04	1.39	0.05	0.00	**
	Graminoid species richness	1.18	0.04	1.71	0.06	0.00	**
	Lichen cover	1.80	0.41	0.03	0.02	0.00	**
ln(x+1)	Litter cover	4.80	0.57	7.63	0.79	0.00	**
	Molinia caerulea cover	7.24	0.79	13.80	1.10	0.00	**
	Positive species richness	0.57	0.04	1.44	0.07	0.00	**
	Pteridium aquilinum cover	15.73	1.22	9.56	1.04	0.00	**
ln(x+1)	*Rubus* spp. cover	5.90	0.68	2.95	0.47	0.00	**
1/(x+1) weak	*Sphagnum* spp. cover	0.34	0.17	0.55	0.15	0.01	*
	Trees/scrub cover	13.79	1.12	7.57	0.87	0.00	**
ln(x+1)	*Ulex* spp. cover	6.23	0.68	9.45	0.89	0.00	**
	Bryophyte cover	12.65	1.05	9.83	1.11	0.07	n.s.
ln(x+1)	Negative species cover	4.97	0.67	2.30	0.40	0.09	n.s.
ln(x+1)	Bare ground – undisturbed	1.94	0.34	1.61	0.36	0.22	n.s.
ln(x+1)	*Deschampsia flexuosa* cover	2.84	0.43	2.27	0.41	0.35	n.s.
1/(x+1) weak	Bare ground – disturbed	0.95	0.30	0.95	0.29	0.37	n.s.
	Negative species richness	0.36	0.03	0.40	0.03	0.41	n.s.
ln(x+1)	*Ulex europaeus* cover	5.52	0.69	4.93	0.72	0.71	n.s.
failed	*Schoenus nigricans* cover	0.01	0.01	0.00	0.00		
failed	Exotics species cover	0.29	0.18	0.00	0.00		
failed	*Nardus stricta* cover	0.19	0.08	0.08	0.03		
failed	Erosion cover	0.34	0.18	0.15	0.07		

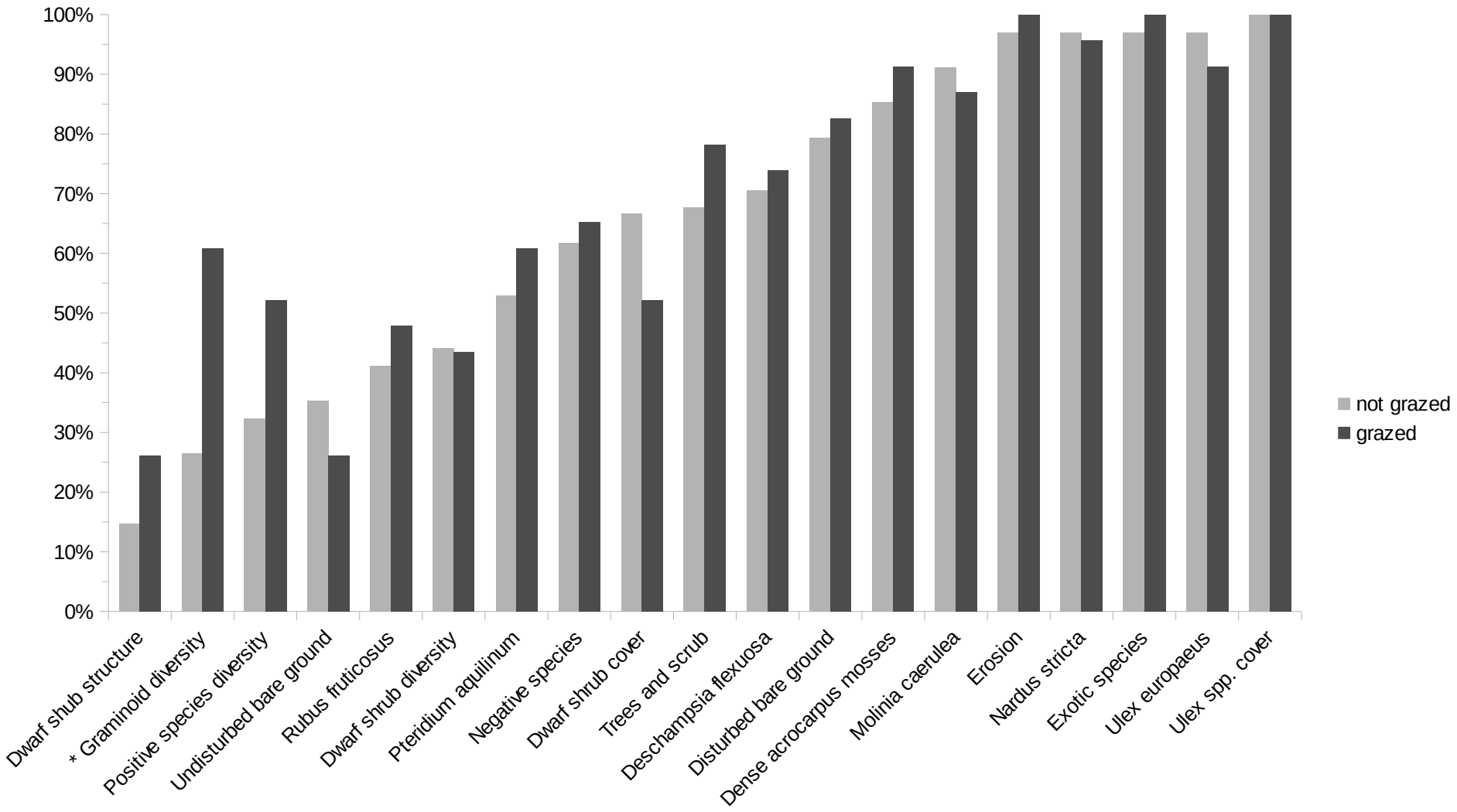

Figure 12 Pass-rates for individual attribute targets in the non-SSSI dry heath sample, for stands with (n=34) and without (n=23) known grazing. Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005).

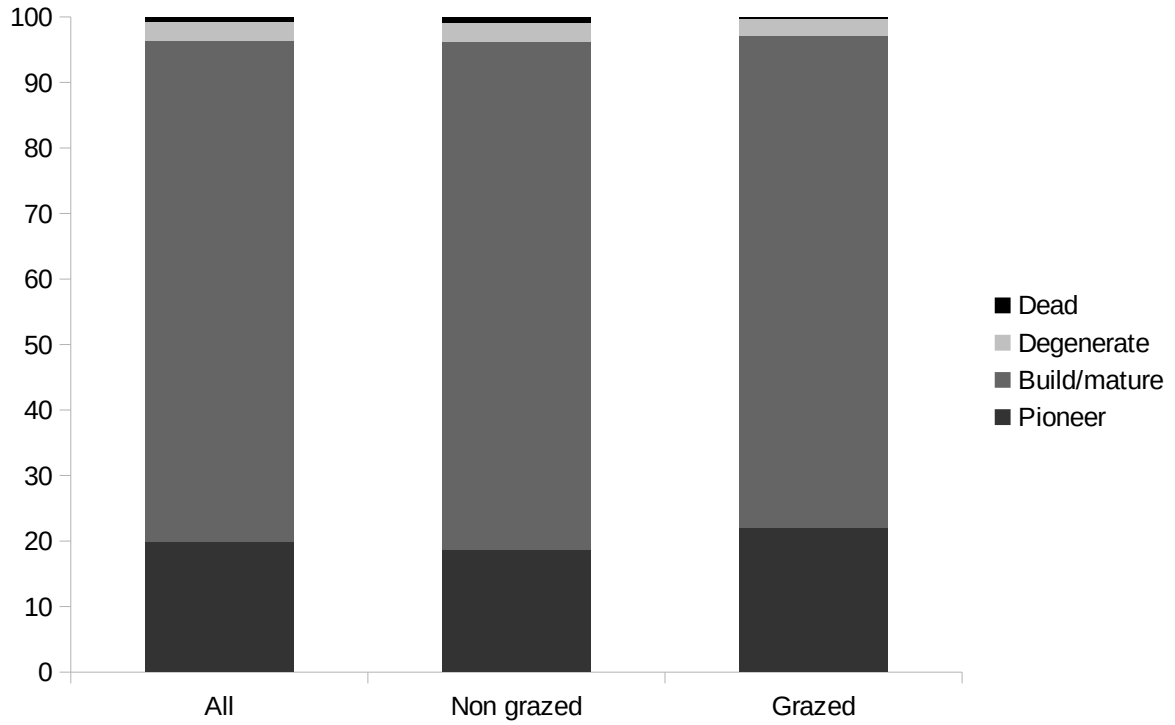

Figure 13 Dwarf-shrub age-structure of the 2016 vegetation within ungrazed (n=647 stops), and grazed (n=508 stops) stands. Based on stop-level data. NB: Targets for dry-heath are 10-40% pioneer, 20-80% building, <30% degenerate, <10% dead.

The SSSI sample

4.22 Table 13 below shows the details of the SSSI sample of stands. The sample is predominantly dry heath, but with more wet heaths than in the non-SSSI sample (22 compared to 2).

4.23 All stands failed at least one attribute target. Pass-rates were used to look for broad differences in SSSI heath condition within and without HO1/HO2 options. Figure 14 shows the number of attributes, out of the 19 possible, passed in the SSSI dry heaths within and outside of HO1/HO2 options. Figure 15 is the equivalent for wet heaths, out of 15 possible attributes. On average, the dry heath SSSI stands within HO1/HO2 options passed 72% of their attribute targets, compared to 67% of non-HO1/HO2 stands. In wet heaths the figures were 74% and 72% respectively.

4.24 The condition assessment pass-rates for individual attributes can be found in Figure 16 (dry heath) and Figure 17 (wet heaths) below, showing results of Yates' corrected chi-squared analyses.

4.25 Pass-rates were statistically significantly higher for negative species in the HO1/HO2 sample, although lower for positive species. In wet heaths there were no significant differences in pass-rate, possibly partly due by the low sample size.

4.26 In the dry heaths, the overall pass-rates were lowest for dwarf-shrub age-structure, positive species diversity, and undisturbed bare ground. Similarly, in the wet heaths, pass-rates were low for dwarf-shrub age-structure (particularly outside HO1/HO2), undisturbed bare ground, positive species diversity, but also graminoid species diversity, and lichens and Sphagnum (where present).

Table 13 Details of the SSSI sample. *Includes one chalk heath and one dune heath, and four stands in moorland HLS options; **Includes one stand in HK7 for grassland restoration (heath only a small area).

	HO1/HO2			non-HO1/HO2			ALL
Assessed as	**dry**	**wet**	**total**	**dry***	**wet****	**total**	
Number of stands	**50**	**16**	**66**	**24**	**6**	**30**	**96**
Dwarf-shrub cover							
>25%	45	14	59	18	3	21	80
10-25%	3	2	5	3	2	6	11
<10%	2	0	2	2	1	3	5
Natural England Area Team							
1. Northumbria			0		1	1	1
2. Cumbria	2		2	1		1	3
3. Yorkshire & Northern Lincolnshire	1		1		1	1	2
4. Cheshire, Greater Manchester, Merseyside & Lancashire	1		1			0	1
5. East Midlands	1		1	1		1	2
6. North Mercia	1		1	2		2	3
9. Norfolk & Suffolk	3		3	6		6	9
10. Thames	14	1	15	2	1	3	18
11. Somerset, Avon & Wiltshire			0	3		3	3
12. Devon, Cornwall & Isles of Scilly	5	1	6	7	2	9	15
13. Dorset, Hampshire & Isle of Wight	15	5	20	3		3	23
14. Sussex & Kent	14	1	15	1		1	16
Current heath option							
HO1	12	3	15	-	-	-	
HO2	33	4	37	-	-	-	
HO1 and HO2	4	5	9	-	-	-	
HO2 and ?HO3	1	0	1	-	-	-	
Within HLS agreement boundary	-	-	-	10	1	11	
non-heathland HLS option on stand (where known)*				4	1 (+2)		
Years in current HO1/HO2 option to 1st September 2016							
Min	0.01	3.43	0.01	-	-	-	
Max	10.09	10.09	10.09	-	-	-	
Mean	6.06	7.2	6.35	-	-	-	
Stand size (ha)							
Min	0.14	2.22	0.14	0.12	0.37	0.12	0.12
Max	207	40.46	207.05	169.12	12.5	169.12	207.05
Mean	20.48	15.81	19.91	36.97	3.1	31.51	23.65
Size class							
Small <5ha	23	3	26	11	1	12	38
Medium 5-20ha	19	2	21	3	4	7	28
Large >20ha	15	3	18	12	0	12	30
Stand – proportion of whole SSSI Unit (%)							
Min	0.30	0.13	0.30	0.30	6	0.30	0.30
Max	100	98	100	100	31	100	100
Mean	43	57	41	41	18	38	41

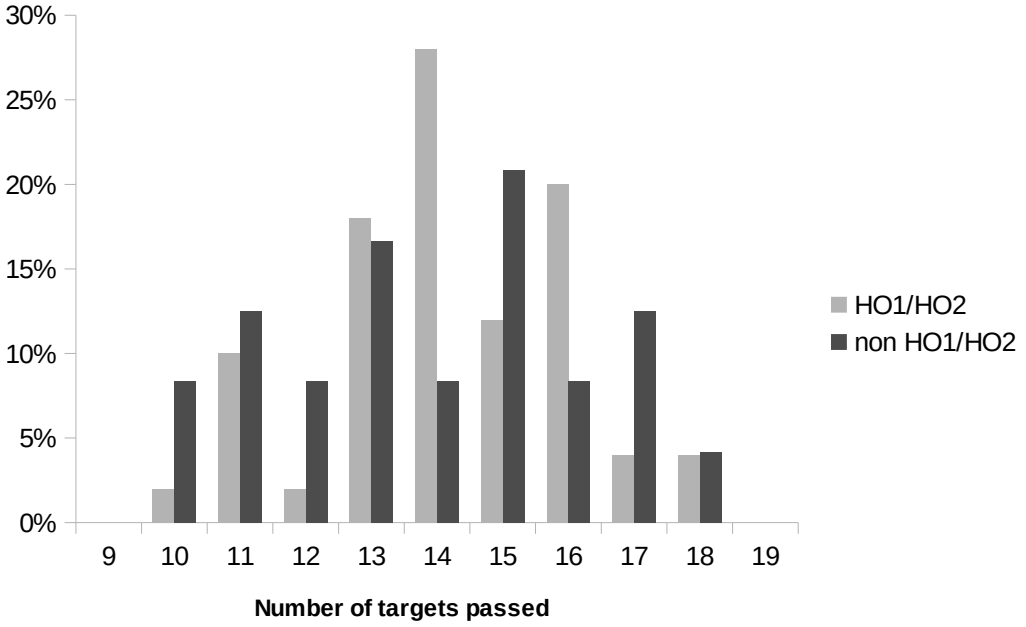

Figure 14 Percentage of stands by number of targets passed out of a possible 19 by the SSSI dry heath stands within (n=50) and outside (n=24) HO1/HO2 options.

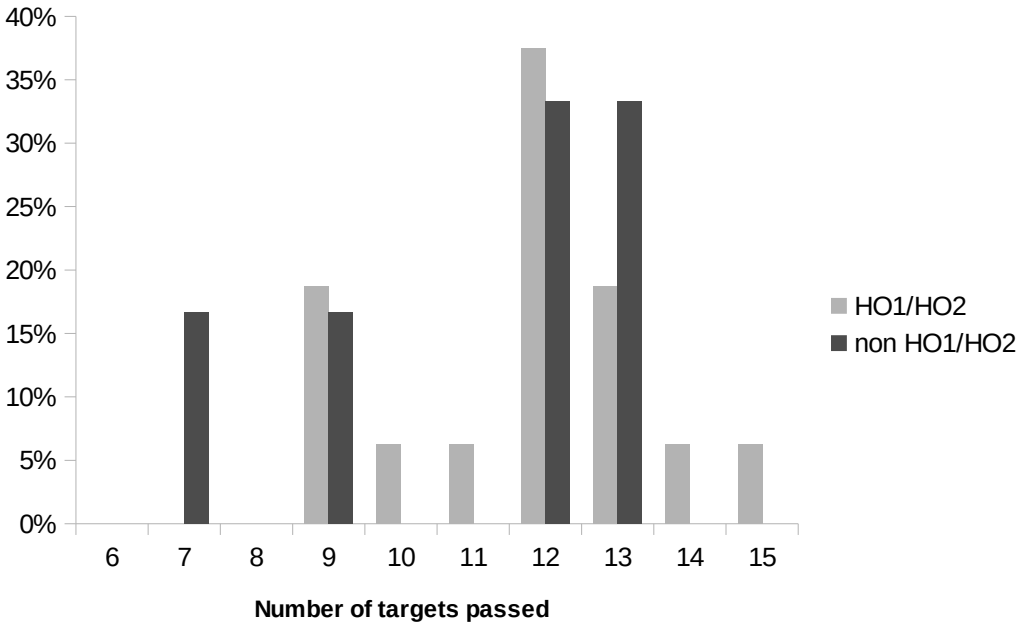

Figure 15 Number of targets passed out of a possible 15 by the SSSI wet heath stands within (n=16) and outside (n=6) HO1/HO2 options. Note: Low sample sizes.

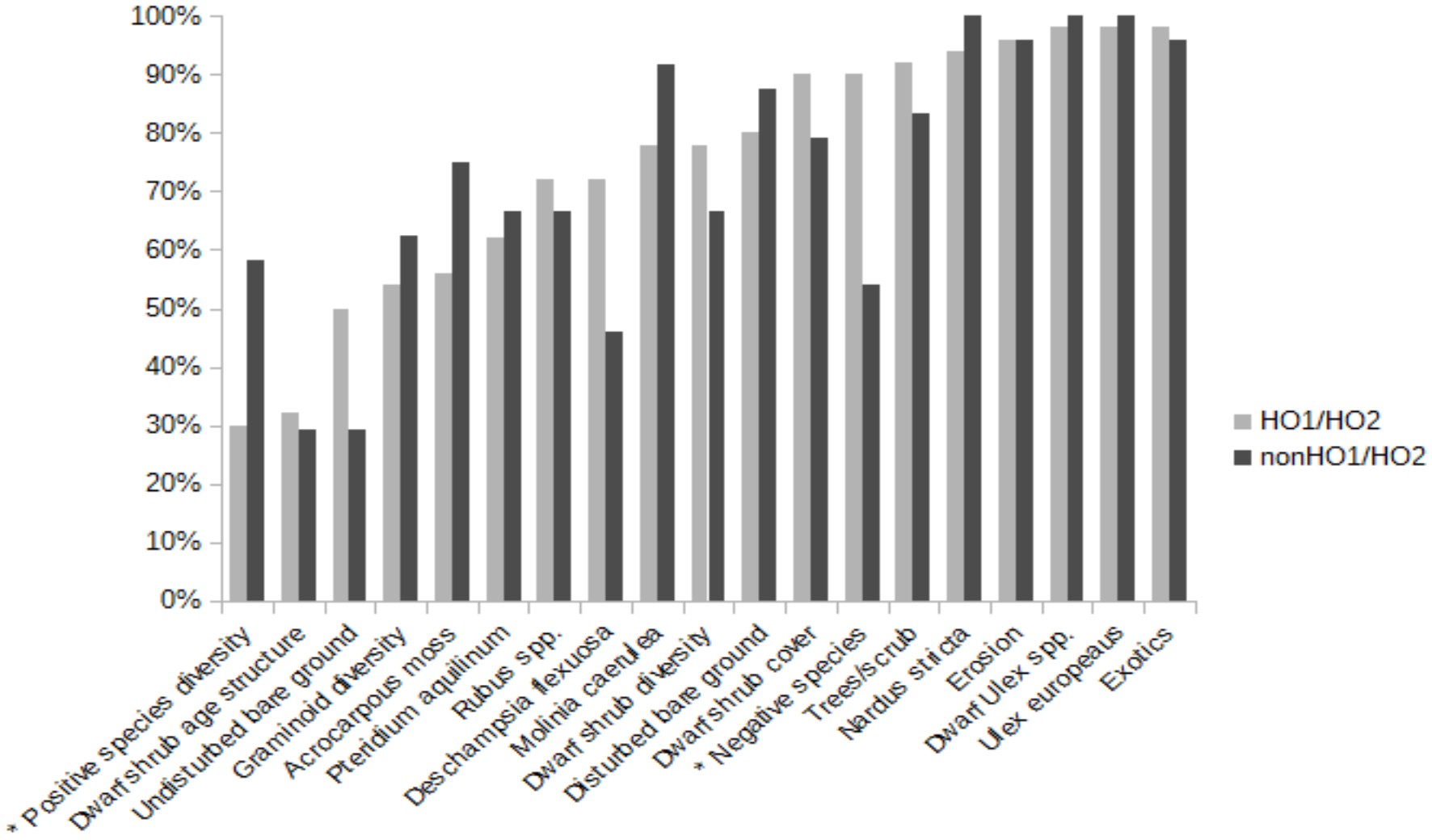

Figure 16 Pass-rates for individual attribute targets in the SSSI dry heath sample, for stands predominantly within (n=50) and outside (n=24) HO1/HO2 options. Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005)

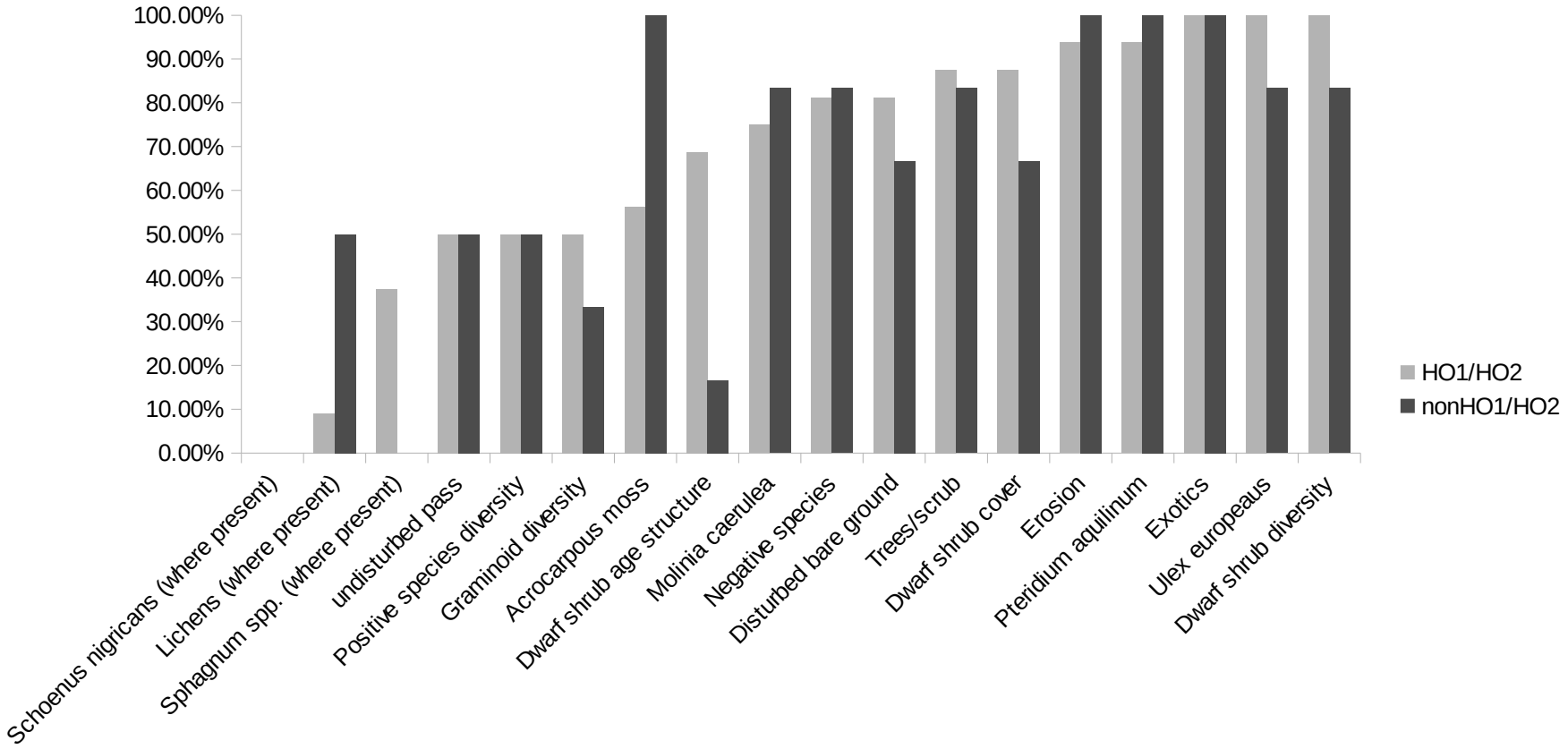

Figure 17 Pass-rates for individual attribute targets in the SSSI wet heath sample, for stands predominantly within (n=16) and outside (n=6) HO1/HO2 options. Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005).

4.27 Analyses were also performed on the raw individual attribute values, both as site averages (for wet and dry heath separately), and individual stop attributes (wet and dry combined). Statistically significant differences between option groups were tested by unpaired two-tailed t-tests. Table 14 shows the average attribute values where there were significant differences between the HO1/HO2 groups in the dry heath sample and Table 15 shows the same in the wet heath sample. Full data, including the non-significant results, may be found in Appendix 6 and Appendix 7.

4.28 Table 14 shows that dry SSSI heath within HO1/HO2 options had significantly more scrub and bracken; higher dense acrocarpous moss cover and frequency, and higher cover and frequency of *Sphagnum* spp. and *Molinia caerulea* cover than those outside these options. They had lower *Deschampsia flexuosa* frequency and lower cover of negative species.

4.29 However there was no significant difference in the total dwarf-shrub cover and there were no obvious visible difference in the overall age-structure.

4.30 Stop level data also show numerous differences between the two options. The HO1 stands had higher cover of dwarf-shrub (and dwarf-*Ulex* spp.), higher dwarf-shrub and graminoid species richness; lichen and Sphagnum spp.; slightly more scrub and dense acrocarpous mosses cover. Both disturbed and undisturbed bare ground cover was significantly greater in those stands.

4.31 On the other hand, HO2 stands had higher cover of both disturbed and undisturbed bare ground, of *Pteridium aquilinum* and litter, and *Deschampsia flexuosa*. They had a greater richness of dwarf-shrub, graminoid and positive indicator species present overall.

4.32 Table 15 shows that the wet heaths within HO1/HO2 options tended to have a greater cover and a greater diversity of dwarf-shrub, as well as higher cover of *Sphagnum* spp and dense acrocarpous mosses. However, they had a lower cover of *Ulex* spp. Sample sizes were not great enough to investigate the differences between HO1 and HO2 in the wet heaths.

4.33 Figure 18 shows the dwarf-shrub age-structure of the SSSI stands in within and outside of HO1 and HO2 options. This shows that there was little difference in age-structure between the groups.

Table 14 Raw attribute values, for SSSI dry heath stands within and outside HO1/H2 options, and also by actual HLS option (including wet and dry heaths). Based either on site averages (n=50 and 24 respectively) or individual stop data (HO1 (n=380) and HO2 (n=929) options, or no such option (n=566). Site-level analyses use predominant option for stand; stop based analyses use stop-specific option status. Only shows attributes with significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005. Full data is found in Appendix 6.

			HO1/HO2		non-HO1/HO2		HO1/HO2 vs non		HO1		HO2		HO1 vs HO2	
Basis	**Transforma-tion**	**Attribute**	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
Stand (dry heaths)	ln+1	Dense acrocarpous moss cover	2.35	0.39	1.77	1.28	0.03	*						
		Dense acrocarpous moss frequency	7.44	0.90	4.00	1.25	0.02	*						
		Deschampsia flexuosa frequency	4.65	0.92	8.58	1.60	0.04	*						
		Molinia caerulea cover	12.19	1.09	7.17	1.59	0.01	*						
	ln(x+1)	Negative species cover	0.42	0.18	1.58	0.42	0.01	*						
		Pteridium aquilinum frequency	7.71	0.89	4.79	1.21	0.05	*						
	ln+1	*Sphagnum* spp. cover	1.13	0.40	0.02	0.02	0.00	**						
		Sphagnum spp. frequency	2.37	0.62	0.33	0.21	0.00	**						
		Trees/scrub frequency	10.17	0.75	5.00	1.17	0.00	**						
stop (wet and dry heaths)	1/(x+1)	Bare ground – disturbed	0.80	0.10	0.31	0.08	0.00	**	0.11	0.08	1.02	0.14	0.00	**
	ln(x+1)	Bare ground – undisturbed	1.94	0.22	1.45	0.29	0.00	**	0.91	0.16	2.51	0.27	0.00	**
		Bryophyte cover							20.91	1.64	9.09	0.68	0.00	**
	1/(x+1)	Dense acrocarpous moss cover	1.58	0.23	1.49	0.39	0.00	**	2.35	0.52	1.95	0.23	0.00	**
	ln(x+1)	*Deschampsia flexuosa* cover							1.28	0.38	3.56	0.42	0.00	**
		Dwarf-shrub cover							61.48	1.79	46.43	1.06	0.00	*
		Dwarf-shrub richness	1.92	0.03	1.57	0.04	0.00	**	1.79	0.05	2.10	0.03	0.00	**
		Graminoid species richness	2.35	0.04	2.10	0.05	0.00	**	1.38	0.05	2.32	0.05	0.00	**
	1/(x+1)	Lichen cover							1.95	0.49	0.28	0.08	0.00	**
	ln(x+1)	Litter cover	3.42	0.29	2.93	0.39	0.01	*	2.40	0.38	5.71	0.49	0.00	**
		Molinia caerulea cover	20.70	0.82	17.47	1.24	0.03	*						
	1/(x+1)	Negative species cover	0.74	0.11	1.37	0.24	0.00	**						
		Positive species richness							0.58	0.06	1.31	0.06	0.00	**
	ln(x+1)	*Pteridium aquilinum* cover							4.28	0.81	11.01	0.80	0.00	*
	1/(x+1)	*Rubus* agg. cover	0.99	0.15	1.62	0.30	0.04	*						
	ln(x+1)	*Sphagnum* spp. cover	2.50	0.24	0.47	0.11	0.00	**	2.72	0.54	3.37	0.33	0.02	*
	ln(x+1)	Trees/scrub cover							5.57	0.80	5.34	0.54	0.03	*
	ln(x+1)	*Ulex* spp. cover	5.48	0.47	8.33	0.85	0.00	**	5.56	0.87	2.92	0.37	0.02	*

Table 15 Raw attribute values, for SSSI wet heath stands within (n=16) and outside (n=6) HO1/H2 options. Only shows attributes with significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005. Full data is found in Appendix 7.

		HO1/HO2		non-HO1/HO2		ALL		HO1/HO2 vs non	
T Basis	**Attribute**	*mean*	*SE*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
Stand (wet heaths)	Dense acrocarpous moss cover	1.27	0.50	0.08	0.08	0.95	0.38	0.03	*
	Dense acrocarpous moss frequency	6.06	1.55	1.06	0.82	4.70	1.23	0.01	*
	Dwarf-shrub cover	50.15	4.00	28.93	8.09	44.36	4.10	0.05	*
	Dwarf-shrub species richness	3.93	0.44	2.50	0.43	3.55	0.36	0.03	*
	Sphagnum spp. cover	9.40	1.86	1.95	0.91	7.37	1.54	0.00	**
	Sphagnum spp. frequency	11.81	1.01	5.69	2.56	10.14	1.14	0.01	*
	Ulex spp. cover	1.06	0.58	14.59	6.23	4.75	2.10	0.00	**

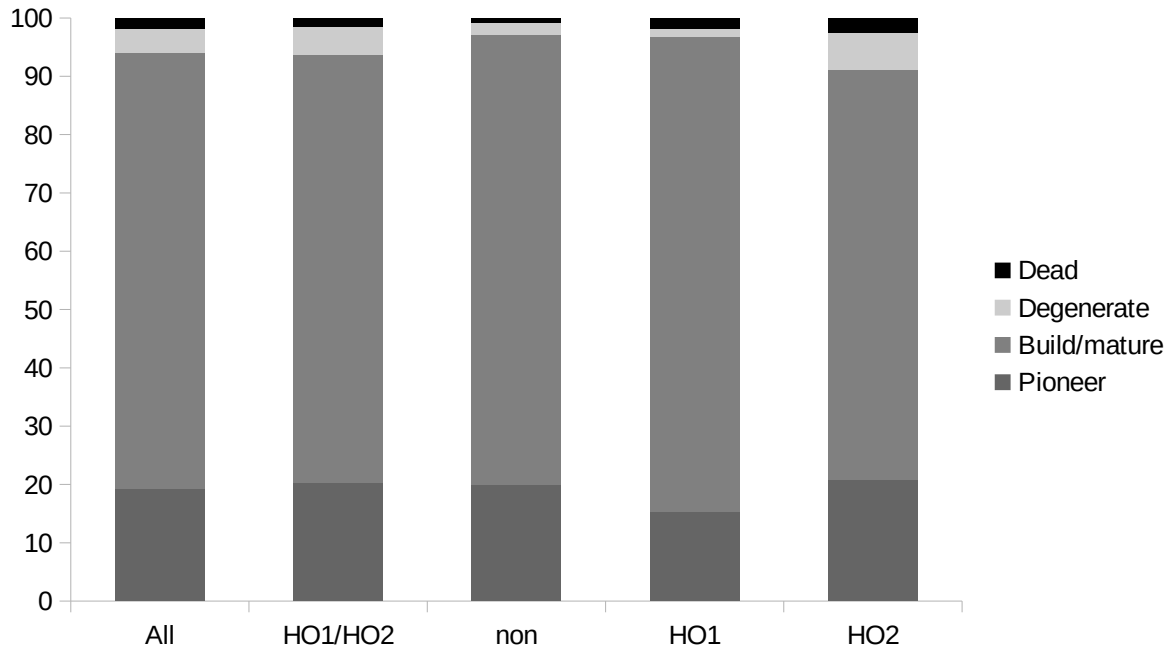

Figure 18 Dwarf-shrub age-structure of the 2016 SSSI vegetation within predominantly HO1 (n=380 stops) and HO2 (n=929 stops) or no such option (n=566 stops). Based on stop-level data. NB: Targets for dry-heath are 10-40% pioneer, 20-80% building, <30% degenerate, <10% dead.

4.34 Figure 19 shows the difference in the condition of SSSI dry heath stands with and without grazing. (An analysis of wet heath stands was not possible due to low sample sizes). Grazing was linked to a significant increase in pass-rate for positive indicator species, graminoid diversity and dwarf-shrub diversity. There was little difference in the age-structure of grazed and ungrazed stands

4.35 Table 16 shows the attributes recorded in the SSSI stands (wet and dry heaths together), in grazed and in ungrazed stands. This shows that grazed stands had greater levels of both disturbed and undisturbed bare ground, as well as greater variety of graminoid, positive indicator and dwarf-shrub species. However, the dwarf-shrub cover was lower, as was the cover of scrub, bracken, lichens and bryophytes.

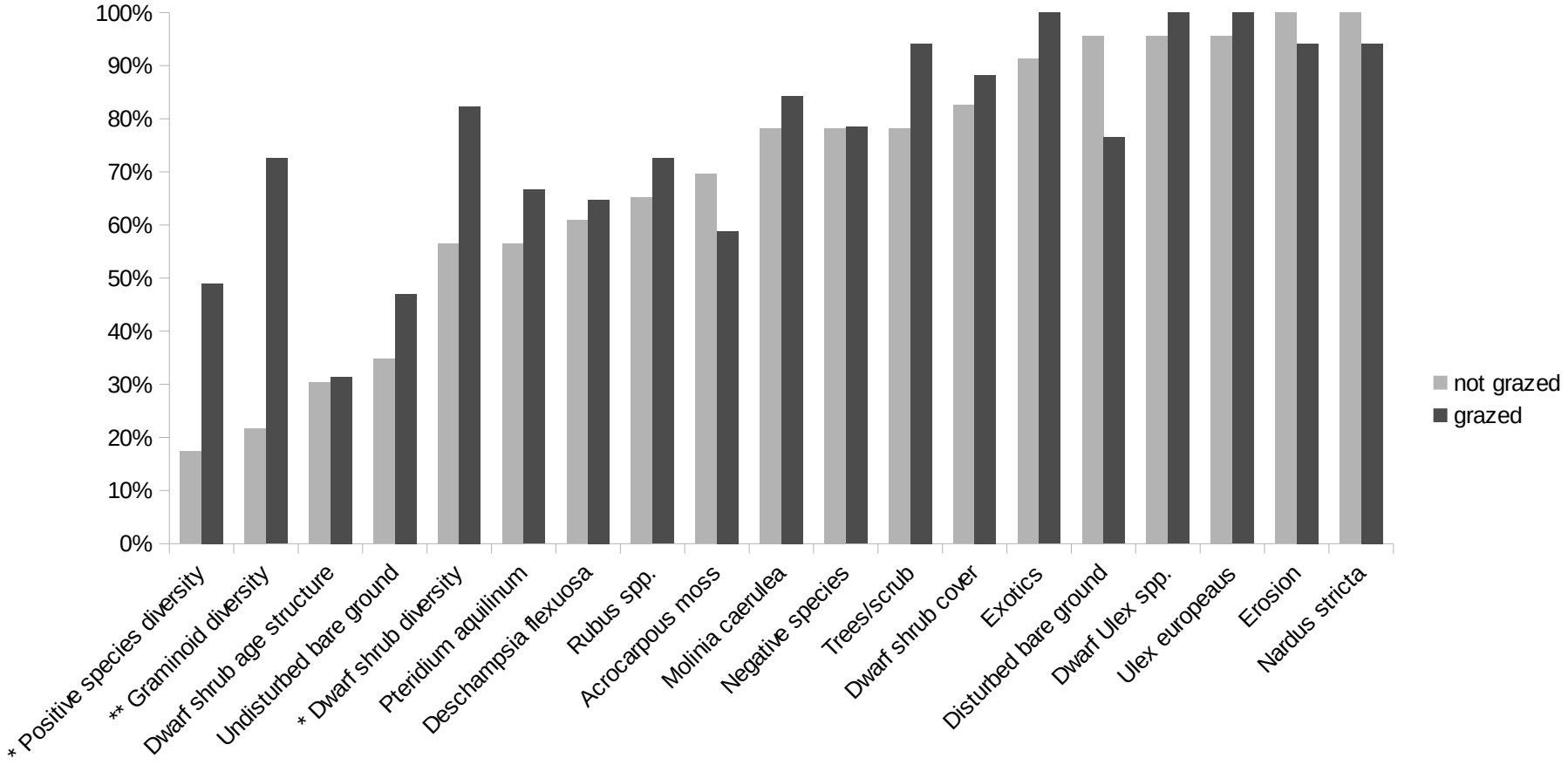

Figure 19 Pass-rates for individual attribute targets in the SSSI dry heath sample, for stands with (n=51) and without (n=23) known grazing. Significant results as tested by individual Chi-square tests, with Yates' correction applied (*=p<0.05, **=p<0.005).

Table 16 Raw attribute values from stops within (n=1435) and outside (n=440) livestock grazed stands

Transformation	Attribute	not grazed		grazed		Grazed vs non-grazed	
		mean	*SE*	*mean*	*SE*	*p.*	*sig.*
	Bare ground – disturbed	0.05	0.05	0.80	0.10	0.00	**
ln(x+1)	Bare ground – undisturbed	1.86	0.41	1.88	0.17	0.00	**
	Bryophyte cover	21.57	1.56	7.64	0.48	0.00	**
ln(x+1)	Dwarf-shrub cover	52.95	1.91	47.08	0.88	0.01	*
	Dwarf-shrub richness	1.49	0.05	2.00	0.03	0.00	**
	Graminoid species richness	1.13	0.04	2.35	0.04	0.00	**
1/(x+1)	Lichen cover	1.77	0.43	0.33	0.07	0.00	**
ln(x+1)	Litter cover	5.31	0.76	3.86	0.28	0.02	*
failed	*Nardus stricta* cover	0.00	0.00	0.07	0.02		
	Positive species richness	0.46	0.05	1.49	0.05	0.00	**
	Pteridium aquilinum cover	11.52	1.22	7.47	0.54	0.00	**
failed	*Schoenus nigricans* cover	0.03	0.01	1.24	0.20		
ln(x+1)	*Sphagnum* spp. cover	1.81	0.43	2.53	0.23	0.00	**
ln(x+1)	Trees/scrub cover	9.80	1.07	3.51	0.32	0.00	**
	Negative species richness	0.17	0.02	0.21	0.01	0.13	n.s.
	Exotics species cover	0.34	0.23	0.01	0.01	0.16	n.s.
ln(x+1)	Dense acrocarpous moss	3.23	0.60	1.48	0.17	0.22	n.s.
	Molinia caerulea cover	18.45	1.56	20.41	0.71	0.25	n.s.
	Ulex spp. cover	4.98	0.78	5.12	0.41	0.34	n.s.
1/(x+1)	Negative species cover	0.64	0.15	0.77	0.13	0.36	n.s.
1/(x+1)	*Rubus* agg. cover	0.90	0.23	1.00	0.15	0.60	n.s.
ln(x+1)	*Deschampsia flexuosa*	2.64	0.56	2.98	0.29	0.94	n.s.
1/(x+1)	*Ulex europaeus* cover	3.15	0.69	2.66	0.31	0.94	n.s.

Other habitat features

4.36 This section outlines the more qualitative responses from surveyors on the additional habitat features, particularly for invertebrates and reptiles, recorded during the surveys.

4.37 Table 17 shows the occurrence of south-facing slopes in the sample. Whilst approximately 70% of SSSI stands supported south-facing slopes, less than 60% of non-SSSIs did. This may be related to the greater size of SSSI stands and there was little difference between the frequencies of slopes-types.

Table 17 The occurrence of south-facing slopes in the sample

South-facing Slopes and Gradients	% Stands in HO1/HO2	% Stands outside HO1/HO2
No south-facing slopes	37.1	53.4
South-facing slopes present somewhere within stand	62.9	46.6
Gentle slopes	52.6	36.2
Moderate Slopes	17.5	12.1
Steep (or vertical) slopes)	10.3	12.1
Gradient not defined	1.0	12.1

NOTE: stands may support one, two or all three slope types

4.38 Table 18 shows the occurrence of (micro)topographic features in the sample. There was considerable variation in the recording of (micro)topography and it is highly likely that many features will have been missed. In addition, how features were reported evidently varied between stands and partly between surveyors. It is difficult to draw many conclusions from this data.

Table 18 The occurrence of (micro)topographic features in the sample

Features	% Stands in HO1/HO2	% Stands outside HO1/HO2
Basin	14.4	19.0
Pit	8.2	3.4
Pool	5.2	5.2
Ditch/dyke/stream	12.4	12.1
Bank	37.1	19.0
Ridge	19.6	8.6
Cliff	18.6	5.2
Rabbit scrapes	0.0	5.2
Management scrapes	3.1	1.7
Path edge	13.4	6.9
Undulating	9.3	8.6
Rocky areas	3.1	6.9
Little variation	30.9	32.8
No features	6.2	20.7
Features not defined	4.1	8.6

NOTE: stands may support more than one feature (except 'features not defined')

4.39 Surveyors attempted to record the broad type and extent of bare ground across each stand during fieldwork, although it was not always possible to do this as a result of time constraints.

4.40 There was almost no difference in the number of stands with bare ground between SSSI and non-SSSI stands, nor between the HO1/HO2 and non-HO1/HO2 samples (Table 19). Similarly there was little or no difference in substrate types between SSSIs and non-SSSIs nor within/without HO1/HO2, although the two instances of bare chalk and bare clay were confined to SSSIs (one within HO1/HO2 the other outside).

Table 19 The types of bare ground in the sample

Substrate	% Stands in HO1/HO2	% Stands outside HO1/HO2
Sand	58.8	41.4
Peat	44.3	13.8
Other (clay, gravel, chalk)	3.1	1.7
Substrate not recorded	15.5	36.2
No bare ground	5.2	15.5

NOTE: more than one substrate type was recorded in many stands

4.41 Based on surveyor's comments, the percentage frequency of bare ground across each stand has been placed within one of four broad categories (Table 20). This suggests a possible slight increase in bare ground in stands within HO1/HO2 compared to those without. 78% of stands with 'frequent' bare ground were within SSSIs.

Table 20 The extent of bare ground in the sample, based on surveyors comments

Extent of Bare Ground	% Stands in HO1/HO2	% Stands outside HO1/HO2
Little or very little bare ground	25.8	29.3
Occasional and/or locally frequent bare ground	22.7	10.3
Frequent and/or locally abundant bare ground	16.5	12.1
Bare ground frequency not recorded	29.9	32.8
No bare ground	5.2	15.5

4.42 The recording of invertebrate burrows was of secondary importance to other activities during fieldwork and their presence was undoubtedly under-recorded (Table 21). However, burrows

were noted to occur within 60 stands (39% of the total sample). Most were seen in association with the margins of paths, although all bar three stands had seen recent scrub management. Seventeen stands had seen recent litter/soil/turf stripping. Indeed 80% of stands (with management information available) supporting 'many' burrows supported management scrapes of one form or another.

Table 21 Percentage frequency of invertebrate burrows

Invertebrate Burrows	**% Stands in HO1/HO2**	**% Stands outside HO1/HO2**
Presence/absence not recorded	2.1	0.0
No burrows seen	53.6	70.7
Some burrows seen	37.1	24.1
Many burrows seen	7.2	5.2

4.43 70% of stands where invertebrate burrows were recorded were within SSSIs; 71% within HO1/HO2. Invertebrate burrows were recorded from 44% of stands within HO1/HO2 stands, whereas they were only recorded within 29% of non-HO1/HO2 stands (although the difference is not statistically significant).

4.44 Table 22 shows the records of veteran trees and deadwood made during the survey. Six of the nine stands supporting veteran trees were within the New Forest. All but two were within SSSIs. There was little or no difference in the presence/absence of mature trees and dead wood habitats between SSSIs and non-SSSIs. However, 76% of stands within HO1/HO2 reported at least one form of dead wood habitat, whereas only 47% of stands outside HO1/HO2 did so. This difference is highly statistically significant ($X2 = 14.1$, $p = <0.001$).

Table 22 Frequency of veteran trees and dead wood features

Veteran Tree and Dead Wood	**% Stands in HO1/HO2**	**% Stands outside HO1/HO2**
No dead wood habitats	23.7	53.4
Veteran trees	7.2	3.4
Non-veteran mature trees present	24.7	19.0
Other dead wood habitats	42.3	24.1
Not recorded	2.1	0.0

5 Results: management interventions

5.1 Surveyors made their best attempts to identify the key management activities affecting site condition, through field observations and landowner/manager consultation. Whilst this was achieved for most key management activities, the patchy responses from landowners/managers meant that a number of gaps remain (Table 23). The management activities with the most information gaps relate to weed control and bracken management; the two most difficult (often impossible) activities to identify in the field. Furthermore, it was easier to elicit information from landowners/managers in HO1/HO2 than those that were not.

Table 23 Information gaps in key management activity categories

Management Activity	% Stands in HO1/HO2	% Stands outside HO1/HO2
Livestock grazing	0.0	0.0
Prescribed burning	3.1	13.8
Weed control	17.5	37.9
Scrub control	6.2	13.8
Bracken management	10.3	20.7
Heather cutting/mowing	9.3	19.0
Bare ground creation	0.0	0.0

5.2 Figure 20 shows the percentage frequency (having removed information gaps from analysis) of known management activities for stands within and outside HO1/HO2 options. Scrub control was the most common type of management, followed by livestock grazing. Heather cutting and bracken management were also frequently encountered. Six of the seven types of management activity were significantly more frequent within HO1/HO2 options than outside these options (differences tested by Chi-square).

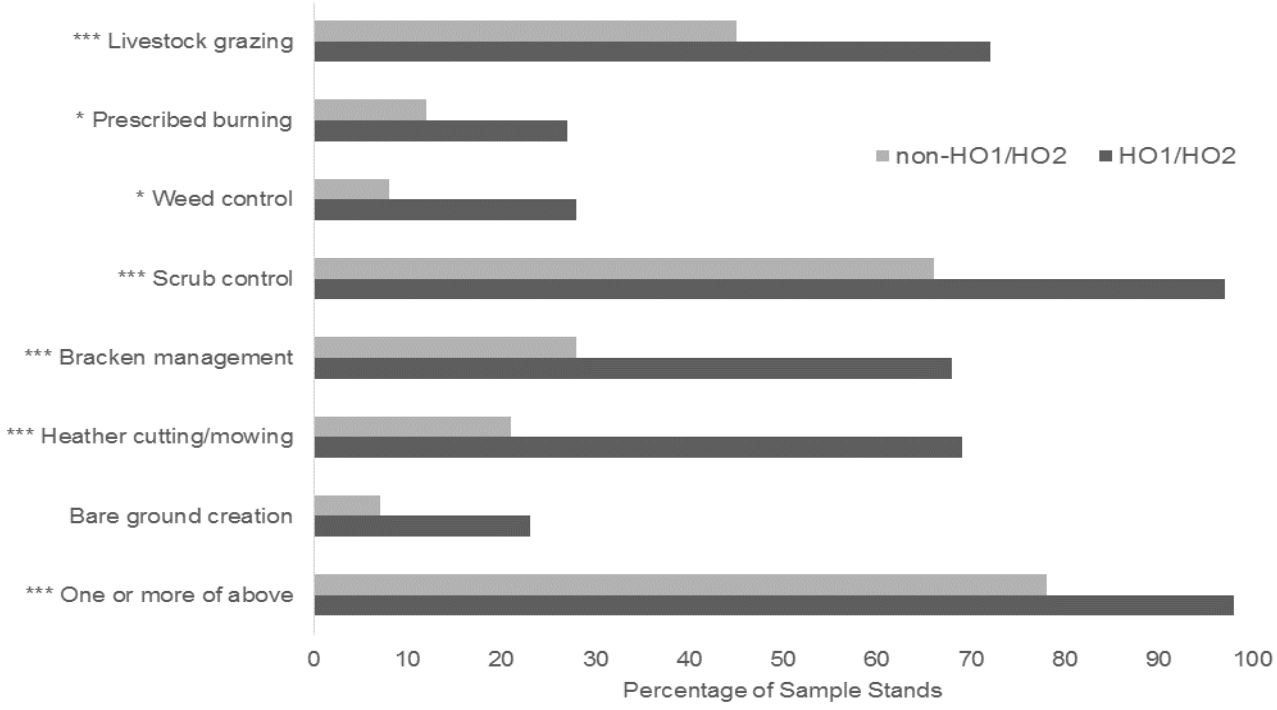

Figure 20 Percentage frequency (minus data gaps) of management activities per sample group. Significant results *= p <0.05, **= p <0.01, *** = p <0.001.

5.3 Table 24 outlines the changes in known management activity between 2005/06 and 2016 surveys in the non-SSSI sample. This shows that although the HO1/HO2 stands tended to receive more management in 2005/06, they also gained more management activities in the ten year period. Furthermore, while 31% of non-HO1/HO2 non-SSSI stands appear to receive no management, only 6% of those in HO1/HO2 do.

Table 24 Change in the number of stands in known management activity between 2005/06 and 2016 in HO1/HO2 (n=31) and non-HO1/HO2 (n=28) stands.

Management activity	Option	introduced	stopped	continued	none
Grazing	HO1/HO2	14	0	7	10
	non	2	1	1	24
dwarf-shrub cutting	HO1/HO2	7	1	8	15
	non	2	2	5	19
Scrub control	HO1/HO2	16	0	10	5
	non	9	0	6	13
Bracken control	HO1/HO2	16	2	2	11
	non	0	0	0	0
No management (neglect)	HO1/HO2	0	8	2	2
	non	0	9	9	9

5.4 Where information was available on burning (93% of the total sample), 41% of stands, or parts of stands, either include prescribed burning as part of their management or have been the subject of recent (within the past 5-10 years or so) wildfires (mostly accidental, but sometimes as a result of arson).

5.5 Where known, 27% of stands, or parts of stands, within HO1/HO2 included prescribed burning. Of these 56% are within the New Forest. By comparison, only 12% of non-HO1/HO2 stands (where known) include prescribed burning as a management tool. The differences between the two sample groups were statistically significant ($X^2 = 5.5$; $p = <0.02$).

5.6 Perhaps reflecting greater public access, non-prescribed (accidental and deliberate) recent wildfires have been recorded from 21% of HO1/HO2 stands but only 14% of non-HO1/HO2 stands. Nevertheless the difference is not statistically significant ($X^2 = 2.5$; $p = <0.2$).

5.7 Information on weed control was available for 75% of sampled stands. Where known, 28% of stands within HO1/HO2 (the majority within the New Forest) and 8% within non-HO1/HO2 were subject to at least some weed (excluding Rhododendron) control management. This usually covers the cutting and/or chemical treatment of species such as ragwort and thistles, as well as exotic invasive species such as Japanese knotweed. It was most commonly noted (the New Forest aside) on council owned land or private farms.

5.8 Of the 141 stands where information was available on scrub control, 86% are the subject of at least some form of scrub management, ranging from intermittent small scale ‘scrub bashing’ undertaken by volunteers using hand tools during work parties on nature reserves to wholescale mechanical clearances undertaken by contractors using heavy forest plant. Where information is available, 97% of stands within HO1/HO2 include some form of scrub management. This compares to a still relatively high 66% of those outside HO1/HO2, although there is still a very highly significant difference between the two sample groups ($X^2 = 25$; $p = <0.001$).

5.9 Whether or not bracken management takes place was determined for 86% of sampled stands. The most common methods, often undertaken in combination with each other, were cutting and spraying. Only a few stands were the subject of rolling. 69% of stands where it was possible to determine it within HO1/HO2 include some form of bracken management. This compares to only 28% of those outside HO1/HO2, a very highly significant difference between the two sample groups ($X^2 = 25.1$; $p = <0.001$).

5.10 Of the 135 stands where information was available, 53% were the subject of at least some form of heather cutting/mowing. This was usually in the form of repeated mowing of pseudo-pioneer heath and grass-heath along firebreaks and besides paths or rotational/mosaic

cutting of building to degenerate heath as part of a (usually *ad-hoc*) programme to enhance overall structural diversity. Where the latter, it was usually the case that only a relatively small or very small proportion of a stand was cut at any one time and cutting may be very infrequent. Less commonly, heather cutting/mowing was included within the wider management aim of bracken and/or scrub control. 69% of stands within HO1/HO2 included some form of heather management. This compares to only 21% of those outside HO1/HO2. As the results of Chi-squared analysis show, there is a very highly significant difference between the two sample groups.

5.11 It is believed that the usually small size of cut areas often meant that few or no structured walk stops were recorded from recently cut heath.

5.12 Twenty nine per cent of stands included within the sample supported management-created bare ground associated with turf stripping, soil/litter scraping and/or rotovation (but excluding incidentally created bare ground associated with scrub clearance, tree felling, grazing, burning, mowing, rolling, etc). In most cases the aim of management was to create bare ground habitat for invertebrates and/or reptiles, promote pioneer heath and/or restore dwarf-shrub heath following scrub removal. Four golf course stands included turf nurseries where heather turf was being cut from areas of extant or recently restored heath for use in course repairs elsewhere.

5.13 Twenty three per cent of HO1/HO2 stands included at least one area of management-created bare ground, whereas only 7% of non-HO1/HO2 stands did so. Of the latter, 75% were within Natural England owned NNRs. Nevertheless, there is no statistically significant difference between the two sample groups.

5.14 Eighteen per cent of stands within HO1/HO2 included at least one bare ground scrape created for the specific purpose of promoting invertebrates and/or reptiles. All scrapes were within the South East (Dorset, Hampshire & the Isle of Wight; Thames Valley; and Sussex & Kent Area Teams), bar one which was within the boundaries of the Devon, Cornwall & Isles of Scilly Natural England Area Team. Of the 3 stands supporting scrapes similarly created for the specific purpose of invertebrates/reptiles outside HO1/HO2, all were within Natural England owned NNRs (one within the Thames Valley, the other two within Norfolk & Suffolk).

5.15 Whilst results reveal that bare ground creation is much greater in stands managed within HO1/HO2, the overwhelming majority of sites within the scheme do not include bare ground creation. There are no HLS supplements or capital items specific to bare ground creation in the manner that they are for bracken control or scrub clearance.

5.16 Ninety per cent of surveyed stands are the subject of at least one form of management outlined above: 98% of those within HO1/HO2 and 78% of those outside HO1/HO2. As the result of Chi-squared analysis shows, there is a very highly significant difference between the two sample groups.

Livestock grazing

5.17 Sixty two per cent of the 155 stands were believed to be under grazing management at the time of the 2016 survey; with a statistically significant ($p<0.001$) higher occurrence in the HO1/HO2 stands (71%) compared to the non-HO1/HO2 stands (46%).

5.18 Landowners/managers of livestock-grazed sample sites (some of which included more than one sample stand) were asked various questions during consultation about grazing, particularly with regard to when it began, what livestock are used and the grazing period, stocking rate and grazing infrastructure. Landowners/managers that are not currently livestock grazing their sites were asked whether they would like to and if so, what the barriers preventing them are.

5.19 It was possible to determine broadly when grazing was first introduced or, more usually, restored for 55 of the 96 stands within the sample that are currently grazed by livestock (note that whilst many owners/managers gave the year and sometimes the actual date that grazing was introduced/reintroduced, others only knew broadly when this was).

History of Current Livestock Grazing	% Stands
Long history of livestock grazing (Over 40 yrs?)	22.9
Livestock introduced/reintroduced in the 1970s	1.0
Livestock introduced/reintroduced in the 1990s	6.3
Livestock introduced/reintroduced in the 2000s	10.4
Livestock introduced/reintroduced in the 2010s	16.7
Landowner/manager not available/no response	42.7

5.20 Of the 22 stands known to have had a long history of grazing, 16 were within the New Forest and three within the Quantocks. Nineteen were within HO1/HO2. The one stand that has been livestock grazed since the 1970s is a Natural England owned NNR and therefore not eligible for HLS.

5.21 All stands where grazing is known to have been introduced/reintroduced in the 1990s are within HO1/HO2. By contrast three of the stands where grazing is known to have been introduced/reintroduced in the 2000s are not currently in HO1/HO2, although one of these is also a Natural England owned NNR. Of the sixteen stands where grazing is known to have been introduced/reintroduced since 2010, all bar one is within HO1/HO2.

5.22 Whilst these results clearly suggest that livestock grazing has been recently introduced/reintroduced as a consequence of funding made available under HLS, it should be noted that no information was available on start date for 70% of non-HO1/HO2 livestock grazed stands, as opposed to only 30% for stands within HO1/HO2. This is presumably because it was easier to elicit information from landowners/managers in HO1/HO2 than those that were not.

5.23 The type of livestock currently grazing the sample stands was identified for all but seven stands. Of these (n=89), 55 stands were grazed by one livestock type, the remainder by a mixed stocking regime (in some cases information was made available on past livestock, sometimes quite different to that currently used).

Livestock Type	% Stands
Cattle	69.8
Sheep	30.2
Goats	1.0
Ponies and/or horses	49.6
Donkeys*	14.6
Pigs*	14.6
Unknown	7.3
*confined to New Forest stands and not necessarily active within all sample stands	

5.24 Whilst on rare occasions breeds of sheep were defined, in the overwhelmingly number of cases they were not. By contrast pony breed was defined in all cases bar four. 18 stands (all bar two within the New Forest) were grazed by New Forest Ponies (all bar one of these was grazed by mixed stock, usually cattle and ponies). Nine stands were grazed by Exmoor Ponies, two by Dartmoor Ponies and one by both Exmoor and Dartmoor Ponies.

5.25 Amongst cattle, no information on current breed was available for 17 stands with a further 19 (almost all in the New Forest) grazed by a mixture breeds. By far the most commonly named breed was Belted Galloway, currently grazing 17 stands, one in combination with other breeds (Belted Galloways are also amongst the number of breeds grazing in the New Forest). By comparison all other breeds were very uncommon: Holsteins and Holstein crosses (3 stands), Highland (3, two in combination with other breeds), Dexter crosses (2), Black Galloway (2, one in combination with other breeds), Shorthorn (2, one in combination with other breeds), English Longhorn (1), Red Poll (1), Hereford crosses (1) and Devon Red (1), although also known to be included within at least one mixed herd grazed stand).

5.26 All stands where Belted Galloway were named as the sole livestock were managed under HO1/HO2. Where a date for the commencement of livestock grazing was given, all post-date

2000; 67% post-date 2010.

5.27 Information on grazing period was available for 64% of the stands that are known to be currently livestock grazed: 82% of these are managed under HO1/HO2; 73% are within SSSIs. Of these 51% are known to be grazed, or at least open to grazing, throughout the year, although livestock may change (eg from cattle in summer to sheep in winter). By far the majority are mixed stock grazed (all New Forest stands fall within this category). Only three are grazed throughout the year by cattle (two stands fall within a single low intensity cattle grazed non-HO1/HO2 site that was divided into two stands in 2005/6). Two are pony-only grazed and one horse-only.

Grazing Period	**% Stands**
Year round	32.3
Summer and Spring-Autumn only	19.8
Variable/flexible	7.3
April-December/January	3.1
November-February	1.0
Landowner/manager not available/no response	36.5

5.28 Nineteen stands (33% of those with a defined grazing period), including one site where grazing period was described as being for 8 months of the year, and another where it was described as being for 9 months of the year, are summer or spring-autumn grazed only. Of these, all bar two are within HO1/HO2 and all bar three cattle or mixed cattle/sheep grazed.

5.29 Grazing across seven stands (six of which are cattle-grazed only) was described as variable/flexible, usually according to conditions (in one case depending on sward height monitoring). It is assumed that most if not all of these are also summer/spring-autumn grazed.

5.30 Of the four remaining stands where grazing period was made available, one stand is grazed from April to December and two from April to January. The other is sheep-grazed between November and February. All four lie within SSSIs, although only the stand grazed between April and December is within HO1/HO2.

5.31 There was insufficient information available to assess stocking rates, as only six land managers were able to supply this information in any great detail.

5.32 No information on fencing was available for 17 of the 96 livestock grazed stands. Of the remainder, 53 are within permanently fenced enclosures, although some of these are large and some part of a paddock system where animals are either moved from one compartment to another or allowed to graze freely between different compartments. Grazing was facilitated by temporary electric fencing across only seven stands (all within HO1/HO2). One stand was within an area where livestock graze within invisible fencing. 18 stands (all within HO1/HO2) were within extensively grazed areas covering a minimum of 540 ha: 16 within the New Forest; two within Ashdown Forest.

5.33 Of the 59 sample stands not currently grazed by livestock, landowner/manager responses to the question whether they would like to see livestock grazing introduced/reintroduced were obtained for 34 stands. In many cases a simple ‘yes’ or ‘no’ answer was given. However, landowners/managers who desired grazing sometimes outlined obstacles currently present. ‘Possibly’ responses include ‘possibly’, ‘would have no objection’, ‘not thought about yet’ and ‘would be interested in a feasibility trial run’.

Would owner/manager like to introduce/restore livestock grazing	**% Stands**
Yes	28.8
Possibly	11.9
No	16.9
Landowner/manager not available/no response	42.4

5.34 Nine of the 17 stands where the response was that landowners/managers would like to see

grazing introduced/reintroduced carried a practicality caveat. These are discussed in 5.37.

5.35 In the case of stands where owners/managers responded that they were against grazing, all bar two came with a qualification. In four cases grazing was regarded as impossible for reasons of practicality. In one case the landowner/manager did not want to graze the sample site because an adjacent site is grazed and it is of value to them to compare grazed and ungrazed sites. In only three cases did owners/managers not desire grazing because they regarded the habitat as unsuitable.

5.36 From this limited evidence, it would appear that the vast majority of heathland owners/managers regard livestock grazing very favourably.

5.37 For the 34 livestock grazed stands where landowners/managers were available to respond to the question whether they would like to see their sites grazed, one or more barriers to grazing were suggested for all but six (four of these relate to stands where landowners/managers did not regard grazing as desirable).

Barriers to livestock grazing	% Stands in HO1/HO2	% Stands outside HO1/HO2
Fencing of common land	61.9	38.5
Costs (financial/resource)	23.8	53.8
Public site	19.0	15.4
Dogs	14.3	15.4
Ownership/lease issues	9.5	15.4
Lack of available livestock	4.8	23.1
Site too small	0.0	23.1
Site heavily scrubbed/wooded	0.0	23.1
Difficulty of access	4.8	7.7
Golf Club members against	0.0	7.7
Reason/s not given	9.5	0.0

5.38 On the basis of this evidence, fencing common land to facilitate livestock grazing remains an important issue (note that several stands with current livestock grazing are managed with temporary electric fencing under the '10% ruling'. For most if not all of these, owners/managers would prefer to have extensive grazing within a single perimeter fence).

5.39 Landowner/manager responses to the question *'Besides grazing, are you able to manage your sites as you would wish?'* were received for 93 of the 155 stands.

'Besides grazing, are you able to manage your site as you would wish?'	% Stands in HO1/HO2	% Stands outside HO1/HO2
Yes	58.8	13.8
Mostly	0.0	3.4
No - lack of funding	8.2	10.3
No - problems with site users	2.1	8.6
No - problems over access	2.1	0.0
No - grazing issues	4.1	1.7
Landowner/manager not available/no response	26.8	62.1

NOTE: sometimes more than one reason was given for why owners/managers could not manage their site as they would wish

5.40 Given the failure of any sampled stand to pass all generic attribute targets, it is interesting that 65 (70%) of responses, where given, were 'yes' (actually more, but on occasions this was qualified by information that suggests that owners/managers are not in fact able to manage their sites as they would wish).

Other factors

5.41 Figure 21 shows the percentage of sample sites/stands within seven broad categories of

owners/tenants. Whilst conservation bodies (mostly county Wildlife Trusts, the National Trust, Natural England and a range of other organisations with the primary management aim of countryside conservation) owned or managed the majority of sites in both HO1/HO2 and non-HO1/HO2, significantly more were in HO1/HO2 than not ($X^2 = 5.8$; $p = <0.05$). Most sites under private ownership/management had no HO1/HO2 options, although numbers were not significantly different from those within HO1/HO2.

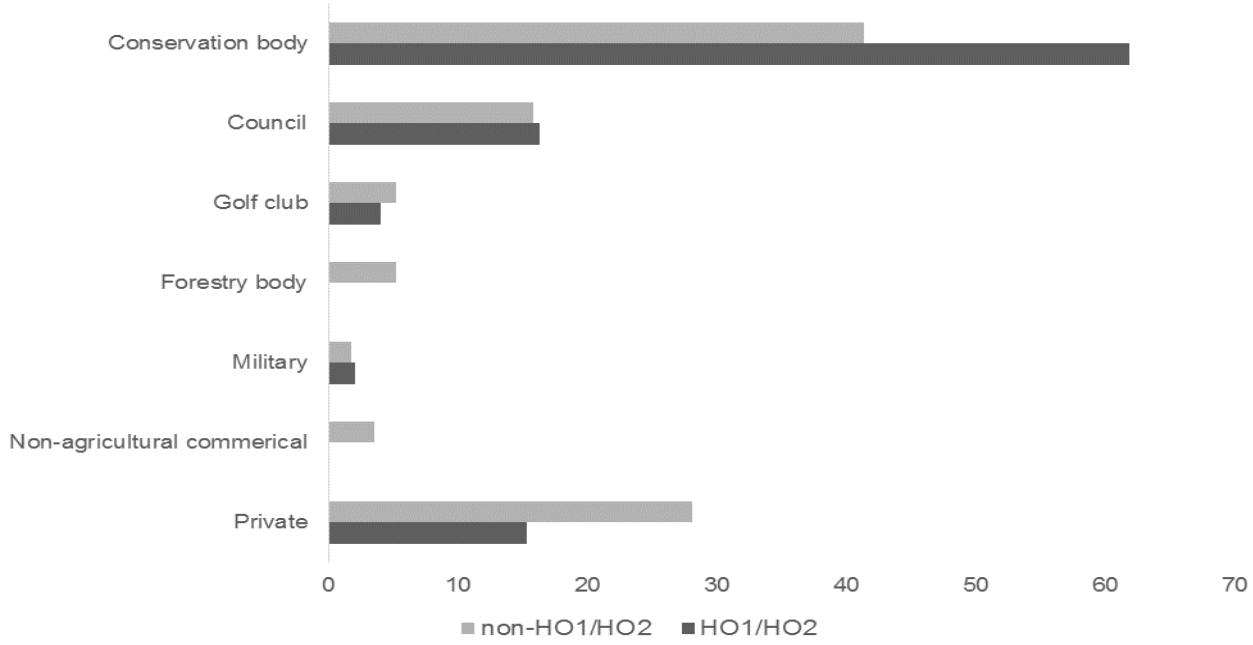

Figure 21 Percentage of sample sites/stands within seven broad categories of owners/tenants

6 Results: HLS implementation

6.1 For the 97 sites within HO1/HO2, surveyors were asked whether they regarded the HLS option (HO1/HO2) to have been appropriately identified by comparing what they had just surveyed to information provided by HLS options maps and agreements. Table 25 shows how surveyors responded.

Table 25 Surveyors responses to the question *'is the HLS option and its boundary appropriate'*?

Is the HLS option (HO1/HO2) and its boundary appropriate?	**% Sites**
Yes	**48.5**
No	**47.4**
HO1/HO2 includes non-heathland habitat that should not be included	*(35.1)*
HO1/HO2 does not cover the full extent of heathland within, for example, a SSSI Unit	*(4.1)*
SSSI Units include both HO1 and HO2	*(9.3)*
HO1 not appropriate to heath condition and should have been targeted as HO2	*(6.2)*
Unknown – insufficient HLS information available	**4.1**

6.2 The most common non-heathland habitat that should have been excluded from HO1/HO2 was woodland. Whilst small areas of woodland are eligible for inclusion within HO1/HO2, many sites supported quite substantial blocks of (often coniferous) woodland with no aim to restore them to heath. In other cases large expanses of bracken or grassland, again with no aim to restore them to heath were included within HO1/HO2. By contrast, small areas of woodland, bracken and/or grassland were excluded from some HO1/HO2 sites when they would have been more appropriately included within them.

6.3 For the nine SSSI sites where both HO1 and HO2 were present within a single Unit, dual targeting was presenting certain difficulties for owners/managers trying to meet different IoS targets. Dual targeting presumably makes it overly complicated for advisers to assess whether targets are being met as well.

6.4 A full assessment of the Indicators of Success (IoS) on these agreements is beyond the scope of this project, and has been better covered by other studies (eg Mountford and others 2013). However, the surveyors made the following comments:

- Many IoS were taken directly from the handbook without site-specific modification. For example, many heaths in the South East had targets for western gorse, despite the South East being beyond the range of this species.
- Few IoS appeared to have considered bryophytes carefully. For example, many in the South East used a >10% target despite stands commonly being carpeted by mosses, often to the detriment of bare ground and sometimes lichens.
- Some IoS lacked scrub targets.
- The age-structure targets were rarely appropriately site-specific. For example, golf courses where all the heath is regularly mown.

6.5 Where possible, landowners/managers of HO1/HO2 sites were guided to answer four questions about HLS. For necessity, many responses have been summarised.

'Did management change as a result of going in into HLS?'

6.6 Of the landowners/managers who responded 'yes', at least 17 sites (32%) were formerly within Countryside Stewardship and 15 covered by some other form of funding, eg EU Life projects (2 other stands are known to have been managed under a previous agri-environment scheme, but it is not known which). Only 12 are known to have been managed without previous grant scheme assistance. For seven stands where owners/managers said management had changed as a result of going into HLS, it is not known whether the stand was managed under a previous grant scheme or not.

6.7 Of the 19 stands where owners/managers did not believe that management had changed as a result of going into HLS, 13 had previously been in CSS with one funded by another grant scheme. There was no response for three stands. Only 2 stands are known to have not received funding from a previous grant scheme.

'Did management change as a result of going in into HLS?'	**% Sites**
Yes	54.6
No	19.6
Landowner/manager not available/no response	25.8

'What do you understand the HLS objectives to be?'

6.8 For the purpose of assessment landowner/manager responses have been placed within one of three categories: general 'heathland conservation' (any stand where there was no clear indication whether the owner/manager regarded the objective to mean maintain or restore), 'heathland maintenance' and 'heathland restoration'.

6.9 All bar one stand placed within the category 'heathland conservation' is managed either wholly or mostly under HO1. Similarly all bar one stand within the category 'heathland maintenance' is managed either wholly or largely under HO1. Of the 59 stands placed within the category 'heathland restoration', 50 (85%) are managed either wholly or largely under HO2. This would suggest that by and large owners/managers have a good understanding of what the HLS objectives for their sites are.

'What do you understand the HLS objectives to be?'	**% Sites**
Heathland conservation	12.4
Heathland maintenance	6.2
Heathland restoration	60.8
Landowner/manager not available/no response	20.6

'Are these objectives being met?'

6.10 For the purpose of assessment, landowner/manager responses have been placed within one of five categories.

6.11 84% of stands wholly or predominantly managed under HO2 fall within the category of 'yes', compared to only 47% of stands managed wholly or predominantly under HO1. The only stands where owners/managers did not think that the objective was being met, or where it was only being met in part, were within HO1.

6.12 In many cases a response of 'yes', came without qualification. In others reasons why the objective was being met were qualified with, for example, 'the area of heath has expanded'. On a number of occasions, owners/managers were keen to point out that objectives were only being met due to the funding made available by HLS. Several offered high praise to Natural England staff.

6.13 The reasons why stands not regarded as meeting the objectives or only meeting the objectives in part were variously described as 'difficult to manage', 'still settling in', 'needs more grazing' and 'insufficient resources'.

'Are these objectives being met?'	**% Sites**
Yes	58.8
Mostly	13.4
In part	3.1
No	1.0
Don't know	1.0
Landowner/manager not available/no response	22.7

'Are the HLS objectives, options, Indicators of Success and management proposals appropriate?'

6.14 For this question responses have been placed within one of four categories. 'Yes' responses

were received for 66% of stands managed wholly or predominantly under HO2 (where a response was given) but only 40% of those managed under HO1. These tended to be qualified with examples of why heathland condition had improved since entering HLS or direct answers to options and IoS (eg 'not too prescriptive' and 'realistic'). For the majority of 'mostly' and 'no' responses landowners/managers suggested that the IoS were either inappropriate or 'not particularly appropriate' for their site. 47% of stands managed wholly or predominantly under HO1 were allocated to the 'no' category, compared to only 14% of those within HO2. This may suggest that owners/managers may regard the more rigorous IoS targets set for HO1, especially where they were not tailored to site-specific conditions, as being difficult to achieve.

'Are objectives, options, IoS and management proposals appropriate?'	**% Sites**
Yes	45.4
Mostly	11.3
No	3.1
Don't know	15.5
Landowner/manager not available/no response	24.7

7 Discussion

Heathland composition and condition

7.1 No stand passed all the generic CSM targets. However, targets had not been tailored to each individual site. A particular attribute value “increasing” or “decreasing” over time can only be judged as positive or negative in relation to the conservation targets for that site. Eg in a stand with a dense cover of mature heather, reducing the dwarf-shrub cover will be a positive change, whereas in a stand under restoration from scrub removal, increasing the dwarf-shrub cover may be the target to aim for.

7.2 Heathlands in all sample groups had low pass-rates for dwarf-shrub age-structure and undisturbed bare ground condition targets. This may have a negative impact on those priority species associated with heathland that require bare ground and early stages of vegetation (53%) and those that require a grass-heath matrix (38%) (Webb et al 2010). Pass rates were also low for generic positive indicator, graminoid and dwarf-shrub species diversity targets. However, in both SSSIs and non-SSSIs there was some weak evidence for better overall stand condition within HO1/HO2 options, though this was only statistically significant for a small number of attribute targets.

7.3 Non-SSSI stands within HO1/HO2 receive higher levels of active management than those outside these options, and there were positive signs of better heathland condition through this management, particularly against targets for dwarf-shrub and graminoid diversity and negative species. Further positive benefits of HO1/HO2 included lower levels of typically 'negative' features such as scrub, bramble, negative indicator species and dense acrocarpous mosses, and increased 'positive' features including dwarf-shrub frequency and richness, and bryophytes and lichens. These differences were detectable, despite inclusion of some actively managed heathlands (eg NNRs and land under moorland HLS options) in the non-HO1/HO2 group. Stands within HO1 had higher cover and richness of dwarf-shrub compared to HO2 options, suggesting appropriate option targeting.

7.4 Analysis of 2005/06 non-SSSI data showed that some of these differences existed ten years previously (albeit not at levels high enough to affect condition overall), indicating targeting in terms of the selection of stands for agreements and options. However despite this, there are signs that increased levels of management under HLS may be driving vegetation change, and stands which ended up in HO1/HO2 options improved in some aspects over-time, whereas those outside these options did not. For example, there were increases in graminoid diversity and disturbed bare-ground cover only in the HO1/HO2 group, as well as a modest reduction in dwarf-shrub cover. Sites outside of current HO1/HO2 options, started with less management activity, and appear to have become increasingly neglected over time since, as evidenced by reductions in undisturbed bare ground cover and dwarf-shrub species richness. However, there is not a simple picture, as stands both within and outside of the HLS options increased in scrub, bracken and bramble over time, and dense acrocarpous increased in cover the non-HO1/HO2 group, but decreased in cover while increasing in frequency within these options. Both groups also increased in positive species richness, although the increase was greatest in the HO1/HO2 stands. Despite these mixed/positive findings, still 38% of non-SSSI HO1/HO2 stands declined in the number of targets passed over the ten year period.

7.5 The (albeit slight) pre-existing baseline differences in 'starting-point', probably the result of scheme targeting, may have influenced the extent and the rate at which the vegetation could change over time. For example, if the frequency or cover of a particular species/species group is already at the upper limit, it has less ability to increase. However, despite this, comparison with baseline data shows some evidence that non-SSSI stands with and without HO1/HO2 options to be moving in different directions, as discussed above, and this can probably be related to differences in level of management activity. How this can be extrapolated to SSSIs is not clear, due to the lack of baseline data for SSSIs.

7.6 It is not clear when or how in the last ten years these differences came about. The average length of time in the current HLS agreement was c.5 years (some entering the scheme as recently as one year before the survey), and the agreement history for the stands are not known. However, 81% of stands now in HO1/HO2 were in some form of agri-environment scheme in 2005/06, whereas only 36% of non-HO1/HO2 stands were so. Therefore the differences in vegetation between 2005/06 and 2016, might be attributed to previous agri-environment schemes to some unknown extent, as well as HLS. A recent project based on both site mangers' experience and a literature review (Shellswell and others 2016) quantified the time that it takes before positive (or negative) ecological change can be observed. The original situation and the type of intervention can affect the time required to observe improvements.

7.7 In the SSSI sample, there was more limited evidence of better condition within the HO1/HO2 options than outside. There were increased levels of dwarf-shrub and graminoid richness and lower cover of gorse within the options, again probably related to the higher levels of active management in this group. However, the SSSI and non-SSSI samples did not always show the same patterns between HO1/HO2 groups for the same attribute. For example, the cover of dense acrocarpous mosses was higher in SSSI stands in HO1/HO2 than outside; the reverse was true in non-SSSI stands. It is possible that this is related to a longer history of management, perhaps burning. SSSIs also, surprisingly, had more bracken and trees/scrub on stands within HO1/HO2 than those outside, but this was reversed in the non-SSSI. This suggests that the relationship with lack of HO1/HO2 options and reduced management is strongest in the non-SSSI sample.

7.8 If positive species diversity is inherently poor on a site, it may be difficult for this to improve, and certainly within the lifetime of an HLS project. However, there was some evidence that in non-SSSI stands at least, HO1/HO2 options were associated with greater positive indicator species diversity, although levels had increased in both groups over time. The opposite was true in SSSIs, with greater positive species richness outside of HO1/HO2 options - this may relate as much to the fact that areas of land that are within SSSIs, even those not in heathland options, are still likely to be botanically rich and receiving targeted management, where as in non-SSSIs lack of an option is strongly associated with reduced management.

Relationship between heathland options and habitat structure

7.9 Reduced dwarf-shrub structural diversity was greatly limiting overall condition of heathlands in all groups, and the cover of pioneer growth recorded was generally low relative to CSM generic targets. There was no clear evidence that HO1/HO2 was related to a more varied dwarf-shrub structure, although there were slight qualitative suggestions that these options may be associated with slightly higher levels of pioneer dwarf-shrub in the non-SSSI stands. However, dwarf-shrub structure changes occur naturally slowly, and although it can be more quickly improved by management, many of the HLS agreements were in the relatively early stages.

7.10 Undisturbed bare ground was one of the most commonly failed targets, but yet is crucial for many Priority species (Webb and others 2010). Across the board, the cover of undisturbed bare ground was low relative to the requirements of the CSM generic targets, albeit with some notable exceptions at particular sites. Disturbed bare-ground, which in this study included bare ground from management, may however provide additional positive benefits for associated species in some cases.

7.11 In general, the introduction of HO1/HO2, and associated increases in management activity appears to have increased the extent of bare ground. In non-SSSIs, there was a significant increase in disturbed bare ground over time in the HO1/HO2 group, and a reduction in undisturbed bare ground in the non-HO1/HO2 group. In SSSIs, both disturbed and undisturbed bare ground cover was higher within HO1/HO2 compared to outside.

7.12 The positive relationship between grazing management and all types of bare ground (undisturbed, disturbed and erosion) was only clear in the SSSI sample. It is therefore suggested that other, non-grazing, management is driving the creation of bare ground in the

non-SSSI sample, perhaps the early stages of scrub and bracken control, which also clearly increased in frequency in the non-SSSI HO1/HO2 stands over time.

7.13 It was found that specific bare-ground creating management occurs on 29% of all stands, and as such was the least frequently occurring management activity type. Whilst results reveal that bare ground creation is greater (if not statistically so) in stands managed within HO1/HO2, the majority of sites within the scheme do not include bare ground creation. HLS does not provide options or capital items specific to bare ground creation in the manner that they are for bracken control or scrub clearance.

Impacts of livestock grazing

7.14 Vegetation analyses suggested that grazing is largely beneficial for heathland condition, and is significantly associated with higher levels of species richness of dwarf-shrubs, graminoid species and positive indicators. It also appeared to be effective at controlling scrub, bracken and bramble, and dense acrocarpous mosses, although reducing cover of lichens, and dwarf-shrub cover overall (though this may not always be a negative change). There was no evidence for an impact of grazing on age-structure, though it was associated with increases in both disturbed and undisturbed bare-ground.

7.15 Grazing occurred on 62% of stands and was significantly more frequent in those within HO1/HO2 options than those without. Of stands that weren't already grazed, a sizeable proportion of owners/managers reported a desire or willingness to graze sometime in the future, albeit often with caveats on practicalities that would first need to be overcome, or gave practical reasons which would prevent grazing altogether. The vast majority of heathland owners/managers regarded livestock grazing favourably. The issue of fencing common land to facilitate grazing is an important issue, followed by cost, and a range of site-specific practicalities.

Management, neglect and habitat loss

7.16 At least some management was recorded in 78% of non-HO1/HO1 stands overall, with the figure 98% within HO1/HO2 options. Within the non-SSSI sample, 31% of non-HO1/HO2 stands had no recorded management, compared to only 6% within the options. The majority of heaths are managed by conservation bodies which it is expected would implement conservation management as needed. Some loss of habitat in the non-SSSI sample was recorded, eg part of a stand had been lost to a new road, and part of a stand to housing.

7.17 The landowner consultation, and the comparison of 2005/06 and 2016 management information, clearly suggest that HLS has facilitated more active heathland management, and management had often changed on entering HLS. In some cases where it had not changed, this is because the site was already in an earlier scheme. This increase in management activity may well be responsible for the differences in vegetation and increases in bare ground, described above, and is expected to instigate condition improvements as the agreements progress. However, more needs to be done to ensure that bare ground and age-structure diversification continues into the future (including into any new schemes or agreements), particularly where there has only been a transient effect of scrub/bracken removal techniques.

7.18 70% of the 60% of landowners who responded, said that they felt happy with the way they managed the stands though even within HO1/HO2, lack of funding was cited as reason for not being able to do so, together with more site-specific issues such as access. Despite this, no stand passed all generic attribute targets, although this may improve throughout the lifetime of the agreements.

Scheme implementation

7.19 There was a very high (c.50%) incidence of stands where surveyors considered that option boundaries were not appropriate. The main reason was inclusion of areas of non-heathland

habitat, which was not likely to be restored to heathland, but also mixed options within SSSI Units, and incorrectly assigned HO1 vs HO2 options. This is not a constraint of the scheme, as RLR parcels can go into more than one option.

7.20 Seventy percent of responding land managers (60%) felt that the options and IoS were at least mostly appropriate, and the great majority of them believed that management objectives were being met (93% of cases where an answer was given). Negative answers were largely directed at the suitability or inflexibility of IoS (something surveyors also commented on), though many land managers did not know whether the IoS were appropriate (20% of cases where an answer was given). This suggests that a greater understanding of IoS, as well as overall management objectives amongst landowners and managers is desirable, and that IoS need to be better tailored to sites.

7.21 The management employed across the sites was very variable, and this variability could either indicate good site-specific management planning, a lack of knowledge as to what is a suitable management regime, or just site managers doing their best to manage their sites under a host of restrictions and practical constraints. There also appeared to be some variability in the extent to which landowners and Natural England staff were actively involved in site management.

7.22 Heaths owned and managed by conservation bodies were more frequently entered into HO1/HO2 schemes than privately owned heaths. This suggests that more might be done in future to encourage scheme uptake by private owners, as well as conservation organisations.

Methodological considerations

7.23 The following considerations should be born in mind when interpreting these findings.

- Data interpretation of the effect of the options on vegetation was complicated by the fact that a comparison was being made between stands within HO1/HO2, with stands with possibly other mechanisms of management facilitation, in particular, the inclusion of NNRs and stands under HLS moorland options.
- Some analyses may be hindered by low sample sizes or large in-group variation, and also by the issues outlined in Table 7 in Section 2.
- Many HLS stands were in the New Forest. However, this was the result of a random selection of SSSI units, and therefore is still considered representative of heathland overall.
- The CSM method may not be sensitive enough to detect subtle differences in vegetation. More significant differences were detected using the individual stop datasets.
- Generic CSM targets were rigidly applied, and, contrary to the CSM guidance, this project did not include tailoring targets for each attribute to reflect the natural variation across the country.
- Because digital option boundaries were not available, the sampling approach meant that SSSI Units within an agreement boundary with heathland options applied somewhere within it, but which did not actually have HO1/HO2, had to be rejected from the HLS sample at a late stage, but could not then be part of the non-HO1/HO2 sample. This may have possibly introduced some bias, depending on the reasons the agreement holder/HLS officer had for their exclusion from the option, particularly for non-HO1/HO2 stands in area of high-concentrations of heath. (The decision to sample in this way was made because doing otherwise would have conversely biased against such areas of heathlands.) It is possible that, if stands were excluded from options in place elsewhere in the agreement due to poor heathland condition, this may have driven in the high rejection rate for non-HO1/HO2 SSSI units.
- Because of the evolving nature of the sampling process, and the initial requirement to be able to compare to historic whole-Unit CSM data, only SSSI Units which were >95% within or outside of a target whole HLS agreement were included in the sample-able populations.

Units with a more even split between in and out of such agreements were excluded, and it cannot be ascertained how frequently this happened. (Note, because of lack of digital option boundaries, it was still quite possible for the selected Units to be only part covered by relevant option). Similarly, SSSI sample Units were filtered on the expected existence of 2006/2009 condition assessment data (although this later proved unobtainable or unusable in the majority of cases).Fortunately it is believed that until recently the frequency and timing of the rolling programme of CSM data was independent of site condition.

- The Common Standards for Monitoring (CSM) Lowland Heathland (JNCC 2009) require that sites have tailored site-specific targets if necessary. This was not possible in this project, as such tailored targets do not exist for non-SSSI stands, and standardised targets were required to allow comparison between groups. This may have resulted in some stands being assessed too harshly. To some extent this issue was avoided by analysis of raw attribute values,
- Lack of existing data precluded the option of stratifying by heathland type (ie wet/dry). Therefore the sample of wet heaths was small. Similarly, the number of non-SSSI 2005/06 survey stands discovered to be in HO1/HO2 in 2015 was small, and so the sample size was smaller than desired.
- A large number of statistical tests were under-taken (including on inter-correlated variables), increasing the chance of generation false-positive results. However standard multi-tests corrections can be very conservative and the because of the relatively low sample-size and high variation, and the results have been presented uncorrected.

Comparisons with other surveys and evaluations

7.24 Natural England and Defra have been assessing the effectiveness of the agri-environment schemes (AES) for some years and the results of past projects are publicly available or in the process of being published (eg Pywell and others 2012, Natural England 2013, Wilson and others 2013, Critchley and others 2016). Systematic monitoring and evaluation of the schemes was one of the key lessons highlighted by Radley (2013). The assessment of the effectiveness of these schemes have also been the focus of academic research (eg Kleijn and others 2006, Batáry and others 2015), looking not only at the biodiversity impacts but also at the financial implications and at how the effectiveness of the AES could be improved, eg by better farmer training and advice.

7.25 Each new AES builds on the information and experience gained from previous ones, on the evidence about which interventions are likely to be more successful and on new scientific evidence (see eg Radley 1013). For example, before HLS no soil analysis were regularly carried out before attempting to restore or re-create some habitats, or there were rigid stocking rates required (Peel & Diack 2007). Soil assessments are now regularly carried out and there are no mandatory stocking rates but flexible rates that can be adapted according to the vegetation response. However, despite the effort that goes each time into developing the schemes' architecture and define the options (see eg Stevenson and others 2005), the constraints on resources on the one hand, and the prioritisation of the negotiation of new agreements over evaluation of results on the other, has meant that sometimes the delivery has been inconsistent (Radley 2013).

7.26 Some AES options are designed to reduce the impact of agricultural activities on species or habitats, including creating new habitats; others are designed to maintain a more or less intensive management regime to ensure that secondary succession is arrested and species of the early stages of succession can thrive. Although targeting the right options to the right sites is very important for the success of the agreements, there is some evidence that this is not always the case (Batáry and others 2005, Stevenson and others 2005, Natural England 2013). Grassland creation has been attempted on soils with too high P levels (Stevenson and others 2005) and upland heathland restoration has failed in areas with consistently high levels of grazing and burning. This report on lowland heathlands shows that maintenance options have been applied to sites which initially had too high cover of scrub or trees, or

included non-heathland features, therefore being set to fail.

7.27 Peel (in prep) and Mountford and others (2013) reported that whereas creation of species-rich grasslands options were very successful, the restoration of existing grasslands was not, despite more funding going into those sites and options. There reasons seemed to be both, targeting of the wrong areas (eg too high nutrient levels) or incorrect use of the options (eg no seeds added). Although Mountford and others (2013) concluded that most HLS options had been located within the appropriate habitat, the lack of appropriate targeting and clear outcomes from the onset was identified as a lesson to learn by Radley (2013) for future AES.

7.28 Batáry and others (2015) and Lobley and others (2015) also indicate that the lack of farmer training on environmental awareness is one of the reasons for the relatively lower effectiveness of AES in farmed areas. If training was not possible, at least frequent contact with highly skilled Natural England advisors may be very helpful to increase farmer agri-environmental awareness (Radley 2013). Batáry and others (2015) also suggest that payment for results may lead to positive behavioural change in land managers, and incentivise them to improve their environmental skills.

7.29 One of the problems encountered when trying to determine whether AES are effective or not, is that the effects may take some time to become apparent, in some cases 8-10 years (Batáry and others 2015, Shellswell and others 2016). This means that agreements where the right management is being carried out may not yet show adequate progress. In this project, some of the agreements were only one or two years old, so it would not be surprising if there was no evidence yet of the effectiveness of the measures taken.

7.30 This project has found similar results to those reported by Wilson and others (2013) and Critchley and others (2016) for other heathlands, ie sites failed to meet favourable condition in many cases due to the lack of structural diversity. However, the heathlands surveyed by Critchley and others (2016) were in the uplands and the causes of the suboptimal condition were different to those encounter in the lowlands: high grazing and burning intensity. Mountford and others (2013) also reported lowland heathlands likely to be found in the poorest condition category in their sample and the least likely to meet their Indicators of Success.

7.31 Natural England (2013) highlighted some of the potential solutions which are also likely to improve the effectiveness of lowland heathland options in future AES: better tailoring and targeting of options to sites and better after care and engagement with the agreement holders. Other complementary approaches to improve the condition of features of priority for nature conservation may be further designation of protected sites. Batáry and others (2015) found that creating protected areas and managing them adequately may be more efficient and less costly in protecting species than paying for AES in intensively farmed areas.

8 General conclusion

8.1 Sample-based surveys are used frequently to determine the effectiveness of AES and this project adds to the body of evidence collated in the last 30 years or so.

8.2 There is clear evidence to suggest that HO1 and HO2 heathland options are facilitating a greater range of management activity; and this is leading to higher levels of bare ground - required by many priority and other associated heathland species. However evidence for a positive effect on vegetation was more variable, and may be hampered by various issues (in particular inclusion of NNRs and moorlands in the non-HO1/HO2 sample, lack of baseline data for SSSIs, lack of knowledge of previous agreement history, the relatively short time many of the HLS agreements have been in place, and the possible lack of sensitivity of the generic CSM approach as a monitoring tool).

8.3 In the non-SSSI sample there was evidence to suggest that HO1/HO2 options are associated with positive aspects of heathland vegetation (including diversity of dwarf-shrubs and graminoid species, and cover of lichens and bryophytes). In the SSSI sample, the relationship between the options and vegetation composition was more variable, with cover of scrub and bracken actually higher, and positive indicator species less frequent, within the options. A clear relationship between HO1/HO2 and dwarf-shrub age-structure was not found. Furthermore, 38% of non-SSSIs which were in HLS heathland options in 2015 were actually in poorer condition than ten years ago, though agreement history was not known, and length of time in HLS may be short.

8.4 Grazing is an important management tool and it had many positive effects on heathland vegetation and bare ground. Grazing is generally looked upon favourably by site managers, although there are many practical issues to be overcome, it may not be suitable for every site, and does not always results in the desired increased bare-ground, which may require more specific targeted management approaches. Non-grazing management appeared to be driving the creation of bare ground in the non-SSSI sample, perhaps the early stages of scrub and bracken control.

8.5 Private landowners may need further encouragement to enter into agreements to improve the condition of their heathland sites.

8.6 The project found inconsistencies in the way that the heathland options have been implemented in HLS agreements: eg in some cases the agreement area included non-heathland habitats; or the Indicators of Success were not appropriate for the site.

8.7 Improving the administrative procedures will also help with future scheme evaluation and effectiveness: eg more accurate mapping of where the options were applied; better option targeting depending on the original condition; setting a condition baseline to allow the evaluation of the outcomes; and incorporating feedback and after-care into the AES delivery process.

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Appendix 1 Landowner example letter text

Agreement holder/SSSI owner

As an agri-environment scheme agreement holder you might be aware that, from time to time, Natural England monitors the impact of the schemes on landscape, wildlife and the historic environment. In particular, Natural England is keen to evaluate the implementation and success of the heathland options within Higher Level Stewardship (HO1 - Heathland Maintenance, HO2 - Heathland Restoration, HO3 - Restoration from Forestry, and HO4 - restoration from arable). You have received this letter as our records show that you are managing heathland within an SSSI under one of these options, and I am therefore writing to ask for your help in allowing a contracted surveyor access the land shown on the enclosed map, as part of a National Survey, covering approximately 160 sites across England. The purpose of the survey would be to compare heathlands both within SSSIs and agri-environment schemes, and those without. The study also hopes to better understand how heathland management can help create habitat for rare associated heathland species (such as smooth snake, Dartford warbler, insects and plants etc), and the role that grazing may play. I can assure you that all information gathered will remain strictly confidential, and individual field data will not be published or made available to any third party. Only aggregated results and conclusions will be reported.

We would be very grateful if you would allow one of our contracted Hewins Ecology surveyors to access the land to undertake the survey. They would focus their efforts on any parts of the SSSI unit currently covered by the Higher Level Scheme (HLS) heathland option(s). The surveyors would walk across the survey site to record plant species and habitat information. The survey should take no more than a few hours and you will not need to be present when they carry out their visit. A summary of the survey may be prepared and sent to you in the winter, if you wish.

We would also like to take the opportunity to discuss briefly with you any heathland management or capital works you may have undertaken on the site, or any other information or concerns you may have regarding the habitat. This is so it can contribute to our understanding of the uptake and success of the Higher Level Stewardship Scheme options for heathlands.

I would be very grateful if you would be willing to allow access to survey, and could contact the surveying team directly to indicate whether or not this is the case. One of the surveyors would then contact you nearer the time to arrange a mutually convenient date for the survey, and chat to you about the site management and your use of the scheme, if possible. However, I also enclose a reply form and return envelope, to use if you prefer.

The Natural England HLS adviser/SSSI officer for your site will be notified separately about the survey.

If there are any points you wish to discuss about the project overall, please do not hesitate to contact me, or the surveyor lead (details above).

Non-SSSI owner

Back in 2005/2006 the above site (see enclosed map) was included in a survey of a random sample of heathland sites, carried out by Defra, English Nature and the RSPB, to better understand the character of heathland in the countryside as a whole and to compare land within agri-environment schemes with land outside agreements. Natural England would now like to include this site in a repeat survey this summer. The purpose of the survey would be to compare changes in heathlands both within SSSIs and agri-environment schemes, to those without. The study also hopes to better understand how heathland management can help create habitat for rare associated heathland species (such as smooth snake, Dartford warbler, insects and plants etc), and the role that grazing may play. I can assure you that all information gathered will remain strictly

confidential, and individual field data will not be published or made available to any third party. Only aggregated results and conclusions will be reported.

We would be very grateful if you would allow one of our contracted Hewins Ecology surveyors to access the land to undertake the repeat survey. The surveyors would walk across the survey site to record plant species and habitat information. The survey should take no more than a few hours and you will not need to be present when they carry out their visit. A summary of the survey may be prepared and sent to you in the winter, if you wish.

We would also like to take the opportunity to discuss briefly with you any heathland management you may have undertaken on the site, or any other information or concerns you may have regarding the habitat.

I would be very grateful if you would be willing to allow access to survey, and could contact the surveying team directly to indicate whether or not this is the case. One of the surveyors would then contact you nearer the time to arrange a mutually convenient date for the survey, and chat to you about the site management, if possible. However, I also enclose a reply form and return envelope, to use if you prefer.

Finally I apologise if these contact details from 2005/06 are no longer correct, but I would be very grateful if you could indicate to Hewins Ecology any updates that should be made to our records.

If there are any points you wish to discuss about the project overall, please do not hesitate to contact me, or the surveyor lead (details above).

Appendix 2 Table of attribute variables

Attribute	**2016**		**2005/06**	
	stand	stop	stand	stop
Bare ground - disturbed cover	y	y	y	y
Bare ground - disturbed frequency	y			
Bare ground - undisturbed cover	y	y	y	y
Bare ground - undisturbed frequency	y			
Bryophyte cover	y	y	y	y
Bryophyte frequency	y		y	
Dense acrocarpous moss cover	y	y	y	y
Dense acrocarpous moss frequency	y		y	
Deschampsia flexuosa cover	y	*y*	y	
Deschampsia flexuosa frequency	y		y	
Dung frequency	y			
Dwarf-shrub cover	y	y	y	y
Dwarf-shrub frequency	y		y	
Dwarf-shrub at least frequent	y		y	
Dwarf-shrub species richness	y	y	y	y
Dwarf-shrub structure – building	y		y	
Dwarf-shrub structure – dead	y		y	
Dwarf-shrub structure – degenerate	y		y	
Dwarf-shrub structure – pioneer	y		y	
Erosion cover	y	y		
Exotics species cover	y	y	y	y
Exotics species frequency	y		y	
Graminoid species at least occasional	y		y	
Graminoid species richness	y	y	y	y
Lichen cover	y	y	y	y
Lichen frequency	y		y	
Litter cover	y	y		
Molinia caerulea cover	y	y	y	y
Molinia caerulea frequency	y		y	
Nardus stricta cover	y	y	y	y
Nardus stricta frequency	y			
Negative species cover	y	y	y	y
Positive species at least occasional	y		y	
Positive species richness	y	y	y	y
Pteridium aquilinum cover	y	y	y	y
Pteridium aquilinum frequency	y		y	
Rubus spp. cover	y	y	y	y
Rubus spp. frequency	y			
Schoenus nigricans cover	y	y		y
Schoenus nigricans frequency	y			
Sphagnum spp. cover	y	y	y	y
Sphagnum spp. frequency	y			
Trees/scrub cover	y	y	y	y
Trees/scrub frequency	y		y	
Ulex europaeus cover	y	y	y	y
Ulex europaeus frequency	y			
Ulex spp. cover	y	y	y	y
Ulex spp. frequency	y			

Appendix 3 Species glossary

Scientific name from JNCC (2009)	Common name (BSBI, 2017)
Agrostis spp.	Bent-grass
Aira praecox	Early-hair grass
Ammophila arenaria	Marram
Anagallis tenella	Bog Pimpernel
Apium nodiflorum	Fool-s water-cress
Arctostaphylos uva-ursi	Bearberry
Armeria maritima	Thrift
Calluna vulgaris	Heather
Carex panicea	Carnation Sedge
Carex pulicaris	Flea Sedge
Carex spp.	Sedge spp.
Chamerion angustifolium	Rosebay Willowherb
Cirsium arvense	Creeping Thistle
Cirsium spp.	Thistle spp.
Corynephorus canescens	Grey Hair-grass
Danthonia decumbens	Heath Grass
Deschampsia flexuosa	Wavy Hair-grass
Digitalis purpurea	Foxglove
Drosera spp.	Sundew spp.
Eleocharis spp.	Spike-rush spp.
Empetrum nigrum	Crowberry
Epilobium spp. (excl. E. palustre)	Willowherb spp.
Erica ciliaris	Dorset Heath
Erica cinerea	Bell Heather
Erica tetralix	Crossed-leaved Heath
Erica vagans	Cornish Heath
Eriophorum angustifolium	Common Cottongrass
Erodium cicutarium	Common Stork's-bill
Fallopia japonica	Japanese Knotweed
Festuca spp.	Fescue spp.
Filago minima	Small Cudweed
Filipendula vulgaris	Meadowsweet
Galium saxatile	Heath Bedstraw
Galium verum	Ladies Bedstraw
Genista anglica	Petty Whin
Glyceria fluitans	Floating Sweet-grass

Scientific name from JNCC (2009)	Common name (BSBI, 2017)
Helianthemum nummularium	Common Rock-rose
Hypochaeris radicata	Cat's Ear
Juncus squarrosus	Heath Rush
Juncus acutiflorus	Sharp-flowered Rush
Juncus effusus	Soft Rush
Lotus corniculatus	Common Bird's-foot Trefoil
Molinia caerulea	Purple Moor-grass
Myrica gale	Bog-myrtle
Nardus stricta	Mat-grass
Narthecium ossifragum	Bog Asphodel
Oenanthe crocata	Hemlock Water-dropwort
Peltigera	A lichen
Phleum arenarium	Sand Cat's-tail
Phragmites spp.	Reed spp.
Pinguicula spp.	Butterwort spp.
Plantago lanceolata	Ribwort Plantain
Plantago maritima	Sea Plantain
Polygala serpyllifolia	Heath Milkwort
Potentilla erecta	Tormentil
Pteridium aquilinum	Bracken
Ranunculus repens	Creeping Buttercup
Ranunculus spp.	Buttercup spp.
Rhododendron	Rhododendron
Rhynchospora alba	White-beak-sedge
Rumex acetosella	Sheep's Sorrel
Rumex obtusifolius	Broad-leaved Dock
Salix repens	Creeping Willow
Sanguisorba minor (now Poterium sanguisorba)	Salad Burnet
Schoenus nigricans	Black Bog-rush
Scilla verna	Spring Squill
Sedum acre	Biting Stonecrop
Senecio jacobaea	Common Ragwort
Senecio spp.	Ragwort spp.
Serratula tinctoria	Saw-wort
Succisa pratensis	Devil's-bit Scabious
Thymus praecox (now T. polytrichus)	Wild Thyme
Trichophorum cespitosum (now T. germanicum and T. cespitosum)	Deergrass
Typha spp.	Bulrush spp.

Scientific name from JNCC (2009)	**Common name (BSBI, 2017)**
Ulex europaeus	Common Gorse
Ulex gallii	Western Gorse
Ulex minor	Dwarf Gorse
Urtica dioica,	Cowberry
Urtica spp	Nettle spp.
Vaccinium vitis-idaea	Cranberry
Vaccinium myrtillus	Bilberry
Vaccinium spp.	Berry spp.
Viola riviniana	Common Dog-violet

Appendix 4 Raw 2016 attribute values, for non-SSSI stands within and outside HO1/H2 options, and also by actual HLS option in 2016.

Based either on site averages (n=31 and 28 respectively) or individual stop data (HO1 (n=160) and HO2 (n=436) options, or no such option (n=559). Site-level analyses use predominant option for stand; stop based analyses use stop-specific option status. Significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005.

Basis	**Transfor-mation**	**Attribute**	**HO1/HO2**		**non-HO1/HO2**		**HO1/HO2 vs non**		**HO1**	**SE**	**HO2**	**SE**	**HO1 vs HO2**	
			mean	*se*	*mean*	*se*	*p.*	*sig*	*mean*	*se*	*mean*	*se*	p.	sig
Stand	ln(x+1)	Bare ground - disturbed cover	1.44	0.51	0.38	0.20	0.08	n.s.						
		Bare ground - undisturbed cover	1.54	0.34	1.99	0.66	0.30	n.s.						
		Bare ground - undisturbed frequency	9.28	1.39	7.68	1.57	0.80	n.s.						
		Bare ground – disturbed frequency	1.10	0.34	0.50	0.26	0.14	n.s.						
		Bryophyte cover	14.83	4.66	7.51	3.42	0.21	n.s.						
		Bryophyte frequency	10.39	1.35	7.50	1.32	0.10	n.s.						
	ln(x+1)	Dense acrocarpous moss cover	0.53	0.35	1.49	0.96	0.51	n.s.						
		Dense acrocarpous moss frequency	2.23	0.76	2.79	1.12	0.65	n.s.						
	ln(x+1)	*Deschampsia flexuosa* cover	3.47	1.38	1.51	0.59	0.29	n.s.						
		Deschampsia flexuosa frequency	5.77	1.32	3.50	1.09	0.22	n.s.						
		Dung frequency	3.74	0.89	3.89	1.29	0.98	n.s.						
		Dwarf-shrub cover	36.77	4.58	34.95	5.20	0.72	n.s.						
		Dwarf-shrub frequency	14.86	0.71	11.98	1.22	0.05	n.s.						
		Dwarf-shrub species at least frequent	2.65	0.17	1.39	0.17	0.00	**						
		Dwarf-shrub species richness	3.26	0.15	2.00	0.17	0.00	**						

Basis	Transfor-mation	Attribute	HO1/HO2		non-HO1/HO2		HO1/HO2 vs non		HO1	SE	HO2	SE	HO1 vs HO2	
			mean	*se*	*mean*	*se*	*p.*	*sig*	*mean*	*se*	*mean*	*se*	p.	sig
		Dwarf-shrub structure – dead cover	0.34	0.16	2.00	1.17	0.17	n.s.						
		Dwarf-shrub structure – degenerate	2.22	1.10	2.98	0.89	0.59	n.s.						
		Dwarf-shrub structure – pioneer	26.18	5.67	23.76	6.61	0.78	n.s.						
		Dwarf-shrub structure– building	71.27	5.46	71.26	6.33	1.00	n.s.						
	ln(x+1)	Erosion	0.19	0.10	0.02	0.02	0.57	n.s.						
	ln(x+1)	Exotic species cover	0.00	0.00	0.34	0.33	0.32	n.s.						
	ln(x+1)	Exotic species frequency	0.03	0.03	0.39	0.20	0.06	n.s.						
		Graminoid species at least occasional	2.77	0.22	1.89	0.20	0.00	**						
		Graminoid species richness	3.65	0.20	2.64	0.24	0.00	**						
	1/(x+1)	Lichen cover	0.18	0.12	1.79	1.73	0.64	n.s.						
		Lichen frequency	1.69	0.45	1.75	0.75	0.90	n.s.						
	ln(x+1)	Litter cover	7.35	2.08	3.85	1.12	0.17	n.s.						
		Molinia caerulea cover	12.26	3.13	7.89	2.91	0.25	n.s.						
		Molinia caerulea frequency	8.75	1.39	5.07	1.31	0.09	n.s.						
		Nardus stricta cover	0.01	0.01	0.29	0.14	0.06	n.s.						
	1/(x+1)	*Nardus stricta* frequency	0.18	0.09	0.75	0.40	0.19	n.s.						
		Negative species cover	1.69	0.58	5.97	2.36	0.27	n.s.						
		Positive species at least occasional	1.35	0.27	1.18	0.21	0.61	n.s.						
		Positive species richness	3.00	0.31	2.54	0.36	0.33	n.s.						
		Pteridium aquilinum cover	12.77	2.52	13.36	3.28	0.82	n.s.						
		Pteridium aquilinum frequency	7.44	1.09	5.96	1.19	0.43	n.s.						
		Rubus spp. cover	2.70	0.79	6.55	2.03	0.09	n.s.						
		Rubus spp. frequency	4.78	0.97	7.50	1.03	0.48	n.s.						
		Tree/scrub cover	7.14	1.39	15.45	3.75	0.04	*						
		Tree/scrub frequency	8.84	1.10	9.07	1.35	0.95	n.s.						
		Ulex europaeus cover	4.66	1.50	5.70	1.63	0.71	n.s.						
		Ulex europaeus frequency	4.36	0.97	3.29	0.88	0.36	n.s.						

Basis	Transfor-mation	Attribute	HO1/HO2		non-HO1/HO2		HO1/HO2 vs non		HO1	SE	HO2	SE	HO1 vs HO2	
			mean	*se*	*mean*	*se*	*p.*	*sig*	*mean*	*se*	*mean*	*se*	p.	sig
		Ulex spp. cover	8.24	1.91	7.32	1.68	0.89	n.s.						
		Ulex spp. frequency	7.19	1.17	5.00	1.07	0.69	n.s.						
Stop	1/(x+1) weak	Bare ground – disturbed	1.45	0.36	0.42	0.20	0.04	*	1.98	0.79	1.25	0.39	0.22	n.s.
	ln(x+1)	Bare ground – undisturbed	1.69	0.32	1.90	0.38	0.26	n.s.	1.79	0.55	1.66	0.39	0.30	n.s.
		Bryophyte cover	14.73	1.20	7.87	0.90	0.00	**	17.96	2.40	13.55	1.38	0.11	n.s.
	1/(x+1)	Dense acrocarpous moss	0.55	0.14	1.49	0.29	0.02	*	1.74	0.49	0.12	0.05	0.00	**
	ln(x+1)	*Deschampsia flexuosa* cover	2.94	0.43	2.22	0.42	0.01	*	3.00	0.90	2.91	0.49	0.66	n.s.
		Dwarf-shrub cover	37.30	1.57	34.00	1.65	0.15	n.s.	47.14	3.42	33.66	1.71	0.00	*
		Dwarf-shrub richness	1.53	0.05	0.98	0.04	0.00	*	1.71	0.10	1.46	0.06	0.03	*
	failed	Erosion cover	0.21	0.09	0.30	0.20			0.31	0.22	0.17	0.08		
	failed	Exotics species cover	0.00	0.00	0.34	0.21			0.00	0.00	0.00	0.00		
		Graminoid species richness	1.61	0.05	1.20	0.04	0.00	*	1.49	0.09	1.66	0.06	0.10	n.s.
	1/(x+1) weak	Lichen cover	0.20	0.09	1.90	0.47	0.19	n.s.	0.18	0.05	0.21	0.12	0.01	*
	ln(x+1)	Litter cover	7.86	0.76	4.10	0.53	0.00	**	6.25	1.29	8.45	0.93	0.71	n.s.
		Molinia caerulea cover	12.49	0.96	7.60	0.88	0.00	**	4.18	0.97	15.54	1.24	0.00	*
	failed	*Nardus stricta* cover	0.01	0.01	0.29	0.09			0.02	0.01	0.01	0.01		
	ln(x+1)	Negative species cover	1.75	0.31	5.99	0.78	0.00	**	1.27	0.42	1.92	0.39	0.15	n.s.
		Positive species richness	1.18	0.07	0.71	0.05	0.00	**	1.06	0.12	1.23	0.08	0.25	n.s.
		Pteridium aquilinum cover	12.19	1.08	13.89	1.25	0.31	n.s.	14.40	2.22	11.39	1.24	0.24	n.s.
	ln(x+1)	*Rubus* agg. cover	2.76	0.41	6.57	0.78	0.00	**	2.21	0.62	2.96	0.52	0.84	n.s.
	failed	*Sphagnum* spp. cover	0.46	0.13	0.41	0.20			0.00	0.00	0.63	0.18		
	ln(x+1)	Trees/scrub cover	6.59	0.71	15.83	1.29	0.00	**	4.93	1.16	7.19	0.88	0.06	n.s.
	ln(x+1)	*Ulex europaeus* cover	4.84	0.63	5.71	0.78	0.56	n.s.	10.03	1.67	2.94	0.58	0.00	**
		Ulex spp. cover	7.72	0.74	7.57	0.82	0.89	n.s.	4.50	0.84	8.90	0.96	0.00	**

Appendix 5 Raw 2005/06 and 2016 attribute values, for non-SSSI stands currently within and outside HO1/H2 options

Based either on site averages (n=31 and 28 respectively) or individual stop data. All analyses use predominant current (2015) option for stand. *=p<0.05, **=p<0.005.

Basis	**Transfor-mation**	**Attribute**	**non-HO1/HO2 2005/06**		**non-HO1/HO2 2016**		**2005/06 vs 2016**		**HO1/HO2 2005/06**		**HO1/HO2 2016**		**2005/06 vs 2016**		**All 2005/06**		**All 2016**		**2005/06 vs 2016**	
			mean	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*
Stand		Bare ground - disturbed cover	2.10	1.65	0.38	0.20	0.30	n.s.	0.06	0.04	1.44	0.51	0.01	*	1.03	0.79	0.93	0.29	0.91	n.s.
		Bare ground - undisturbed cover	3.58	0.89	1.99	0.66	0.11	n.s.	2.08	0.73	1.54	0.34	0.49	n.s.	2.79	0.57	1.76	0.36	0.10	n.s.
		Bryophyte cover	6.04	1.29	7.51	3.42	0.70	n.s.	6.11	1.90	14.83	4.66	0.04	*	6.08	1.17	11.17	2.89	0.07	n.s.
		Bryophyte frequency	9.20	1.13	7.50	1.32	0.23	n.s.	6.81	1.19	10.39	1.35	0.01	*	7.94	0.84	8.97	0.95	0.31	n.s.
	ln(x+1)	Dense acrocarpous moss cover	0.98	0.45	1.49	0.96	0.80	n.s.	0.86	0.77	0.53	0.35	0.59	n.s.	0.91	0.46	0.98	0.49	0.98	n.s.
		Dense acrocarpous moss frequency	1.18	0.36	2.79	1.12	0.15	n.s.	0.68	0.46	2.23	0.76	0.01	**	0.92	0.30	2.49	0.66	0.01	**
	ln(x+1)	*Deschampsia flexuosa* cover	6.80	2.52	1.51	0.59	0.00	**	5.97	2.08	3.47	1.38	0.29	n.s.	6.37	1.62	2.53	0.78	0.00	**
		Deschampsia flexuosa frequency	5.71	1.33	3.50	1.09	0.01	*	4.87	1.21	5.77	1.32	0.32	n.s.	5.27	0.89	4.64	0.86	0.33	n.s.
		Dwarf-shrub at least frequent	1.43	0.19	1.39	0.17	0.81	n.s.	1.94	0.19	2.65	0.17	0.00	**	1.69	0.10	2.05	0.11	0.02	*
		Dwarf-shrub cover	32.41	4.59	34.95	5.20	0.55	n.s.	41.28	4.55	36.77	4.58	0.16	n.s.	35.52	3.21	35.68	3.36	0.74	n.s.
		Dwarf-shrub frequency	14.86	0.96	11.96	1.22	0.00	**	16.58	0.63	14.86	0.71	0.00	**	15.42	0.63	13.44	0.70	0.00	**
		Dwarf-shrub species richness	2.64	0.23	2.00	0.17	0.00	*	3.48	0.17	3.26	0.15	0.17	n.s.	3.08	0.11	2.66	0.11	0.00	**
	ln(x+1)	Dwarf-shrub structure – dead	5.13	2.43	2.00	1.17	0.15	n.s.	0.89	0.41	0.34	0.16	0.17	n.s.	2.90	0.41	0.34	0.16	0.17	n.s.

Basis	Transfor-mation	Attribute	non-HO1/HO2 2005/06		non-HO1/HO2 2016		2005/06 vs 2016		HO1/HO2 2005/06		HO1/HO2 2016		2005/06 vs 2016		All 2005/06		All 2016		2005/06 vs 2016	
			mean	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*
		Dwarf-shrub structure – degenerate	6.49	1.82	2.98	0.89	0.25	n.s.	4.62	1.69	2.22	1.10	0.22	n.s.	5.51	1.69	2.22	1.10	0.09	n.s.
		Dwarf-shrub structure– building	67.27	5.83	71.26	6.33	0.53	n.s.	56.67	7.27	71.27	5.46	0.07	near	61.70	7.27	71.27	5.46	0.07	n.s.
		Dwarf-shrub structure– pioneer	17.54	5.22	23.76	6.61	0.19	n.s.	18.46	5.57	26.18	5.67	0.11	n.s.	18.02	5.57	x	x	0.11	n.s.
		Exotic species cover	0.00	0.00	0.34	0.33	0.32	n.s.	0.03	0.03	0.00	0.00	0.30	n.s.	0.02	0.01	0.16	0.16	0.36	n.s.
	ln(x+1)	Exotic species frequency	0.00	0.00	0.39	0.20	0.03	*	0.16	0.13	0.03	0.03	0.40	n.s.	0.08	0.07	0.20	0.10	0.24	n.s.
		Graminoid species at least occasional	2.29	0.19	1.89	0.20	0.02	*	2.45	0.20	2.77	0.22	0.15	n.s.	2.37	0.11	2.36	0.12	0.91	n.s.
		Graminoid species richness	3.11	0.21	2.64	0.24	0.06	n.s.	3.29	0.20	3.65	0.20	0.09	n.s.	3.20	0.11	3.17	0.13	0.83	n.s.
	ln(x+1)	Lichen cover	2.02	1.39	1.79	1.73	0.08	n.s.	0.04	0.02	0.18	0.12	0.09	n.s.	0.98	0.67	0.94	0.82	0.40	n.s.
		Lichen frequency	1.95	0.80	1.75	0.75	0.62	n.s.	0.90	0.24	1.69	0.45	0.04	*	1.40	0.41	1.71	0.42	0.26	n.s.
		Molinia caerulea cover	9.00	3.14	7.89	2.91	0.48	n.s.	10.42	3.62	12.26	3.13	0.51	n.s.	9.68	2.42	10.19	2.15	0.76	n.s.
		Molinia caerulea frequent	4.82	1.27	5.07	1.31	0.48	n.s.	8.84	1.48	8.75	1.39	0.90	n.s.	6.71	1.02	7.00	0.98	0.54	n.s.
		Nardus stricta cover	0.52	0.34	0.29	0.14	0.47	n.s.	0.39	0.37	0.01	0.01	0.31	n.s.	0.45	0.25	0.14	0.07	0.21	n.s.
		Negative species cover	3.99	1.34	5.97	2.36	0.19	n.s.	1.63	0.42	1.69	0.58	0.91	n.s.	2.75	0.68	3.72	1.18	0.20	n.s.
		Positive species occasional	1.11	0.23	1.18	0.21	0.74	n.s.	0.87	0.21	1.35	0.27	0.01	*	0.98	0.12	1.27	0.13	0.05	*
		Positive species richness	1.89	0.33	2.54	0.36	0.05	*	1.74	0.27	3.00	0.31	0.00	**	1.81	0.16	2.78	0.18	0.00	**
		Pteridium aquilinum cover	5.28	1.47	13.36	3.28	0.01	*	5.25	1.78	12.77	2.52	0.01	*	5.20	1.17	13.26	2.02	0.00	**
		Pteridium aquilinum frequency	5.25	0.97	5.96	1.19	0.23	n.s.	6.39	1.06	7.44	1.09	0.11	n.s.	5.78	0.73	6.79	0.81	0.04	*
	ln(x+1)	*Rubus* agg. cover	2.08	0.47	6.55	2.03	0.03	*	1.87	0.72	2.70	0.79	0.34	n.s.	1.91	0.44	4.53	1.07	0.02	*
		Sphagnum spp. cover	0.00	0.00	0.40	0.39	0.31	n.s.	1.15	1.24	0.45	0.28	0.38	n.s.	0.61	0.64	0.43	0.24	0.66	n.s.
		Tree/scrub cover	4.91	1.45	15.45	3.75	0.01	**	4.72	1.53	7.14	1.39	0.25	n.s.	4.81	1.06	11.32	1.99	0.00	**
		Tree/scrub frequency	7.54	1.10	9.07	1.35	0.23	n.s.	8.55	1.20	8.84	1.10	0.79	n.s.	8.07	0.82	8.95	0.86	0.28	n.s.
	ln(x+1)	*Ulex europaeus* cover	5.68	1.51	5.70	1.63	0.53	n.s.	4.36	1.49	4.66	1.50	0.86	n.s.	4.99	1.06	5.15	1.10	0.81	n.s.
Stop	1/(x+1) weak	Bare ground – disturbed	2.07	0.55	0.39	0.20	0.26	n.s.	0.06	0.03	1.47	0.35	0.00	**	1.02	0.26	0.95	0.21	0.01	*

Basis	Transfor-mation	Attribute	non-HO1/HO2 2005/06		non-HO1/HO2 2016		2005/06 vs 2016		HO1/HO2 2005/06		HO1/HO2 2016		2005/06 vs 2016		All 2005/06		All 2016		2005/06 vs 2016	
			mean	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig*
	ln(x+1)	Bare ground – undisturbed	3.65	0.49	2.03	0.40	0.00	*	2.01	0.37	1.58	0.30	0.60	n.s.	2.79	0.30	1.79	0.25	0.00	**
		Bryophyte cover	5.84	0.52	7.65	0.90	0.08	n.s.	6.37	0.64	14.83	1.19	0.00	**	6.12	0.42	11.41	0.76	0.00	**
	1/(x+1) weak	Dense acrocarpous moss	1.05	0.31	1.51	0.30	0.00	*	0.83	0.31	0.55	0.14	0.00	**	0.94	0.22	1.01	0.16	0.00	**
		Dwarf-shrub cover	32.03	1.46	34.89	1.68	0.20	n.s.	40.86	1.49	36.44	1.54	0.04	*	36.65	1.05	35.70	1.14	0.54	n.s.
		Dwarf-shrub richness	1.13	0.04	1.00	0.04	0.02	*	1.56	0.04	1.50	0.05	0.36	n.s.	1.36	0.03	1.26	0.03	0.03	*
	failed	Exotics species cover	0.00	0.00	0.34	0.21			0.03	0.02	0.00	0.00			0.01	0.01	0.16	0.10		
		Graminoid species richness	1.27	0.04	1.18	0.04	0.14	n.s.	1.30	0.03	1.63	0.05	0.00	**	1.28	0.03	1.41	0.03	0.00	**
	1/(x+1) weak	Lichen cover	1.95	0.46	1.95	0.48	0.51	n.s.	0.04	0.01	0.19	0.08	0.00	**	0.95	0.22	1.03	0.23	0.43	n.s.
		Molinia caerulea cover	8.62	0.90	7.54	0.89	0.39	n.s.	10.20	0.96	12.48	0.95	0.09	n.s.	9.45	0.66	10.13	0.66	0.47	n.s.
	failed	*Nardus stricta* cover	0.51	0.13	0.29	0.09	0.55	n.s.	0.38	0.16	0.01	0.01	0.03	*	0.44	0.10	0.15	0.04	0.12	n.s.
	ln(x+1)	Negative species cover	3.98	0.50	6.08	0.79	0.67	n.s.	1.29	0.26	1.72	0.30	0.13	n.s.	2.57	0.28	3.80	0.41	0.24	n.s.
		Positive species richness	0.28	0.03	0.71	0.05	0.00	*	0.30	0.03	1.18	0.07	0.00	**	0.29	0.02	0.96	0.04	0.00	**
	ln(x+1)	*Pteridium aquilinum* cover	5.49	0.70	13.60	1.25	0.00	*	5.04	0.66	12.58	1.09	0.00	**	5.25	0.48	13.07	0.83	0.00	**
	ln(x+1)	*Rubus* spp. cover	1.74	0.28	6.67	0.79	0.00	*	1.49	0.24	2.73	0.41	0.00	**	1.61	0.18	4.60	0.44	0.00	**
	failed	*Schoenus nigricans* cover	0.20	0.06	0.02	0.01			0.00	0.00	0.00	0.00			0.10	0.03	0.01	0.00		
	failed	*Sphagnum* spp. cover	0.01	0.01	0.41	0.20			1.12	0.30	0.46	0.13			0.59	0.16	0.44	0.12		
	ln(x+1)	Trees/scrub cover	5.04	0.60	15.21	1.28	0.00	*	4.60	0.53	7.29	0.77	0.00	**	4.81	0.40	11.06	0.74	0.00	**
	ln(x+1)	*Ulex europaeus* cover	6.22	0.76	5.80	0.79	0.24	n.s.	4.48	0.61	4.77	0.62	0.37	n.s.	5.31	0.48	5.26	0.50	0.81	n.s.
		Ulex spp. cover	9.78	1.09	7.24	0.81	0.06	n.s.	18.80	1.35	8.02	0.75	0.00	**	14.50	0.89	7.65	0.55	0.00	**
		n (stops)	*580*		*550*				*637*		*605*				*1217*		*1155*			

Appendix 6 Raw attribute values, for SSSI stands within and outside HO1/H2 options, and also by actual HLS option

Based either on dry heath stand averages (n=50 and 24 respectively) or individual stop data from wet and dry heaths combined (HO1 (n=380) and HO2 (n=929) options, or no such option (n=566). Site-level analyses use predominant option for stand, stop based analyses use stop-specific option status. Significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005.

Basis	**Transforma-tion**	**Attribute**	**HO1/HO2**		**non-HO1/HO2**		**HO1/HO2 vs non**		**HO1**		**HO2**		**HO1 vs HO2**	
			mean	*SE*	*mean*	*SE*	*p.*	*sig.*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
Stand	ln(x+1)	Bare ground - disturbed cover	0.74	0.24	0.41	0.19	0.35	n.s.						
		Bare ground - disturbed frequency	2.38	0.68	0.88	0.54	0.08	n.s.						
		Bare ground - undisturbed cover	2.17	0.39	1.57	0.54	0.34	n.s.						
		Bare ground - undisturbed frequency	11.46	1.08	10.21	1.56	0.44	n.s.						
		Bryophyte cover	13.87	2.73	8.40	3.35	0.19	n.s.						
		Bryophyte frequency	11.77	1.04	9.96	1.51	0.26	n.s.						
	ln(x+1)	Dense acrocarpous moss cover	2.35	0.39	1.77	1.28	0.03	*						
		Dense acrocarpous moss frequency	7.44	0.90	4.00	1.25	0.02	*						
	ln(x+1)	*Deschampsia flexuosa* cover	3.53	1.16	3.85	1.10	0.21	n.s.						
		Deschampsia flexuosa frequency	4.65	0.92	8.58	1.60	0.04	*						
		Dung frequency	6.56	0.94	6.63	1.37	0.97	n.s.						
		Dwarf-shrub cover	51.28	3.05	47.97	5.27	0.48	n.s.						
		Dwarf-shrub frequency	18.17	0.50	17.63	0.65	0.23	n.s.						
		Dwarf-shrub species richness	3.30	0.13	2.79	0.23	0.06	n.s.						
		Dwarf-shrub structure – building	69.65	3.77	74.27	5.03	0.60	n.s.						
		Dwarf-shrub structure – dead	1.50	0.29	0.70	0.30	0.05	*						

Basis	Transforma-tion	Attribute	HO1/HO2		non-HO1/HO2		HO1/HO2 vs non		HO1		HO2		HO1 vs HO2	
			mean	*SE*	*mean*	*SE*	*p.*	*sig.*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
		Dwarf-shrub structure – degenerate	3.95	1.22	2.09	0.90	0.21	n.s.						
		Dwarf-shrub structure – pioneer	22.98	3.54	22.94	5.05	0.94	n.s.						
		Dwarf-shrubs at least frequent	1.46	0.11	1.96	0.15	0.67	n.s.						
	1/(x+1)	Erosion cover	0.19	0.09	0.11	0.10	0.99	n.s.						
	failed'	Exotics species cover	0.13	0.11	0.07	0.07								
	ln(x+1)	Exotics species frequency	0.35	0.13	0.46	0.34	0.89	n.s.						
		Graminoid species at least occasional	2.18	0..28	2.88	0.20	0.80	n.s.						
		Graminoid species richness	2.95	0.35	3.71	0.24	0.30	n.s.						
	1/(x+1)	Lichen cover	0.44	0.15	0.58	0.30	0.56	n.s.						
		Lichen frequency	3.88	0.51	2.96	1.02	0.39	n.s.						
	ln(x+1)	Litter cover	5.48	1.44	2.94	0.98	0.10	n.s.						
		Molinia caerulea cover	12.19	1.09	7.17	1.59	0.01	*						
		Molinia caerulea frequency	15.83	2.41	11.05	4.27	0.31	n.s.						
		Nardus stricta cover	0.09	0.06	0.00	0.00	0.15	n.s.						
	1/(x+1)	*Nardus stricta* frequency	0.63	0.29	0.13	0.09	0.25	n.s.						
	ln(x+1)	Negative species cover	0.42	0.18	1.58	0.42	0.01	*						
		Positive species at least occasional	0.90	0.17	1.96	0.33	0.06	n.s.						
		Positive species richness	2.52	0.30	3.33	0.37	0.90	n.s.						
		Pteridium aquilinum cover	11.57	2.15	8.05	2.49	0.26	n.s.						
		Pteridium aquilinum frequency	7.71	0.89	4.79	1.21	0.05	*						
	ln(x+1)	*Rubus* spp. cover	0.89	0.25	1.99	0.93	0.45	n.s.						
		Rubus spp. frequency	3.35	0.56	4.00	1.15	0.65	n.s.						
		Schoenus nigricans cover	0.19	0.17	3.30	1.91	0.12	n.s.						
		Schoenus nigricans frequency	0.37	0.26	2.08	1.07	0.13	n.s.						
	ln(x+1)	*Sphagnum* spp. cover	1.13	0.40	0.02	0.02	0.00	**						
		Sphagnum spp. frequency	2.37	0.62	0.33	0.21	0.00	**						
	ln(x+1)	Trees/scrub cover	5.62	1.11	3.83	1.30	0.06	n.s.						
		Trees/scrub frequency	10.17	0.75	5.00	1.17	0.00	**						

Basis	Transforma-tion	Attribute	HO1/HO2		non-HO1/HO2		HO1/HO2 vs non		HO1		HO2		HO1 vs HO2	
			mean	*SE*	*mean*	*SE*	*p.*	*sig.*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
		Ulex europaeus cover	2.95	0.82	2.72	1.25	0.84	n.s.						
		Ulex europaeus frequency	3.62	0.57	2.50	1.02	0.32	n.s.						
		Ulex spp. cover	4.48	1.09	7.84	2.35	0.22	n.s.						
		Ulex spp. frequency	5.83	0.82	6.54	1.37	0.71	n.s.						
	1/(x+1)	Bare ground – disturbed	0.80	0.10	0.31	0.08	0.00	**	0.11	0.08	1.02	0.14	0.00	**
	ln(x+1)	Bare ground – undisturbed	1.94	0.22	1.45	0.29	0.00	**	0.91	0.16	2.51	0.27	0.00	**
		Bryophyte cover	7.38	0.51	7.18	0.75	0.82	n.s.	20.91	1.64	9.09	0.68	0.00	**
	1/(x+1)	Dense acrocarpous moss	1.58	0.23	1.49	0.39	0.00	**	2.35	0.52	1.95	0.23	0.00	**
	ln(x+1)	*Deschampsia flexuosa cover*	3.02	0.33	2.90	0.43	0.11	n.s.	1.28	0.38	3.56	0.42	0.00	**
		Dwarf-shrub cover	44.45	0.97	43.04	1.57	0.44	n.s.	61.48	1.79	46.43	1.06	0.00	*
		Dwarf-shrub richness	1.92	0.03	1.57	0.04	0.00	**	1.79	0.05	2.10	0.03	0.00	**
	failed	Erosion cover	0.19	0.06	0.00	0.00			0.00	0.00	0.28	0.09		
		Exotics species cover	0.03	0.02	0.03	0.02	0.95	n.s.	0.33	0.27	0.03	0.02	0.26	n.s.
		Graminoid species richness	2.35	0.04	2.10	0.05	0.00	**	1.38	0.05	2.32	0.05	0.00	**
	1/(x+1)	Lichen cover	0.33	0.08	0.45	0.14	0.58	n.s.	1.95	0.49	0.28	0.08	0.00	**
Stop	ln(x+1)	Litter cover	3.42	0.29	2.93	0.39	0.01	*	2.40	0.38	5.71	0.49	0.00	**
		Molinia caerulea cover	20.70	0.82	17.47	1.24	0.03	*	22.51	1.59	20.42	0.87	0.25	n.s.
	failed	*Nardus stricta* cover	0.02	0.01	0.02	0.02			0.00	0.00	0.08	0.03		
	1/(x+1)	Negative species cover	0.74	0.11	1.37	0.24	0.00	**	0.36	0.16	0.52	0.14	0.90	n.s.
		Positive species richness	1.55	0.05	1.61	0.08	0.55	n.s.	0.58	0.06	1.31	0.06	0.00	**
	ln(x+1)	*Pteridium aquilinum* cover	7.99	0.62	6.95	0.88	0.06	n.s.	4.28	0.81	11.01	0.80	0.00	*
	1/(x+1)	*Rubus* agg. cover	0.99	0.15	1.62	0.30	0.04	*	0.83	0.29	0.65	0.12	0.41	n.s.
	failed	*Schoenus nigricans* cover	1.29	0.23	2.83	0.49			0.48	0.22	0.00	0.00		
	ln(x+1)	*Sphagnum* spp. cover	2.50	0.24	0.47	0.11	0.00	**	2.72	0.54	3.37	0.33	0.02	*
	ln(x+1)	Trees/scrub cover	4.75	0.43	4.00	0.56	0.11	n.s.	5.57	0.80	5.34	0.54	0.03	*
	1/(x+1)	*Ulex europaeus* cover	3.18	0.37	3.43	0.58	0.49	n.s.	3.03	0.73	2.26	0.35	0.13	n.s.
	ln(x+1)	*Ulex* spp. cover	5.48	0.47	8.33	0.85	0.00	**	5.56	0.87	2.92	0.37	0.02	*

Appendix 7 Raw attribute values, for wet heath SSSI stands within and outside HO1/H2 options.

Based on stand data from stands within (n=16) and outside (n=6) HO1/H2 options. Significant results from unpaired two tailed t-tests. *=p<0.05, **=p<0.005.

Transfor-mation	**Attribute**	**HO1/HO2**		**non-HO1/HO2**		**ALL**		**HO1/HO2 vs non**	
		mean	*SE*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
	Dense acrocarpous moss cover	1.27	0.50	0.08	0.08	0.95	0.38	0.03	*
	Dense acrocarpous moss frequency	6.06	1.55	1.06	0.82	4.70	1.23	0.01	*
	Bare ground - disturbed cover	0.63	0.32	1.03	0.61	0.74	0.28	0.57	n.s.
	Bare ground - disturbed cover frequency	3.56	1.74	6.22	3.19	4.29	1.52	0.48	n.s.
	Bare ground - undisturbed cover	1.69	0.51	0.56	0.25	1.38	0.39	0.06	n.s.
	Bare ground - undisturbed frequency	11.00	2.01	7.67	3.00	10.09	1.67	0.38	n.s.
	Bryophyte cover	9.19	4.15	8.64	4.65	9.04	3.22	0.93	n.s.
	Bryophyte frequency	13.13	1.62	11.83	3.43	12.77	1.46	0.74	n.s.
failed	*Deschampsia flexuosa* cover	0.08	0.08	0.00	0.00	0.06	0.06		
	Deschampsia flexuosa frequency	0.38	0.22	0.00	0.00	0.27	0.16	0.11	n.s.
	Dung frequency	5.63	1.48	6.67	1.93	5.91	1.18	0.68	n.s.
	Dwarf-shrub cover	50.15	4.00	28.93	8.09	44.36	4.10	0.05	*
	Dwarf-shrub frequency	19.50	0.32	17.00	1.65	18.82	0.54	0.19	n.s.
	Dwarf-shrub species at least frequent	2.44	0.16	2.17	0.31	2.36	0.14	0.46	n.s.
	Dwarf-shrub species richness	3.93	0.44	2.50	0.43	3.55	0.36	0.03	*
	Dwarf-shrub structure – building	78.56	0.00	75.45	0.00	77.71	0.00	0.76	n.s.
	Dwarf-shrub structure – dead	2.76	0.00	0.32	0.00	2.10	0.00	0.01	*
	Dwarf-shrub structure – degenerate	4.25	0.00	0.39	0.00	3.20	0.00	0.22	n.s.
	Dwarf-shrub structure – pioneer	14.43	0.00	23.84	0.00	16.99	0.00	0.35	n.s.
failed	Erosion cover	0.07	0.07	0.00	0.00	0.05	0.05		
	Exotics species cover	0.04	0.03	0.00	0.00	0.03	0.02	0.23	n.s.

Transfor-mation	**Attribute**	**HO1/HO2**		**non-HO1/HO2**		**ALL**		**HO1/HO2 vs non**	
		mean	*SE*	*mean*	*SE*	*mean*	*SE*	*p.*	*sig.*
	Exotics species frequency	0.69	0.31	0.00	0.00	0.50	0.23	0.20	n.s.
	Graminoid species at least occasional	2.88	0.34	2.5	0.67	2.77	0.30	0.63	n.s.
	Graminoid species richness	3.05	0.242	3.17	0.60	3.41	0.23	0.62	n.s.
1/(x+1)	Lichen cover	1.77	1.51	0.01	0.01	1.29	1.10	0.96	n.s.
	Lichen frequency	4.25	1.14	0.50	0.50	3.23	0.91	0.06	n.s.
	Litter cover	2.98	0.78	3.01	1.55	2.99	0.69	0.99	n.s.
	Molinia caerulea cover	38.51	489	38.84	11.11	38.60	4.52	0.98	n.s.
	Molinia caerulea frequency	19.31	0.44	16.50	3.30	18.55	0.94	0.44	n.s.
	Nardus stricta cover	0.00	0.00	0.00	0.00	0.00	0.00	0.33	n.s.
1/(x+1)	*Nardus stricta* frequency	0.19	0.14	0.00	0.00	0.14	0.10	0.17	n.s.
	Negative species cover	0.57	0.35	0.91	0.75	0.67	0.32	0.70	n.s.
	Positive species at least occasional	1.50	0.39	2.17	0.87	1.68	0.36	0.50	n.s.
	Positive species richness	3.19	0.58	3.00	0.97	3.14	0.48	0.87	n.s.
	Pteridium aquilinum cover	3.05	2.36	0.00	0.00	2.21	1.72	0.22	n.s.
	Pteridium aquilinum frequency	2.56	1.23	0.00	0.00	1.86	0.92	0.23	n.s.
	Rubus spp frequency	0.50	0.20	0.83	0.65	0.59	0.22	0.64	n.s.
ln(x+1)	*Rubus* spp. cover	0.02	0.01	0.10	0.08	0.04	0.02	0.37	n.s.
	Schoenus nigricans cover	0.00	0.00	2.83	2.80	0.77	0.76	0.36	n.s.
	Schoenus nigricans frequency	0.13	0.13	1.28	1.09	0.44	0.31	0.34	n.s.
	Sphagnum spp. cover	9.40	1.86	1.95	0.91	7.37	1.54	0.00	**
	Sphagnum spp. frequency	11.81	1.01	5.69	2.56	10.14	1.14	0.01	*
	Trees/scrub cover	4.73	1.99	6.35	3.89	5.17	1.75	0.72	n.s.
	Trees/scrub frequency	10.00	1.48	9.00	2.94	9.73	1.31	0.74	n.s.
	Ulex europaeus cover	0.94	0.46	5.35	4.10	2.15	1.18	0.33	n.s.
	Ulex spp. cover	1.06	0.58	14.59	6.23	4.75	2.10	0.00	**
	Ulex spp. frequency	2.31	0.75	8.33	3.11	3.95	1.12	0.11	n.s.