Natural England Research Report NERR002

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The condition of lowland heathland: results from a sample survey of non-SSSI stands in England

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Published on 28 September 2007

ISSN 1754-1956

Project details

This report results from research commissioned by Natural England in order to provide information on the condition of non-SSSI heathlands in England. The work was undertaken by Just Ecology Limited under English Nature contract FST 20-32-064 and Defra project MA01040.

A summary of the findings covered by this report, as well as Natural England's views on this research, can be found within Natural England Research Information Note RIN002: The condition of lowland heathland: results from a sample survey of non-statutory stands in England.

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Acknowledgments

Thanks go to Richard Alexander, Brian Crumley and Louise Amos (Natural England) for their help with supply and initial processing of the GIS data; Nigel Symes (RSPB) for the supply of the HEAP polygons and participating in the Steering Group; and Simon Smith (Natural England) for agri-environment agreement boundaries and ownership information. Thanks to Mark Crick (JNCC) and Keith Porter for participating in the Steering Group for this project.

The project was jointly funded by English Nature (now Natural England) and Defra with additional assistance from the RSPB and JNCC.

Summary

Lowland Heathland is a Priority Habitat for conservation under the UK Biodiversity Action Plan (BAP). This Action Plan aims to arrest loss of lowland heathland habitat, improve the condition of existing heathlands and to create new areas of lowland heathland.

A random sample of English non-SSSI lowland heathland stands, both inside and outside of agri-environment agreements, was surveyed during 2005 and 2006 to provide baseline information on condition. This information complements similar condition data routinely collected for all statutory heathland sites and both will be used to monitor progress towards the achievement of the BAP targets.

Methodology

Sites were selected from the Lowland Heathland Inventory (LHI) and the RSPB's Heathland Extent And Potential (HEAP) dataset. The final accepted sample contained 104 stands.

The sampled heathland stands were widely distributed, representing the full geographical spread of the non-statutory heathland population in England.

Approximately equal numbers of sites were selected from within agri-environment agreements including Environmentally Sensitive Areas (ESA), the Countryside Stewardship Scheme (CSS) and the Wildlife Enhancement Scheme (WES) and outside of such agreements (although only 22% of sites in the total population were under agreement). However, it was not known in all cases which options applied within the agreements (ie sites did not always have heathland options).

An adapted version of the Common Standards for Monitoring (CSM) methodology and field form was used. A range of structural and species composition attributes were recorded and assessed against generic targets.

A second set of targets was also used, based mainly upon those suggested for species-poor sites within the heathland CSM guidance.

The BAP definition of heathland applied was fairly broad and the stands selected for survey ranged from heaths with a high cover of dwarf shrub species, to those with such species only scattered throughout. (However non-heathland habitats including extensive stands of grassland, bracken or scrub woodland without significant amounts of dwarf shrubs were excluded.)

Further information was recorded at the stand level, including on management activities and related attributes.

Results

No stand passed all attribute targets (either standard or species-poor sites CSM targets) and hence none could be considered to be in favourable condition. Stands passed an average of 69% of standard CSM targets and 73% of the species-poor sites CSM targets.

Even when less stringent targets developed for the Higher Level Stewardship (HLS) Scheme were applied, less than 5% of the dry heathland sample was considered to be in favourable condition (although this figure rose to 43% if the targets for dwarf shrub structural diversity were excluded).

The results showed relatively low pass rates for a wide range of attribute targets. A high proportion of dry heathland stands (41%) failed to even meet the basic target of 25-90% cover of dwarf shrubs and

many failed targets for cover of such species as *Rubus* species, *Pteridium aquilinum* and other negative indicators.

Though there was no effect on condition assessment overall, individual pass rates were higher for species-poor sites CSM targets than for the standard targets. In particular, graminoid diversity pass rates rose from 42% to 98%, desirable forb pass rates from 32% to 57%, and dwarf shrub diversity rose from 42% to 91% and 69% using the two options for species-poor sites targets respectively (at least two species occasional or at least one species frequent). Increasing the proportion of dwarf *Ulex* and *Genista* species allowable within the dwarf shrub component of the sward from 50% to 60% had little effect on pass rates for this attribute.

In wet heaths, attribute targets were often not met most notably due to low cover of dwarf shrubs (38% pass rate), and too high frequency of *Molina caerulea* (13% pass rate). Pass rates were also low for frequencies of desirable forbs (38%) and graminoid diversity (13%).

The use of species-poor sites CSM targets for dwarf shrub diversity and frequency of *Molinia caerulea* had no effect of pass rates in wet heaths. The pass rate for a revised target for *Molinia caerulea* cover was 29%, but had no impact on the overall pass rate for the species overall. The desirable forbs target increased pass rates from 38% to 63% in wet heaths, when using the species-poor CSM option.

Stands greater than 8 ha in size tended to have a wider range of dwarf shrub species present, which occurred at higher frequency, than in smaller stands.

Nearly a third of the sites in the sample were managed for conservation purposes (by scrub control, grazing, heather mowing/cutting, burning and bracken management), most frequently within agri-environment agreements. Many were used for various forms of recreation (38%).

Both within and outside of agri-environment schemes, ‘publicly’ owned land was more likely to receive some kind of conservation management. Both ‘public’ and private land was more likely to receive conservation management if it was within an agri-environment scheme.

Discussion

The pass rate of 0% compares to 17% for UK SSSI heathlands (Williams 2006), though there may be differences in the way in which CSM has been applied in the two datasets, both in terms of stand selection and target setting.

Agri-environment agreements appeared to facilitate positive conservation management, though such positive action was not restricted to agreement stands. However, the interpretation of differences between agri-environment groups was limited by the coarseness of the agreement groupings used and by the lack of detailed information on length of time under agreement. Public ownership of land was also associated with greater levels of conservation management. Such management may, overtime, lead to recovery towards good/favourable condition.

The source inventories were found to contain some significant areas of non-heathland habitat. Conversely, heathland habitat was thought to extend beyond areas covered by the inventories.

The application of rigid statutory targets may not be wholly appropriate for non-statutory stands, particularly given the huge variety of heathland types within the sample and the broad inclusion criteria.

Recommendations

Review and update of the Lowland Heathland Inventory and the Heathland Extent And Potential dataset.

Review the CSM heathland guidance, in particular the dwarf shrub targets, the frequency/cover of *Molinia caerulea* in wet heaths, the number of forb and graminoid species required and the convenience of adding further negative indicators. (Potential revised targets are discussed further in the report.)

Repeat this survey at regular intervals, possibly with the rolling addition of new sites, to enable proper assessment of BAP targets.

Target agri-environment initiatives to lowland heathland sites and seek to increase uptake of agreements and to ensure that options are appropriate for heathland maintenance and restoration.

Consider a program for the designation of more lowland heathland sites.

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List of acronyms

Acronym	Full Name
BAP	Biodiversity Action Plan
CSM	Common Standards for Monitoring
CSS	Countryside Stewardship Scheme
DSH/O	Dwarf Shrub Heath/Other
EN	English Nature
ESA	Environmentally Sensitive Area
HEAP	Heathland Extent And Potential
HLS	Higher Level Stewardship
JNCC	Joint Nature Conservation Committee
LHI	Lowland Heathland Inventory
RDS	Rural Development Service
RSPB	Royal Society for the Protection of the Birds

1 Introduction

Background

1.1 This project concerns Lowland Heathland, which has been identified as a Priority Habitat for conservation on the UK Biodiversity Action Plan (BAP) and for which there is a costed Habitat Action Plan (HAP) (UK Steering Group 1995). This Action Plan aims to arrest loss of lowland heathland habitat, improve the condition of existing heathlands and to create new areas of lowland heathland. Heathlands may be threatened by agricultural improvement, lack of grazing, scrub invasion, or urban development. However, many heathlands are under agri-environment agreements, many of which aim to protect them from such factors. There is a need for monitoring work to determine whether heathlands are still being lost, to gather information on the condition of remaining heathlands, and to provide information on the role of agri-environment agreements in meeting BAP targets. In particular, information is required on the extent and condition of heathland habitat on non-statutory sites (those not under national conservation designations particularly Sites of Special Scientific Interest (SSSI)).

1.2 English Nature (EN), the Rural Development Service (RDS) (both organisations are now Natural England), the Royal Society for the Protection of Birds (RSPB) and the Joint Nature Conservation Committee (JNCC) commissioned this project, with additional funds from the Department for Environment, Food and Rural Affairs (Defra), which focused on existing non-statutory heathlands.

1.3 The project aimed to survey a sample of non-statutory lowland heathland sites throughout England, both inside and outside of agri-environment (AE) agreements. The data obtained will be used to provide baseline information on the condition and extent of a sample of heathlands. This information will complement the records for statutory heathland sites and both will be used to monitor progress against UK BAP targets. A similar study has already taken place on BAP priority habitat lowland grasslands in England (Hewins and others 2005).

Habitat definition

1.4 The revised definition for the Lowland Heathland BAP priority habitat is as follows:

- “Lowland heathland is a broadly open landscape on impoverished, acidic mineral and shallow peat soil, which is characterised by the presence of plants such as heathers and dwarf gorses. It is generally found below 300 metres in altitude in the UK, but in more northerly latitudes the altitudinal limit is often lower. Areas of heathland in good condition should consist of an ericaceous layer of varying heights and structures, plus some or all of the following additional features, depending on environmental and/or management conditions: scattered and clumped trees and scrub; bracken; areas of bare ground; areas of acid grassland; lichens; gorse; wet heaths, bogs and open water.
- Lowland heathland can develop on drift soils and weathered flint beds over calcareous soils (limestone or chalk heath). Lowland heathland is a dynamic habitat which undergoes significant changes in different successional stages, from bare ground (eg after burning or tree clearing) and grassy stages, to mature, dense heath. These different stages often co-occur on a site.
- The presence and numbers of characteristic birds, reptiles, invertebrates, vascular plants, bryophytes and lichens are important indicators of habitat quality.”

1.5 This heathland definition does not mention a minimum dwarf shrub cover. The CSM guidance indicates that it has to have at least 25% to be considered a heathland. However, the guidance for the selection of SSSIs indicates that “to be considered as a heathland site, an area should

have at least 10% cover of heather *Calluna vulgaris*" (NCC, 1989). For this project we considered heathland as having dwarf shrub present.

Lowland Heathland UK BAP targets

1.6 A costed Habitat Action Plan was produced for lowland heathlands in 1995 (UK Steering Group 1995) setting targets for conservation and restoration of this habitat in the UK. In 2006 the targets were revised as follows:

T1. To maintain the current extent of all existing lowland heathland.

T2. To maintain the area of lowland heathland currently in favourable condition.

T3. To improve the condition of lowland heathland on sites currently in unfavourable condition.

T4. To increase the extent of lowland heathland by 7,600 ha by 2015.

T5. To increase the number of heathland patches over 30 ha from 10% of the total resource to 50% by 2030.

1.7 These targets apply to both designated and non-designated sites. This report relates in particular to T1, by updating the information we have on the current extent and distribution of lowland heathland sites; and T2 and T3, by providing a way to measure habitat condition.

Agri-environment schemes

1.8 Heathlands have been targeted for management under several agri-environment schemes run by Defra/RDS and English Nature:

1.9 The Environmentally Sensitive Areas (ESA) Scheme was introduced in 1987 to offer incentives to adopt agricultural practices which would safeguard and enhance defined areas of the country of particularly high landscape, wildlife and historic value. Farmers signed up to 10-year management agreements, receiving an annual payment on each hectare of land entered into the scheme together with payments for capital items. Twenty-two ESAs were designated in England, covering some 10% of the agricultural land area. Of these, two contained significant areas of lowland heathland: Breckland and West Penwith.

1.10 The Countryside Stewardship Scheme (CSS) was a targeted agri-environment scheme available to farmers and land managers in the wider countryside. Like the ESA Scheme, it involved 10-year agreements to manage land in an environmentally beneficial way. Unlike in the ESAs, entry to the scheme was competitive, with priority given to applications that addressed priorities set at the local scale.

1.11 Its objectives were to:

- sustain the beauty and diversity of the landscape;
- improve and extend wildlife habitats;
- conserve archaeological sites and historic features;
- improve opportunities for countryside enjoyment;
- restore neglected land or features; and
- create new habitats and landscapes where appropriate.

1.12 The Wildlife Enhancement Scheme (WES) was a voluntary scheme for SSSIs to enable site managers to manage the land in a wildlife friendly way (English Nature 2003). Under WES, land managers were paid for positive management on SSSIs. WES used simple agreements and

standard payments for annual management (such as grazing, hay cutting or water level management) and capital works (such as hedge laying, tree planting or creating scrapes).

2 Methodology

Site selection

2.1 The site selection process is summarised below:

Source datasets

2.2 Two main datasets were used to define the whole known population of Lowland Heathland polygons in England. These were:

- The Lowland Heathland Inventory (LHI) (English Nature/RSPB 1994). This inventory was obtained from English Nature in GIS form. It contained a total of 3,615 attributed polygons.
- A sub-set of the RSPB's Heathland Extent And Potential (HEAP) database. This consisted of 3,380 polygons identified by searches of recent aerial photographs targeted within a heathland soil mask developed for England (which includes podsols, acidic sandy drifts and shallow peat over old rocks, all below 250 m altitude). The polygons were not attributed, except with area (in ha).

2.3 Combined, these two data sources cover an area of 111,600 ha (including SSSI areas) and overlap by an area of 38,350 ha (34%).

2.4 The following additional GIS datasets were provided by RDS and English Nature to investigate whether heathlands were inside or outside of agri-environment agreements:

- RDS's Environmentally Sensitive Areas (ESA);
- RDS's Countryside Stewardship Scheme (CSS); and
- English Nature's Wildlife Enhancement Scheme (WES).

2.5 All three datasets contained boundaries for agreements in place up to March 2005 and were not updated during the life of the project. However, it should be noted that the lack of detailed information on most of these agreements may have resulted in sites being included in the agri-environment group when the tiers/options involved were not specifically related to heathland management (para. 3.10).

GIS processing

2.6 The LHI was used as the primary data source, though any HEAP polygons (or parts of) not covered by the LHI were also included. Any areas which were within SSSIs were removed. Resulting 'slivers' (<0.2 ha and <2% of their original area) were also removed. All remaining heathland polygons were then attributed by data source (HEAP or LHI), Local Authority area and Government Region, as well as agri-environment agreement uptake data (including whether the site was completely or partly within agreement). (Polygons with <0.5 ha within an agreement category were rejected from that category.)

2.7 Initially 140 polygons were randomly selected from this dataset, stratified to give equal numbers (70) with >0.5 ha of their area within and outside of agri-environment agreements. (When polygons were partly in agreement they were included in the population for both agreement categories.) Note that due to later rejection of relatively large numbers of sites, it was necessary to draw an additional 207 sites from the sample (see 3.3.7).

The 'whole population'

Population size

2.8 There was a total of 5,315 polygons in the non-statutory heathland population layer, covering a total of 33,680 ha. However, the number of polygons was refined to 4,397 (33,636 ha) once the most obvious slivers created by the SSSI cut were removed. Polygons were then overlain with agri-environment agreement boundaries and the area of each within and outside of agreement was calculated.

2.9 This 'refined population' contained 831 polygons which contained >0.5 ha of heathland in agreement and 2,533 polygons with >0.5 ha of heathland outside of agreement. Of these, 319 contained sufficient land in both agreement categories. The total number of 'sample-able' polygons was therefore 3,045.

Data source

2.10 Of the refined set of 4,397 polygons, approximately equal numbers originated from LHI (2,090; 48%) and HEAP (2,307; 52%). Further examination of the data revealed that there was a similarly equal split when only sample-able[1] polygons were included. However, the HEAP polygons tended to be smaller in area – the total area covered by HEAP polygons was 9,560 ha (28%), whilst that covered by the Lowland Heathland Inventory polygons was 24,076 ha (72%). (The relatively high numbers, but small areas of HEAP polygons may in part be due to exclusion of parts of HEAP polygons which overlapped with the LHI.)

Polygon area

2.11 The average polygon size in the refined non-statutory heathland population was 7.65 ha, with polygons ranging from tiny digitising errors to 1,172 ha (Figure 1). Most heathland polygons were <10 ha in area and many (1,313) were <0.5 ha and were probably the result of digitising discrepancies between SSSI boundaries, HEAP polygons and the Lowland Heathland Inventory beyond those which were removed by the sliver removal procedures described above. However, such sites were not of sufficient size to be included in the field sample and hence were of little consequence. The average area of the 3,045 sample-able polygons (>0.5 ha) was 10.9 ha, with survey-able[2] areas (ie areas within the selected agreement category) averaging 9.9 ha.

2.12 Of the refined non-statutory heathland population, only 6% of polygons were >25 ha. Of the 3,045 sample-able polygons, 9% were >25%. Of the survey-able areas, 8% were >25 ha. However, it should be noted that in the case of LHI derived polygons, this is the site size, and not necessarily the size of the actual heathland patch.

[1] Sample-able polygons: LHI + HEAP – SSSI – Slivers >0.5 ha.

[2] Survey-able polygons: as above but with >0.5 ha within either agri-environment category (in or out).

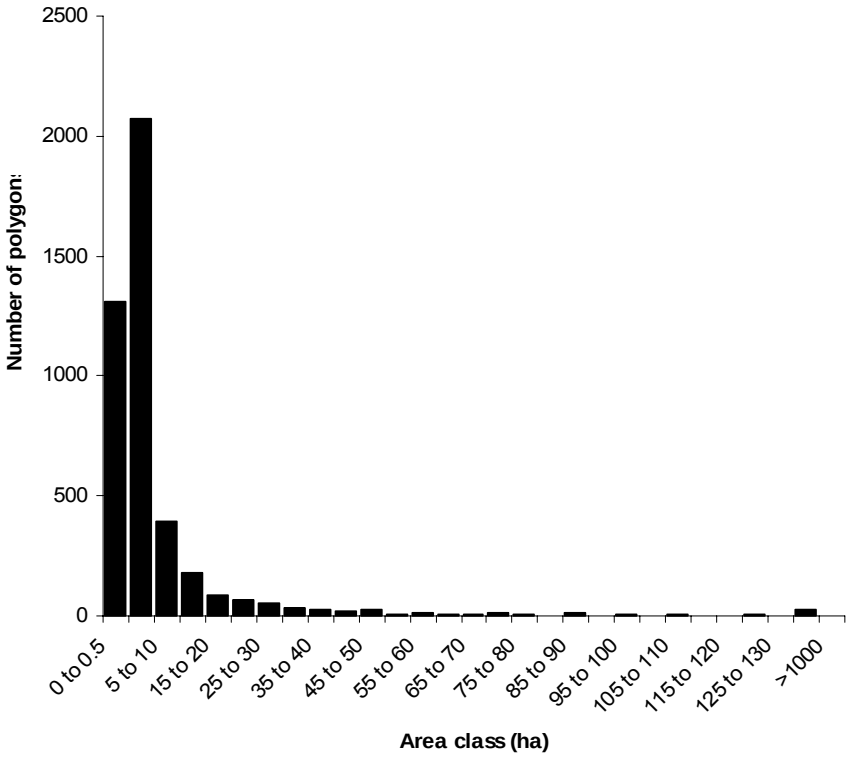


Figure 1. Frequency distribution of polygons by size classes for the refined non-statutory heathland population

Regional distribution

2.13 Figure 2 shows the distribution of the refined non-statutory heathland population by English Government Office Regions. Non-statutory heathlands were concentrated in the South West. This may in part be due to the efforts to improve habitat inventories through the NBN South-West Partnership Pilot project. The distribution of sample-able sites was similar.

Agreement status

2.14 In total, 7,406 ha (22%) of non-statutory heathland was within some type of agri-environment agreement, whereas the majority, 26,223 ha (78%), was not under agreement. (A similar split was seen when only sample-able polygons were examined.) This difference may partly reflect the fact that many heathlands that are under agri-environment agreements may also be within SSSIs and hence have been removed from the population sampled in this survey.

2.15 The majority (66%) of agreement heathland polygons were in the Countryside Stewardship Scheme, followed by the Environmentally Sensitive Area Scheme (21%) and the Wildlife Enhancement Scheme (3%). A minority of polygons (10%) were in a combination of schemes.

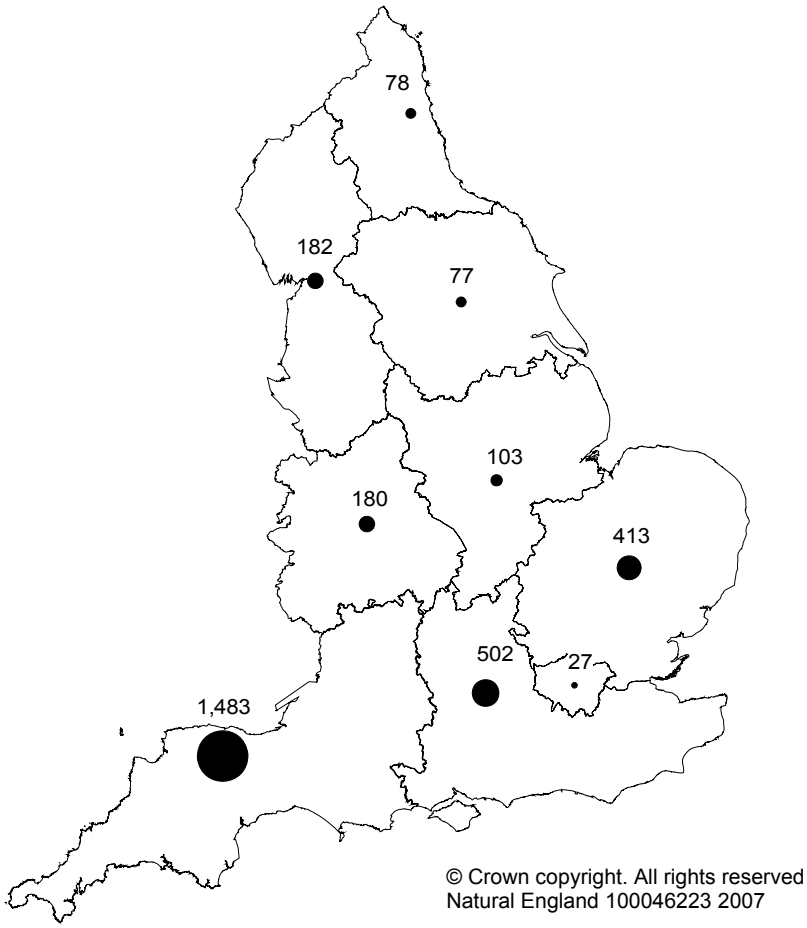


Figure 2. The distribution of the refined non-statutory heathland population polygons by English Government Office Regions

Power analysis

2.16 For a similar survey of non-statutory grasslands, based primarily on a similar English Nature Habitat Inventory, Poulton (2000) applied a power analysis to estimate an appropriate sample size for the survey. This was based on population size, confidence level (95%), a confidence interval and an expected 'measured percentage'. The measured percentage is the proportion of sites in which a specified change takes place between the first and second monitoring visit (eg 25% of sites are destroyed, or 5% of sites come into favourable condition). For example, this approach indicates that if a sample of 100 is taken from a population size of 1,000, a measured change in 50% of the sample means that a similar change in the wider population will occur on between 40.7% and 59.3% of sites, and this can be said with 95% confidence.

2.17 Because this power analysis is based on a distribution curve which peaks at a measured percentage of 50%, it is most difficult to be sure of answers when the measured percentage is 50%. Also, because the distribution curve is not symmetrical, the confidence limits are also only symmetrical about the measured percentage at a measured percentage of 50%. For these reasons, the sample size should usually be determined using measured percentages of 50%, as this is the 'worst case'; if other measured percentages occur in the sample (ie measured changes which are more or less than 50%), the change in the wider population can be inferred with even greater confidence.

2.18 The confidence intervals used in this report were those available from the ready-reckoner available at www.surveysystem.com. (However, it should be noted that this website simplifies the

interval to be symmetrical about the measured percentage. This is only correct if the measured percentage is 50%.)

Choice of population size for power analysis

2.19 A number of population size options were available, each from a different stage of the GIS processing described in paras. 2.6 and 2.7. The best choice was the 'sample-able' population, ie all polygons of >0.5 ha of a single agreement category. This population was estimated to be 3,364. The largest population size available from the GIS processing is that of the original (pre-processing) non-statutory heathland population layer, which was 5,315.

2.20 It was not known whether these population estimates were under- or over-estimates. It was possible that some heathlands had been destroyed since the Inventory was compiled, or that the Inventory, even with the addition of HEAP polygons, may have missed some heathland. If the inventories under-estimated the real heathland population, confidence intervals may also be under-estimated by power analysis, and correspondingly, if the inventories over-estimated the real heathland population, confidence intervals may be over-estimated. However, investigation showed that relatively small variations in population size had relatively little impact on the choice of sample size required.

Application

2.21 When a power analysis was applied to a population size of 3,364, with a 95% confidence level and ±10% confidence interval, a total sample of 93 was needed in the worst case (ie when the measured percentage is 50%). (Only 1 more site, ie a sample of 94, was needed if the population size was estimated to be 5,315.) If the measured percentage was actually only 20% (ie, as seems more likely, sites change less), the confidence interval for a sample of 93 may be improved to ±8%. This sample size is close to the sample of approximately 100 made for each lowland BAP grassland type under a separate contract (Hewins and others 2005).

2.22 A sample of 100 heathlands was therefore recommended for this project. A total of 348 polygons were selected from the population for possible survey in order to make the sample up to 100, taking into account rejections for various reasons (paras. 2.59 and 2.60).

Mapping and choice of survey area

2.23 The selected sites were mapped using (a) 1:10,000 Ordnance Survey data and (b) aerial photographs. These maps were then closely examined, and any sites which obviously and definitely did not contain heathland were rejected (ie those with dense mature woodland, housing or garden). However, it should be noted that a 'worth a go' approach was adopted for field visits, in order to avoid biasing the sample towards only clearly visible (and hence probably good condition) heathlands.

2.24 Any polygons which fell within the original Defra 'Moorland Line' were also rejected as likely to refer to upland heathland or other upland moorland habitats. This line encloses semi-natural moorland habitats in the Less Favoured Area (LFA) (ADAS 1993). These are generally above 250-300m altitude and/or above the upper limit of agricultural enclosure. An artefact produced by the combination of different datasets was further GIS processing slivers, though many of these were also rejected.

2.25 Because of mapping errors within the HEAP layer in particular, the maps were also examined in order to suggest boundary modifications to the selected polygon before survey. It was considered acceptable for a survey to be carried out on a wider area than the selected polygon, as long as it fell within the boundaries of either the whole LHI or HEAP population (or both); though sampling outside of the limits of the known habitat population was not allowed. For example, if a HEAP sliver that was left over from the combination of the HEAP and LHI layers was selected, it was acceptable to instead survey the underlying LHI polygon. Also, if a HEAP (or LHI) polygon was selected but aerial photographs showed that this was simply poorly placed, the survey could be carried out on the probable target area as appropriate. This allowed the results of this survey to be extrapolated to the wider population, but without sampling from outside it.

Field survey

2.26 Landowners were identified using a combination of agri-environment agreement records, internet and telephone searches and contact with nearby landowners. All landowners were then sent a standard letter and return form with stamped return envelope prior to survey. A copy of this letter is given in Appendix 2. Most landowners were eventually traced and contacted, though access was refused on a total of nine sites and landowners could not be located for a further three sites. In order to secure as many access permissions as possible, landowners were informed that the exact location of the sites would be kept confidential and results reported only in an aggregate fashion. Participating landowners were sent a list of the species recorded during the survey with frequency scores.

2.27 Surveys were carried out between 21 September and 28 October 2005 and 12 May and 24 August 2006. Field survey methodology was broadly based on the Common Standards for Monitoring Lowland Heathland guidance, presented in Alonso and others (2003).

2.28 However, SSSIs have conservation objectives for the features for which they are designated and targets set for relevant attributes. The targets can be tailored to the characteristics of individual sites or heathland areas: for example, on a naturally species-poor site, lower targets might be set for specific attributes eg that just one ericaceous, one graminoid and one forb species need be present. It was not possible to incorporate such flexibility in this project due to the lack of knowledge of sites beforehand. Therefore, application of the CSM method here was more stringent (and consistent) than would necessarily be applied on SSSIs.

2.29 All JUST ECOLOGY surveyors attended a day of in-field training in each field season, in conjunction with steering group members from English Nature and RDS.

Mapping

2.30 Firstly the boundary of the sample stand was mapped, with assistance from a GPS[3] or aerial photograph where necessary. If a stand was >25 ha in area, a pre-determined randomly selected sub-sample was taken. Where more than one heathland type was present, separate stands were surveyed (dry, wet, chalk, dune and lichen), and surveys of separate stands were also necessary if the heathland was split between clearly different management units, or selected for both agri-environment agreement categories. Up to two stands were sampled at any one site.

2.31 Stand mapping was based upon the following guidelines:

- Qualifying habitat included heathland with diverse structural and species composition characteristics (para. 1.4).
- Transitional habitats and ‘close to heath’ habitats were included, when they were considered to be recently degraded heathland.
- Recently degraded heathland included areas which had been over-grazed to acid grassland or developed into young secondary woodland or bracken, (as long as they retained a dwarf shrub element). Sites with dwarf shrubs rare or absent were rejected.
- Areas such as mature woodland or dense scrub with no evidence of a heath-like under-storey, or woodland deliberately left as a site margin, were not included. However, scattered scrub and trees, and blocks of scrub with heathland species present were usually included in the selected stand.
- Fragmented stands were mapped and each fragment sampled as part of a single stand.
- When the stand boundary could not be mapped (eg the heathland was below extensive forestry), then an appropriately sized representative sub-sample was taken.
- The extent of any recently cut or burnt patches was mapped and sampled with the rest of the stand.

[3] WAAS enabled Global Positioning System (for example, the Magellan Meridian GPS Europe or similar).

2.32 The maps also included notes of any features of interest or of relevance to any repeat survey.

Attribute recording

2.33 Once the stand had been defined and mapped on the base map provided in the dossier, a pre-planned 'W-shaped' walk across the stand was made, with stops at 20 regularly spaced intervals. The walk aimed to avoid bias towards any particular aspect of the stand, such as parts in good condition or the edges. The route of the walk was mapped in the field.

2.34 The condition assessment (and other) attributes were estimated using mean cover at walk stops, frequency at walk stops and estimates at the whole stand level.

2.35 Table 1 shows the other information that was recorded for each stand. A minimum of one photograph was taken per site. The data were entered into a specially designed generic field form (given in Appendix 3).

2.36 The attributes which were quantified during the survey are shown in Table 2. The lowest percentage cover value used was 0.1% (representing presence). Some of the attributes were based upon an average value of the percentage cover recorded at each stop.

Attribute definitions

2.37 The following attribute definitions were used:

- Disturbed/undisturbed bare ground: percentage of each category at each stop. Undisturbed bare ground excluded litter and rock, but included bare ground in a mosaic with the vegetation and lightly trampled paths. It included any areas which may have supported newly establishing seedlings, basking reptiles or nesting invertebrates. Disturbed bare ground included poaching, vehicle disturbance and larger paths. They referred to brittle soil which would not support newly establishing seedlings or nesting invertebrates or reptiles.
- *Myrica gale* was considered a dwarf shrub in wet heathlands only.
- Vegetation composition: presence or cover[4] of key species at each stop (within $4m^2$ search area). Other species were added where they were of local or other importance.
- Cover of negative indicator species: species included coarse grasses, but excluded exotic species, tress/scrub, gorse, bracken and acrocarpous mosses, which were recorded separately.
- *Pteridium aquilinum* cover: for sites which were visited in spring/early summer before full frond emergence, a note was made if *Pteridium aquilinum* cover was, in the surveyor's opinion, likely to exceed the 10% target in high summer.

[4] As required (specific to heathland type).

Table 1. Information recorded for each stand

Data/attribute	Comment
Site code	Unique ID from non-statutory heathland layer provided by English Nature
Site name	Site name created as appropriate
Heathland type	Wet, dry (lichen, dune and chalk)
Survey date	
Surveyor(s)	
Time on site (hrs)	
AE status	CSS, ESA, WES, non-agreement
NVC(s) if known	
Area (ha)	
Grid reference	
County	
LHI or HEAP or Both	Overlap of the surveyed stand with the LHI or HEAP heathland inventories
Designations/ownership	If owned by a public body or conservation organisation, or privately, or managed as a nature reserve
Grazing	Signs of management activity
Burning	
Supplementary feeding	
Rolling/chain harrowing	
Bracken management	
Heather cutting (mowing)	
Scrub control	
Weed control	
Functioning artificial drainage	
Recent forest clearance	
Agriculture	+ if the activity had a known positive effect - if the activity had a known negative effect ? if the effect was unknown
Conservation	
Urban	
Recreation	
Infrastructure	
Military	
Mineral extraction	
Forestry	
Water abstraction	
Natural events	
Site description	General description of the site and the stand

Table 2. Attributes and methods of assessment, used in the condition assessment of dry (including chalk, dune and lichen) and wet heaths

Attribute	Method of assessment			Dry	Wet
	% cover (average of stops)	Frequency in walk stops	% cover (whole stand estimate)		
a)Physical					
Undisturbed bare ground (%)	√	X	(√)	√	√
Disturbed bare ground/erosion/poaching (%)	√	X	(√)	√	√
Obvious visible pollution (%)			√	√	√
Silt or leachate			√	X	√
b)Dwarf shrubs					
Dwarf shrubs cover (%)	√*	X	(√)	√	√
Proportion (pseudo)pioneer (%)	√**	X	(√)	√	√
Proportion building/mature (%)	√**	X	(√)	√	√
Proportion degenerate (%)	√**	X	(√)	√	√
Proportion dead (%)	√**	X	(√)	√	√
Dwarf shrub diversity		√		√	√
Proportion with signs of heavy grazing impact	√**	X	X	√	√
c)Vegetation composition					
Frequency of key grass species		√		√	√
Nardus stricta (Frequency and %)	√	√		√	X
Deschampsia flexuosa (Frequency and %)	√	√		√	X
Molinia caerulea (Frequency and %)	X	√		X	√
Frequency of desirable forbs		√		√	√
Bryophytes & lichens (excl Acrocarpous)(%)	√	X		√	X
Carpet forming acrocarpous species (%)	√	X		√	√
Lichens (%)	√	X		√	√
Sphagnum spp.(%)	X	X		X	√
Ulex europaeus cover (%)	√	X		√	√
All trees and scrubs (inc. *Rubus*) (%)	√*	X	(√)	√	√
Dwarf shrub *Ulex (minor/gallii)* and *Genista (anglica/pilosa)* (% of total dwarf shrub cover)	√	X		√	X
Pteridium aquilinum (%)	√	X	(√)	√	√
Rubus spp. (%)	√	X		√	X
Exotic species (%)	√*	X	(√)	√	X
Cover of negative indicator spp. group (%)	√*	X	(√)	√	X

Table continued …

Attribute	Method of assessment			Dry	Wet
	% cover (Average of stops)	Frequency at walk stops	% cover - whole stand estimate		
Other additional non-condition assessment attributes recorded in this survey					
Other species or components of ecological significance, based on surveyor's judgement	X	X		X	X
Total grass cover %			X	X	X
Height of dwarf shrub	X			X	X
Presence of pools			X	X	X

(√) indicates whole stand estimate is not the primary measurement, nor used in the analysis of results, but was sometimes recorded if the surveyor felt that the walk may not have been representative. X indicates data is available, but was not used as part of the condition assessment.

* Estimate based on the sum of the % cover of the individual listed species.

**Percentage of the total dwarf shrub element for which growth stage can be distinguished. Mown mat form dwarf shrub was recorded as both 'pseudo pioneer' and a sign of heaving 'grazing' (including mowing).

Analysis

Classification of stands

2.38 All 104 surveyed stands were given a 'feature status' as follows:

- DSH (Dwarf Shrub Heath) - where the cover of dwarf shrubs exceeded 25% (ie meeting the strictest definition of heathland); or
- O (Other) - where the cover of dwarf shrubs fell below 25%; (ie still considered heathland but in poor condition).

2.39 Survey data also existed for seven post-survey rejected sites:

- X (Rejected post survey) - where dwarf shrubs were absent or very rare (ie not heathland). These stands have been excluded from the data analyses presented in this report.

2.40 Stands were also categorised by ownership (public and private) and size ('large' >8 ha and 'small' <8 ha). Eight hectares was the average polygon size within the original non-statutory LHI/HEAP population. GIS analysis was used to investigate overlap with:

- English Nature Lowland Grassland Inventories (lowland calcareous grassland, lowland dry acid grassland, purple moor grass and rush pasture, upland hay meadow and lowland meadow);
- Open Access Land (including common land).

Additional attributes

2.41 The field data included or were used to derive a number of new attributes, which, though not directly part of the CSM condition assessment, have also been included in the results. These were:

- height of dwarf shrubs (cm) (only available for 2006 stands);
- dwarf shrub diversity (number of species);

- number of dwarf shrub species at least frequent in the sward;
- frequency (number of stops) of any dwarf shrub species;
- total grass cover (%);
- listed graminoid diversity (number of species);
- number of listed graminoid species at least occasional in the sward;
- frequency (number of stops) of *Molinia caerulea*;
- cover (%) of *Molinia caerulea*;
- number of desirable forb species at least occasional in the sward;
- listed desirable forb diversity (number of species);
- frequency (number of stops) of acrocarpous bryophytes;
- cover (%) of acrocarpous bryophytes;
- cover (%) of lichens;
- frequency (number of stops) of lichens;
- frequency (number of stops) of negative species;
- frequency (number of stops) of exotic/non-native species;
- frequency (number of stops) of any listed tree/scrub species;
- frequency (number of stops) of *Pteridium aquilinum*; and
- frequency (number of stops) of *Rubus* species.

Condition assessment

2.42 Data were assessed against the targets given in the Common Standards Monitoring (CSM) guidance (Alonso and others 2003; JNCC 2004). This method was developed to assess the condition of designated sites in a consistent way across the UK.

2.43 In addition, a second, lower set of targets was applied, based largely on those for species-poor sites in the CSM guidance (only one dwarf shrub, one forb, one graminoid required). The effect of adjusting the targets for *Molinia* frequency in wet heaths (to ' frequent' instead of 'occasional') and for cover of *Genista/Ulex* in South West Region (to <75% instead of <50%) was also considered.

2.44 Data were also assessed against the simpler condition targets laid out in guidance for the Farm Environment Plan for the new Higher Level Stewardship (HLS) Scheme (RDS 2005). These consist of a revised subset of just four of the CSM attributes and targets (dwarf shrub cover, dwarf shrub age structure, cover of undesirable species and cover of trees/scrub). They are not split by (wet and dry) heathland type. This methodology was devised to provide information on the condition of habitat and other features proposed for management under HLS. It should be noted that, whilst these targets have been applied to all stands, none were actually under HLS agreement.

2.45 The targets used to assess the heathland in this project are summarised in Table 3. The results presented relate to the standard CSM targets, unless stated otherwise.

Table 3. Condition assessment targets for dry/chalk and wet heathlands, based on the Common Standards Monitoring (CSM) and Higher Level Stewardship (HLS) guidance

F= frequent, O=occasional. Shaded cells for HLS = not assessed with this method. Shaded cells for species-poor site targets = no different from standard CSM targets.

* where these differ from the standard CSM targets.

Attribute	Dry CSM	Wet CSM	HLS targets (wet & dry)	Dry Species-poor sites CSM	Wet Species-poor sites CSM	Comment
Undisturbed bare ground	1-10%		-	*	*	
Disturbed bare ground	<1%		-	*	*	
Heavy grazing impact	<1%		-	*	*	Includes mowing
Trampling/erosion	-	<1%	-	*	*	
Silt or leachate	-	None	-	*	*	
Artificial drainage	-	None	-	*	*	
Obvious visible pollution	<1%	-	-	*	*	
Dwarf shrub cover %	25-90%		25-95%	*	*	
Proportion (pseudo) pioneer	10-40%	All stages present	paras. 2.47 and 2.48	*	*	Mown/grazed mat form heather included as pseudo pioneer.
Proportion building/mature	20-80%			*	*	
Proportion degenerate	<30%			*	*	
Proportion dead	<10%			*	*	
Dwarf shrub diversity	at least 2 F or more		at least 2 F or more	at least 2 O OR at least 1 F or more		
Graminoid diversity	at least 1 F and 2 >O or more		-	at least 1 O or more	*	
Nardus stricta cover	<25%	-	-	*	*	
Deschampsia flexuosa cover	<25%	-	-	*	*	

Table continued …

Attribute	Dry CSM	Wet CSM	HLS targets (wet & dry)	Dry Species-poor sites CSM	Wet Species-poor sites CSM	Comment
Nardus stricta frequency	≤ O	-	-	*	*	
Deschampsia flexuosa frequency	≤ O	-	-	*	*	
Molinia caerulea frequency	-	≤ O	-	*	≤ F OR ≤ 30% cover	*Molinia* could be frequent but not very dense.
Desirable forbs[5]	at least 2 O or more		-	at least 1 O or more		Whole stand
Sphagnum sp.	-	>10% if present	-	*	*	Note that CSM dictates that site specific target should be set for other bryophytes. This attribute has not been used in this project.
Lichens	>5% if present	>5% if present	-	*	*	
Dense acrocarpous mosses	< O		-	*	*	
Ulex europaeus cover	<25%	<10%	-	*	*	
Listed trees & scrub	<15%	<10%	<15%	*	*	Note that additional non-listed species have not been included in this attribute in this project, though their impact if included has been investigated and found not to impact pass rates, except where indicated.
Rubus spp.	<1%	-	-	*	*	
All dwarf *Ulex* and *Genista* cover	<50%	-	-	<60%	*	Includes dwarf shrub *Ulex (minor/gallii)* and *Genista (anglica/pilosa)* spp (% of total dwarf shrub cover).
Pteridium aquilinum	<10%		-	*	*	

Table continued …

[5] Heathland type specific list

Attribute	Dry CSM	Wet CSM	HLS targets (wet & dry)	Dry Species-poor sites CSM	Wet Species-poor sites CSM	Comment
Listed exotics cover	*<1%*		-	*	*	Note that additional non-listed species have not been included in this attribute in this project, though their impact if included has been investigated and found not to impact pass rates, except where indicated.
Negative indicators	*<1 %*		-	*	*	
Undesirable species (bracken, negative indicators, invasive non-native plants) cover	-		<10%	*	*	
Indicators of local distinctiveness	-		-	*	*	Note that CSM dictates that a site specific target should be set. This attribute has not been used in this project.

Dwarf shrub structural diversity

2.46 The proportion of each heather growth stage refers to *Calluna vulgaris*. Note that growth phases were not allocated for *Erica tetralix* or dwarf *Ulex* species as they were usually difficult to determine, nor were they allocated for poorly defined forms of *Calluna vulgaris* and other *Erica* species. Hence the proportion is based only on the cover of the dwarf shrubs for which growth stage could be determined. In some stands, particularly wet heathland dominated by *Erica tetralix* or those dominated by dwarf *Ulex* species, the attribute for dwarf shrub structural diversity may be based on only a small fraction of the total dwarf shrub cover (or in some cases could not be determined). On average, the estimate was based on 70% of the dwarf shrub cover in dry heaths, but only 9% in wet heaths. This difference is statistically significant (t-test, p=0.000).

2.47 The HLS FEP condition target for dwarf shrub structural diversity was: "range of age classes of heather present, with cover of young (pioneer stage) heather between 10-15% and cover of old (mature/degenerate) between 10% and 30%" (RDS 2005). Hence this did not match the CSM targets for dry heath (see Table 3).

2.48 The field data were collected using the CSM methodology and therefore no differentiation was made between mature and building heather, so direct assessment using HLS targets was not possible. However, two assessments of dwarf shrub structural diversity were made, based loosely on HLS targets:

- 'Method A': pioneer heather between 10-15% and degenerate between 10 and 30%.
- 'Method B': pioneer heather between 10-15% and degenerate plus half of building/mature between 10 and 30%.

2.49 Pass rates for HLS targets are reported both including and excluding these structural diversity targets.

Statistical analysis

2.50 A skewness value was calculated for all raw data attributes. Variables with an absolute skewness value of >3 which were successfully transformed[6] (skewness <3), as detailed below:

- Disturbed bare ground cover: 1/(x+1)
- Lichen cover: 1/(x+1)
- Frequency (number of stops) of lichens: log (x+1)
- Proportion of dead *Calluna/Erica*: log (x+1)
- Cover of *Ulex europaeus*: log (x+1)
- Cover of *Rubus* species: log (x+1)
- Cover of negative indicator species: log (x+1)
- Cover of acrocarpous bryophyte species: log (x+1)
- Cover of *Deschampsia flexuosa*: log (x+1)
- Frequency (number of stops) of acrocarpous bryophyte species: log (x+1)

2.51 Note that back-transformed values are generally given within this report.

2.52 The following variables had skewness values of >6 but could not easily be transformed, therefore analyses were not performed on these variables:

- cover of *Nardus stricta*;
- cover of exotic species; and
- frequency (number of stops) of exotic species.

[6] Arcsine transformations were ineffective in many cases.

2.53 Basic statistical analyses were performed. Further analysis including modelling and multivariate analysis would be possible, but are beyond the scope of the current project. Only results significant with $p<0.05$ are shown. The following analyses were undertaken:

- Statistically significant differences in condition assessment pass rates between different agri-environment agreement, size class or ownership categories were tested using Pearson Chi-squared two-way contingency analysis with Yate's Correction applied where there were low degrees of freedom.
- Chi-squared tests were also used to examine differences in distribution of stands between agri-environment agreement, size class, open access or ownership categories.
- T-tests were used to test for statistically significant differences in raw attribute data between groups.
- Pearson correlation analyses, with Bonferroni probabilities, were used to test for significant correlations between attributes.

2.54 All analysis was performed using Systat v8.0 and data stored and manipulated in MS Excel 2003.

2.55 The electronic datasets supplied with this report are listed in Appendix 4.

Data sources

2.56 Table 4 shows the primary source dataset for the selected sites, showing whether the site contains heathland or not, where known (determined either by site visit, talking to landowners, or from aerial photographs). It should be noted that this does not show if the two data sources overlap, nor sites for which for the presence of heathland is not known but were still rejected from the sample on other grounds (and hence cannot be used as a direct measure of inventory accuracy).

Table 4. The number of sites containing heathland (if known) for each primary data source

Site type	Primary data source		Total
	HEAP	LHI	
Not heathland	77	70	**147**
Heathland	44	53	**97**
Total	121	123	**244**

2.57 There were approximately equal numbers of polygons sources from the LHI and HEAP inventories, which is representative of the whole population (section 2.8 - 2.15). Table 4 suggests that there are no major differences in the capacity of the two data sets to represent the real distribution of heathland in England and both datasets contained sites which did not meet the definition of heathland used in this project. Furthermore, of the 104 actual heathland stands in the final sample, approximately equal numbers (24 and 29) were covered by the LHI or HEAP inventories alone respectively, whilst the remainder (51) were covered by both inventories. This suggests that whilst some heathland is picked up by both inventories, other areas are only covered by only one data source and combination of the two data sources provided the best means of ensuring that heathland was not missed. However, the inclusion of significant areas of non-heathland habitat is an issue with both inventories.

2.58 Anecdotal evidence from surveyors also suggested that both inventories also miss or only partly cover areas of heathland in the wider countryside.

Site rejections

2.59 During the course of the project, a total of 348 sites were selected from the 'survey-able' population of 3,045 polygons. Ninety-eight of these were surveyed and accepted into the final sample (covering a total of 104 stands). Table 5 shows details of the remaining 250 sites selected from the 'survey-able' sample, which were later rejected. This confirms that there were significant numbers of sites within the LHI/HEAP datasets which were found not to support heathland habitat and that there was considerable overlap with the upland environment. Of the 37 sites rejected as being in the Moorland Line, 32 were in Cornwall, particularly on Bodmin Moor which is generally regarded as upland. The remainder comprised two in Durham and one each in Northumberland, Lancashire and Somerset. Other (more methodological) rejections occurred as a result of the initial data processing methodology applied in this project, particularly due to SSSI slivers, or the requirement for heathland to fall within a particular agri-environment agreement category. Finally, some sites were rejected because landowners could not be identified or refused access permission. The project steering group advised on rejecting sites at the mapping stage.

2.60 The overall rejection rate was 72% of selected sites, though only 32% of sites were rejected for purely ecological (rather than methodological) reasons. It is probable that these rejection rates might have been lower if SSSI land was included, as it is expected that particularly the LHI would be more accurate within SSSIs (which have more available supporting ecological information) and heathland within both LHI and HEAP may be better quality within SSSIs.

Table 5. The number of sites rejected at each stage of the project

Showing whether the sites were selected for the agri-environment agreement sample (AE) or the non agreement (Non-AE) sample.

Stage	No. of sites			Details
	All	AE	Non-AE	
Mapping stage rejection (including aerial photograph interpretation)	1	Details not available		Digitising error
	37			Inside moorland line
	22			No heath in correct AE category
	12			Rush pasture
	35			SSSI sliver
	11			Grassland
	15			Area of heathland too small
	11			Dense bracken and/or scrub
	17			Not heathland (unspecified)
	8			Plantation
	5			Replicate polygon in inventory (Error within HEAP layer – two complete overlapping polygons)
	1			Access difficulty
	12			Woodland
	187	**84**	**147**	**Sub-total**
Rejected prior to visit	9	5	4	Access refused
	7	3	4	Landowner said not habitat
	3	0	3	Owner not traced
	19	**8**	**11**	**Sub-total**
Rejected on site	37	22	18	Varying non-heath habitats particularly bracken, scrub, rush pasture, woodland, tall herb and grassland
Rejected post survey	7	5	2	Dwarf shrubs were present, but rare. Survey was carried out, but later rejected
Total	**250**	**119**	**178**	

3 The sample

Stand details

3.1 Figure 3 shows the distribution of the surveyed stands. There was a wide geographic spread, with a large representation of stands in the south-west of the country (stands in Cornwall made up 29% of the un-rejected sample). This is comparable with that in the wider population (para. 2.13 and Figure 2).

3.2 Table 6 shows the number of stands surveyed by heathland type, agri-environment status and heathland feature. Details of these stands may be found in Appendix 4. In total seven stands were rejected post-survey, these are included in Appendix 4, but have been excluded from all other analyses. Of the 104 stands in the sample (from 98 sites), the majority (96) were dry heathland, leaving only 8 wet heathland stands.

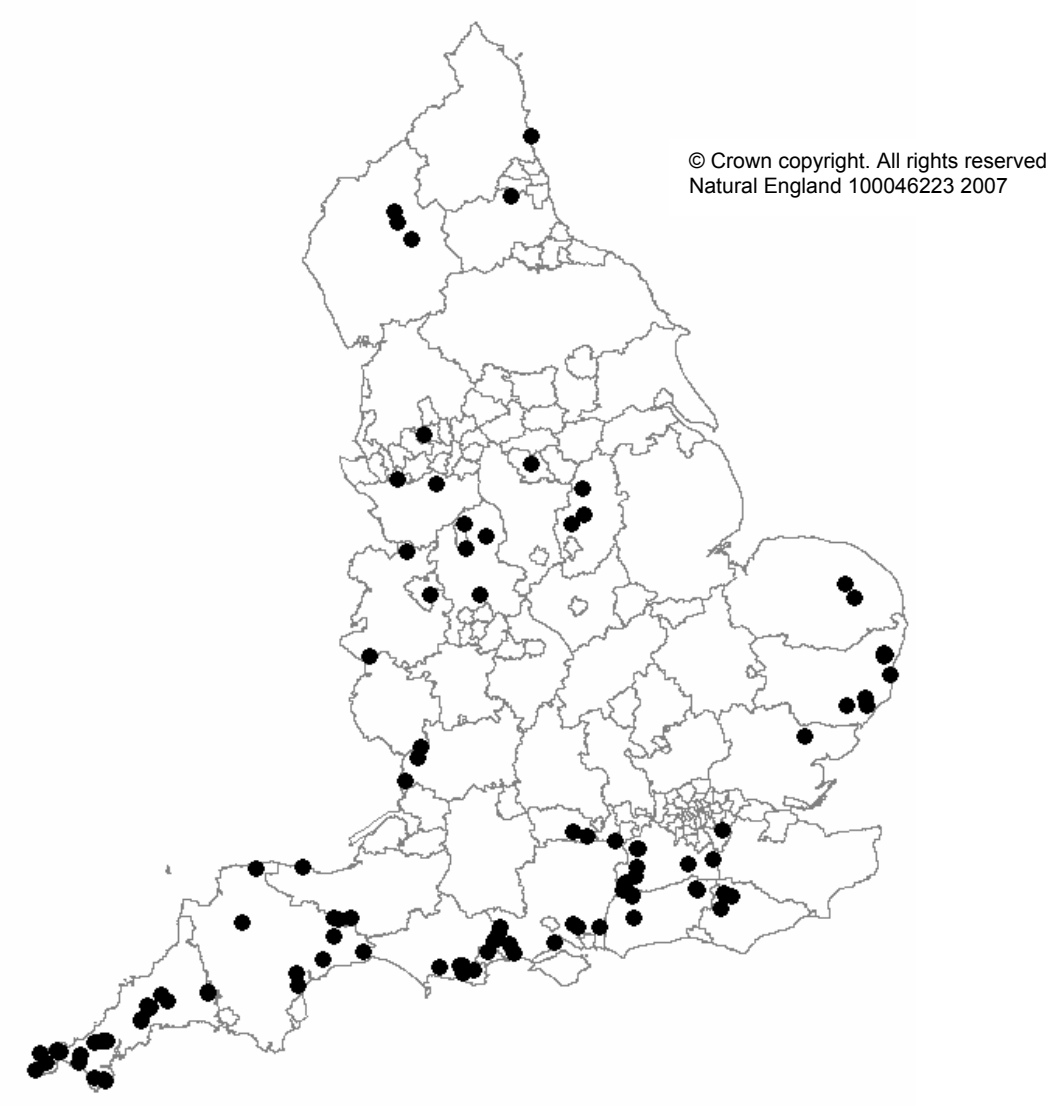


Figure 3. Distribution of the stands

3.3 Forty-six stands were under agri-environment agreements. As in the wider population (para. 2.15), CSS was the most frequent agri-environment scheme in the sample (38% of stands). Eleven percent of stands were in ESA agreements whilst only one was in a WES agreement

(which extends into the neighbouring SSSI). Fifty-eight stands were not under any agri-environment agreement, though some were still managed sympathetically for conservation.

3.4 Just over half of the stands (53) were covered by both LHI and HEAP data sources, though 25 and 33 were covered by only the LHI or HEAP respectively.

3.5 Stands ranged from 0.13 ha to 23.51 ha in size, with an average stand size of 4.26 ha. It is interesting to note that this is significantly less than the average selected polygon size (10 ha), suggesting that the source inventories contain significant elements of non-heathland habitat (though note that direct comparison is partly limited by the mapping protocol and extension of surveyed stands into neighbouring inventory polygons).

Table 6. Number of surveyed stands, showing heathland type, agri-environment agreement category (AE) and feature status

AE Scheme	Dwarf shrub heath	Other	Total
a)All heath types			
CSS	22	13	35
ESA	6	4	10
WES	0	1	1
All AE	28	18	46
Non-AE	32	26	58
Sub total	**60**	**44**	**104**
b)Dry heaths			
CSS	22	11	33
ESA	5	4	9
WES	0	0	0
All AE	27	15	42
Non-AE	30	24	54
Sub total	**57**	**29**	**96**
c)Wet heaths			
CSS	0	2	2
ESA	1	0	1
WES	0	1	1
All AE	1	3	4
Non-AE	2	2	4
Sub total	**3**	**5**	**8**

Note that six sites had two stands.

3.6 Nearly half (49) of stands were privately owned, with local councils (18), Forestry Commission (11) and golf courses (10) accounting for many of the rest. The high incidence of Forestry Commission and golf course ownership may in part be an artefact due to the mapping of separate habitat polygons within a single forestry or golf course 'site'. There were no differences in the proportion of stands which meet the definitions for a heathland feature in the agreement and non-agreement samples.

3.7 Whilst 46% of all dry heathland stands and 42% of 'small' (<8 ha) dry stands were in 'public' ownership, as many as 71% of 'large' stands were owned/managed by public bodies. The

average ‘public’ stand was 5.7 ha and ‘private’ stand 3.3 ha (p=0.025), as there is a tendency for ‘public’ bodies to own the larger heathland stands. However, it should be noted that stand size was partly influenced by the sampling strategy and field protocol and even small stands might be part of wider heathland landscapes, so interpretation of this finding needs care.

3.8 A GIS overlap query with the open access layer was used to determine public access. Not all of the sample was open access, as not all sites fit the definition of heathland used for the open access mapping process: eg some were ‘heathy’ bits of farmland or ‘heathy’ clearings within forestry or golf courses. Forty-five per cent of stands had some form of open public access or were common land. Public stands were more likely to be open access (p=0.021), with 56% of ‘public’ stands having open access, compared to 32% of ‘private’ stands. Though there was no significant difference in the occurrence of agri-environment agreements in the ‘public’ and ‘private’ sector (52% and 41% respectively), there was some suggestion that sites with open access were more likely to be included in agreements (56% compared to 38%, p=0.087).

Overlap with other habitat inventories

3.9 An investigation was performed to see which of the surveyed stands overlapped with inventories for other habitat types (obtained from the English Nature website). The results may be found in Table 7 below. This shows that both heath with more (DSH) and less (O) than 25% dwarf shrub cover (as well as land that was found not to be heathland) may overlap with areas on both the Lowland Dry Acid Grassland (LDAG) and Purple Moor Grass and Rush Pasture (PMGRP) inventories. This is true of polygons sourced from both the LHI and HEAP datasets. This may imply not only that there are errors or poor mapping resolution within the LHI/HEAP and LDAG and PMGRP inventories, but also that some inventory overlap may be justified, where habitat mosaics or transitions occur. How such sites are treated may depend on site management objectives.

Agreement details

3.10 Of the agri-environment agreements, only the ESA agreements had any tier information available at the time of reporting (Table 8). The ESA tier categories involved tended to be fairly broad and contain habitats other than heathland; no heathland-specific tiers were encountered though the West Penwith ESA Rough Land Tier is targeted principally at heathland. Thus, tier information would not have provided any useful method of filtering sites for heathland habitat prior to survey. Nevertheless, some of the ESA tiers involve included a requirement for agreeing management plans which should provide a mechanism for tailoring management to be appropriate for heathlands. Four stands were on agreements in West Penwith ESA, two each in the Blackdown Hills and Exmoor ESAs and single stands in Clun, South Downs and Suffolk River Valleys ESAs. It is perhaps surprising that no sites were included from Breckland ESA the other principally heathland ESA. This may reflect the grassy nature of some Breckland heathlands which could have resulted in them being excluded from the sample. West Penwith ESA was the subject of a separate ‘Rough Land’ vegetation monitoring resurvey recently (Toogood and others 2006) and heathland monitoring has previously been undertaken in some detail here (ADAS 1996) and in the Breckland ESA (ADAS 1997).

Table 7. Overlap between surveyed stands and lowland priority grassland habitat inventories, showing the feature status of the stand and the underlying heathland inventory data sources

Priority habitat	County	Feature status	Data source
LDAG: Lowland Dry Acid Grassland	Dorset	DSH	HEAP
		O	Both
	Gloucestershire	DSH	Both
		O	Both
	Nottinghamshire	O	Both
	Somerset	X	Both
	Suffolk	DSH	Both
		O	Both
Sub total			8
PMGRP: Purple Moor Grass and Rush Pasture	Bolton	DSH	LHI
	Cornwall	O	HEAP
		X	Both
	Devon	X	HEAP
	Gloucestershire	DSH	HEAP
	Somerset	DSH	Both
		DSH	LHI
Sub total			**7**
Total			**15**

More (DSH) and less (O) than 25% dwarf shrub cover; X = rejected post-survey.

Table 8. Details of the ESA tiers of surveyed stands

Site	Type	County	Feature status	Tier
716	dry	Cornwall	DSH	West Penwith ESA tier for rough land
737	dry	Cornwall	DSH	West Penwith ESA tier for rough land
2514	dry	Cornwall	DSH	West Penwith ESA tier for rough land
1178	dry	Devon	DSH	Exmoor ESA tier for Enclosed unimproved permanent grassland
1189	dry	Somerset	DSH	Blackdown Hills ESA tier for unimproved pasture and rough land.
2570	wet	Somerset	DSH	Blackdown Hills ESA tier for unimproved pasture and rough land.
694	dry	Cornwall	O	West Penwith ESA tier for rough land
304	dry	Shropshire	O	Clun ESA tier for extensive permanent grassland and rough grazing.
364	dry	Suffolk	O	Suffolk River Valleys ESA tier for low input grassland
2719	dry	Somerset	X	Exmoor tier for enclosed unimproved permanent grassland.
534	chalk	West Sussex	O	South Downs ESA tier for permanent grassland on the chalk.

More (DSH) and less (O) than 25% dwarf shrub cover; X = rejected post-survey.

The character of the sample

3.11 A very wide range of heathland types were surveyed (see Appendix 1), including those with good dwarf cover and managed primarily for conservation objectives (eg Plate A), those undergoing conservation bracken management (eg Plate B), heathland associated with rotational forestry management (eg Plate C), those under extensive heathland restoration agreements (eg Plate D), heathland associated with golf courses and racecourses (eg Plate E), grazed (Plate F) and ungrazed (Plate G) *Ulex gallii*-rich heaths in the south-west of the country, lichen heath with relatively low cover of dwarf shrubs (eg Plate H) and wet heath with (Plate I) and without (Plate J) *Myrica gale*. Some heathlands were damaged by recreational driving (eg Plate K), arson (Plate L), suffered by dominance of dense acrocarpous mosses (Plate M), or invasion by exotic species (eg Plate N), *Deschampsia flexuosa* (Plate O) or scrub (Plate P). Plate Q shows heathy grassland maintained by rabbit grazing and recreational trampling (showing positive impact of experimental rabbit exclusion on heather growth).

3.12 Appendix 6, table E, lists other species or attributes found in the stands and thought to be relevant for the assessment.

4 Results

Overall heathland condition

4.1 No stand passed all of the CSM targets, hence none of the heathland stands surveyed were considered to be in favourable condition. Even when using the lower CSM targets for species-poor sites, none of the heathland stands were in favourable condition.

HLS targets

4.2 Using the HLS FEP condition targets (dwarf shrub cover/diversity; age structure; trees/scrub cover and negative indicators), less than 5% (1.1 to 4.3%) of the dry heathland sample were considered to be in favourable condition (depending on which structural diversity calculation method is used, para. 2.48), with this figure rising to 43% if the targets for dwarf shrub structural diversity are excluded.

4.3 No wet heathland stand passed all the HLS targets, though two (25%) passed all HLS targets except those for structural diversity.

4.4 The single chalk heathland stand failed both sets of targets.

Individual attributes

4.5 The percentage of attributes passed by individual heathland stands (using standard and species-poor sites CSM targets) is shown in Figure 4. Whilst a small number of stands only just failed the condition assessment, many more failed a significant proportion of attributes, with stands passing an average of 69% of standard CSM targets and 73% of species-poor sites targets.

4.6 Figure 5 shows the pass rates for individual attributes in dry, wet and all heathland stands using the standard CSM targets. Some attributes had high pass rates (eg exotic species, dense acrocarpous mosses, scrub, *Ulex europaeus* cover), whereas other attributes, such as graminoid targets, desirable forbs, dwarf shrub cover and diversity, were rarely met.

Species-poor sites targets

4.7 Figure 6 shows differences in pass rates between species-poor sites and standard CSM targets, where differences exist. Revision of the graminoid diversity target from at least one species at least frequent to at least one species at least occasional increased the pass rate for this attribute dramatically (from 40% to 98%), resulting in pass rates for all grass attribute increasing from 19% to 55% Similarly, a large increase in the dwarf shrub diversity pass rates occurred when the target was lowered from at least two species frequent to only one species frequent (49% to 88%). Less of an increase in pass rate occurred when the target was revised to at least two species at least occasional (49% to 67%). Revising the desirable forb from two species at least occasional to one, increased the pass rate from 32% to 57%. However, in dry heaths, revision of the target for dwarf *Ulex* and *Genista* species from 50% cover to 75% had little impact in the pass rates (83% to 84%). In wet heaths, revising the maximum allowable frequency of *Molinia caerulea* from occasional to frequent had no effect on pass rates.

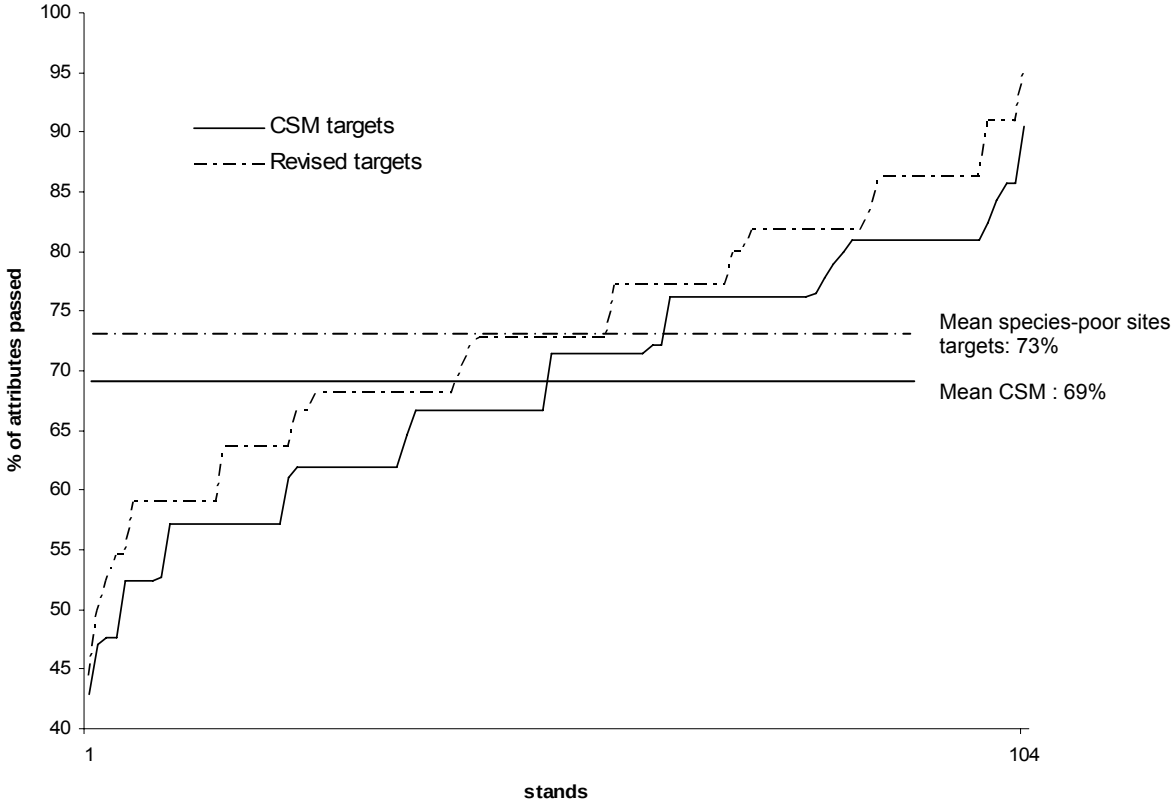


Figure 4. The percentage of attributes passed by individual heathland stands, using standard and species-poor CSM targets

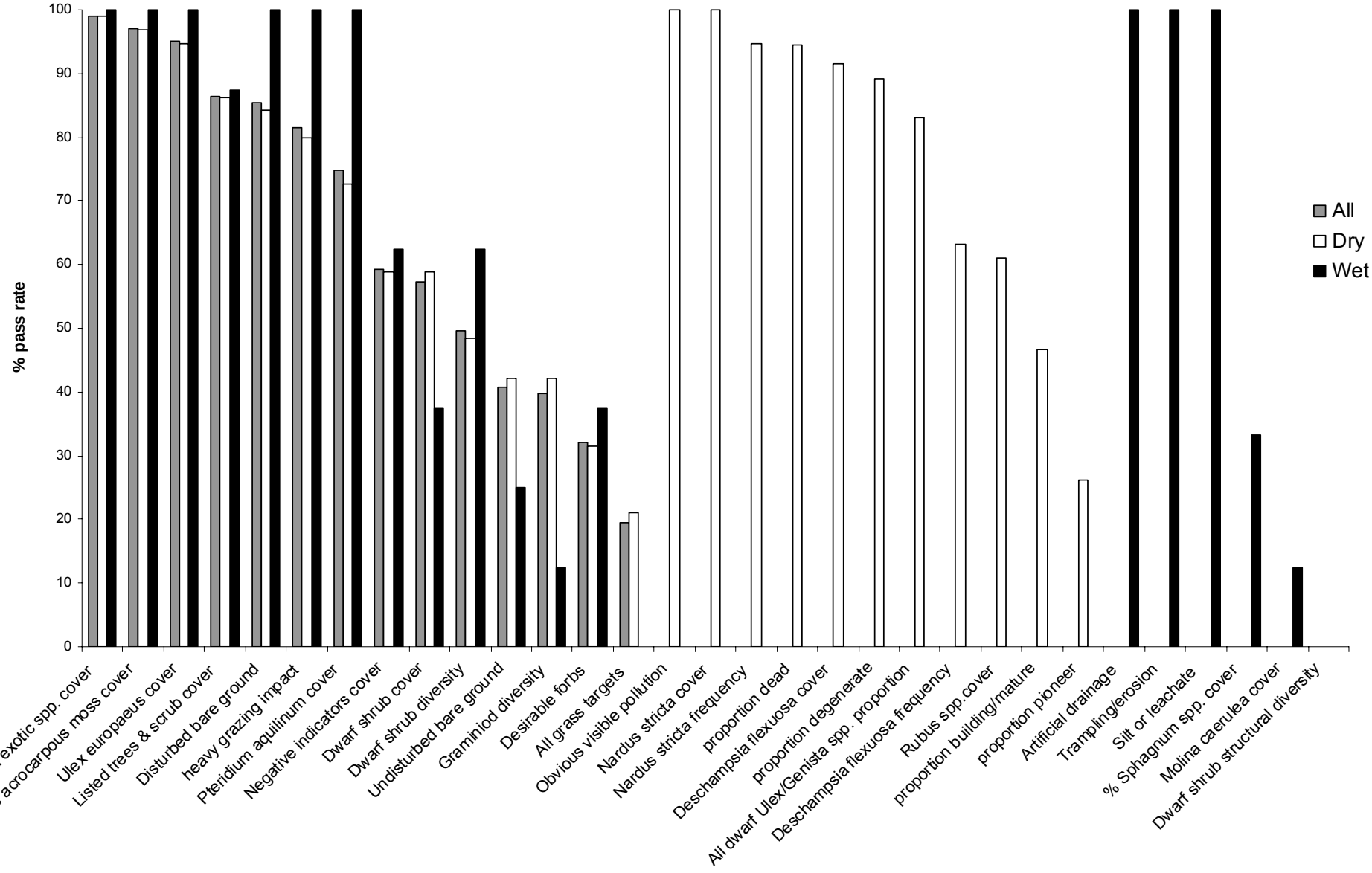


Figure 5. Pass rate for dry, wet and all heathland stands

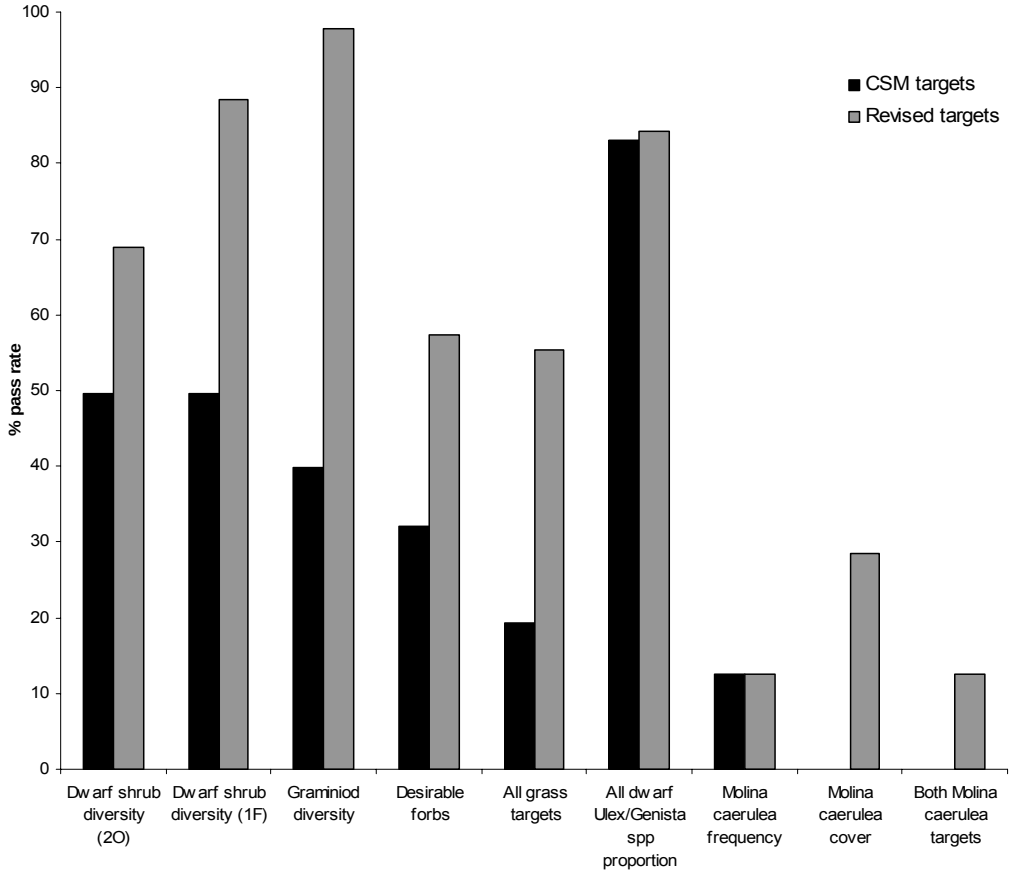


Figure 6. Comparison of pass rates for standard and species-poor CSM targets

Management activities

4.8 Table 9 shows signs of management activities observed on individual stands. The most common management activity across the stands was scrub control (on 23.5% of stands), followed by grazing (22.5%), heather mowing/cutting (19.6%), burning (11.8%) and bracken management (7.8% Plate B). On dry heath, management activities were generally more frequent within agri-environment agreements than outside, with the exception of heather mowing/cutting, which occurred particularly on many of the non-agreement golf courses. (It should be noted that these observations are based only on visible signs of management at the time of survey.)

Table 9. Signs of management activities observed, showing the percentage of stands on which that activity occurred (number of stands in brackets)

Management activities	Agreement status and heath type								
	AE				Non-AE				All
	Dry heaths		Wet heaths		Dry heaths		Wet heaths		
	DSH (27)	O (15)	DSH (1)	O (3)	DSH (30)	O (24)	DSH (2)	O (2)	(104)
Scrub management	22.2	57.1	0	0	16.7	13	50.0	0	**23.5**
Grazing	25.9	35.7	100	33.3	3.3	17.4	0	0	**22.5**
Heather cutting/mowing	25.9	35.7	0.0	33.3	26.7	13	0	0	**19.6**
Burning	11.1	28.6	0.0	66.7	3.3	4.3	0	0	**11.8**
Bracken manag. (inc. spraying)	18.5	21.4	100	0	6.7	4.3	0	0	**7.8**
Recent forest clearance	3.7	7.1	0	0	3.3	4.3	0	0	**4.9**
Supplementary feeding	0	0	0	0	0	4.3	0	0	**1**
Rolling/chain harrowing	0	0	0	0	0	0	50.0	0	**1**
Functioning artificial drainage	0	0	0	0	0	4.3	0	0	**1**

Feature type: DSH=Dwarf Shrub Heath; O=Other (see 2.3.1 for definitions).

Note that more than one management activity may have been recorded on any one stand.

4.9 Table 10 shows the management factors likely to have a positive or negative impact on the heathland stands. Thirty-one (30%) of the stands were subject to on by some type of conservation influence (ie management primarily for conservation objectives), the effects of which are mostly positive (the four exceptions being sites where the effect of conservation factors were unknown, either because a positive effect of management activities was not yet apparent or the conservation activities were felt by the surveyor to be inappropriate). Forty (38%) of the stands were used for recreational activities (particularly public recreation, but also, in the case of a small number of stands, game rearing/shooting), with mostly negative or unknown impacts. Other commonly encountered factors were forestry (stands beneath or closely associated with forestry plantations; plate C), agriculture (most particularly grazing) and mineral extraction (stands associated with active or recently abandoned quarries), all of which showed both positive and negative effects dependant on the site in question. No sites appeared to be influenced by water abstraction or natural events and few were influenced by an urban setting, infrastructure or military use.

4.10 Chi-squared tests showed that grazing management occurred on significantly more (31%) stands within agri-environment agreements compared to those outside (9%, p=0.004); the same was true for bracken management (18% compared to 3%, p=0.036).

Table 10. Management factors recorded on the heathland stands (number of stands in brackets)

Management		Agreement status and heath type								
		AE				Non-AE				
		Dry Heaths		Wet Heaths		Dry Heaths		Wet Heaths		All
		DSH (27)	O (15)	DSH (2)	O (3)	DSH (30)	O (24)	DSH (1)	O (2)	(104)
Agriculture	+	3	3				1			**7 (7%)**
	-	1				1	1			**3 (3%)**
	?	1		1			1			**3 (3%)**
Conservation	+	14	6		1	4	2			**27 (26%)**
	-									**0 (0%)**
	?	3	1							**4 (4%)**
Urban	+									**0 (0%)**
	-						1			**1 (1%)**
	?									**0 (0%)**
Recreation	+	2				3				**5 (5%)**
	-	2	2			3	3			**10 (10%)**
	?	10	5			6	4			**25 (25%)**
Infrastructure	+									**0 (0%)**
	-		1				1			**2 (2%)**
	?									**0 (0%)**
Military	+						1			**1 (1%)**
	-						1			**1 (1%)**
	?									**0 (0%)**
Mineral extraction	+	1					1			**2 (2%)**
	-						1			**1 (1%)**
	?	2								**2 (2%)**
Forestry	+					1		1	1	**3 (5%)**
	-					3	3			**6 (6%)**
	?					3				**3 (3%)**

Feature type: DSH=Dwarf Shrub Heath; O=Other (see 2.3.1 for definitions).

+ = positive effect, - = negative effect, ?=effect unknown.

Note that more than one management factor may have been recorded on any one stand.

4.11 Chi-squared tests (on pass rates) and t-tests (on raw attribute data) on the combined wet and dry heathland sample (excluding rejected stands) highlighted some key differences in the vegetation of sites related to the four most frequently encountered management activities (summarised in Figures 7 to 10). In summary, these show that:

4.12 Stands with heather cutting/mowing (Figure 7):

a) were twice as likely to pass targets for graminoid diversity, which was higher than for those without this management;

b) were less likely to exceed the upper limits for the proportion of the dwarf shrub component made up by dwarf *Ulex/Genista* species; and
c) had a lower proportion of these species;
d) were more likely to pass *Pteridium aquilinum* cover targets, having lower cover (p=0.023);
e) had a high cover of undisturbed bare ground; and
f) had shorter dwarf shrubs with a higher proportion of (pseudo) pioneer growth stage.

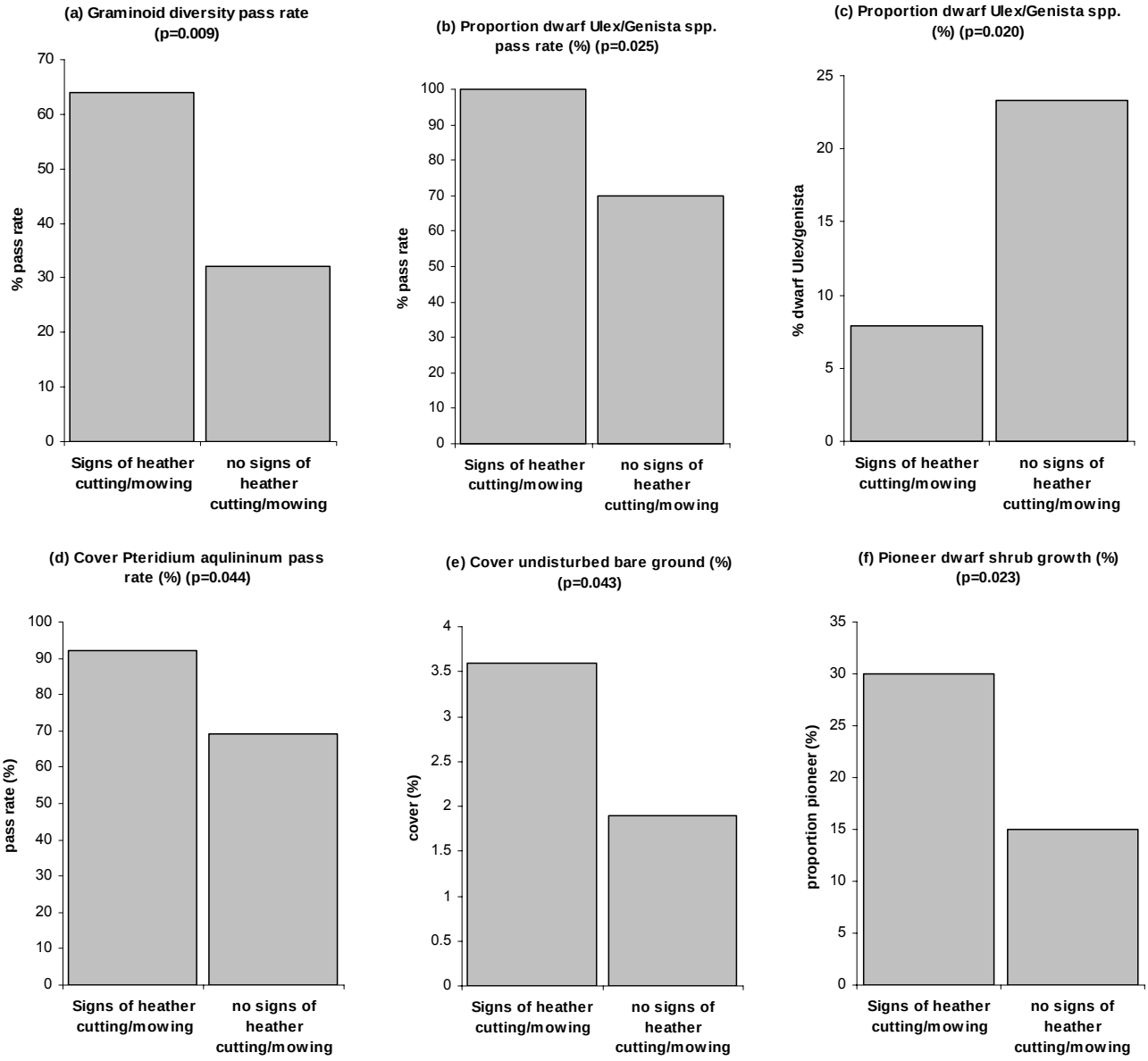
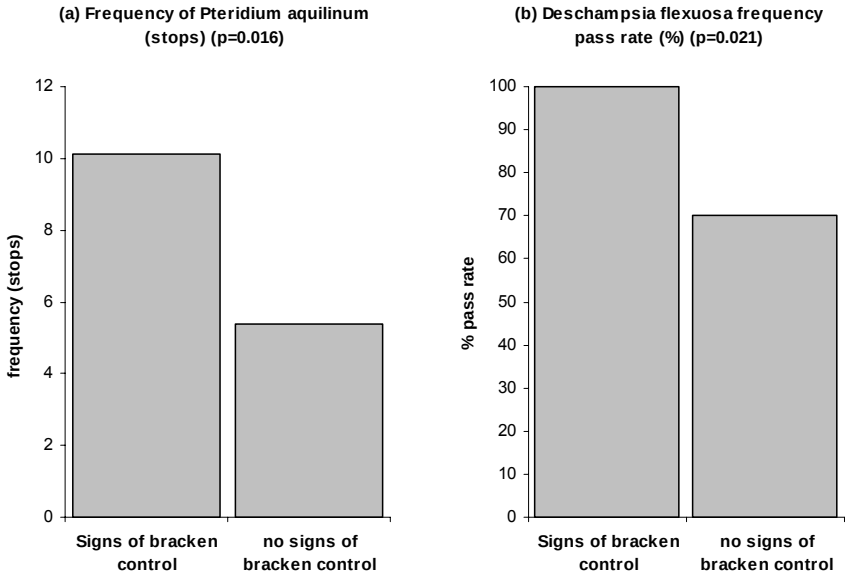


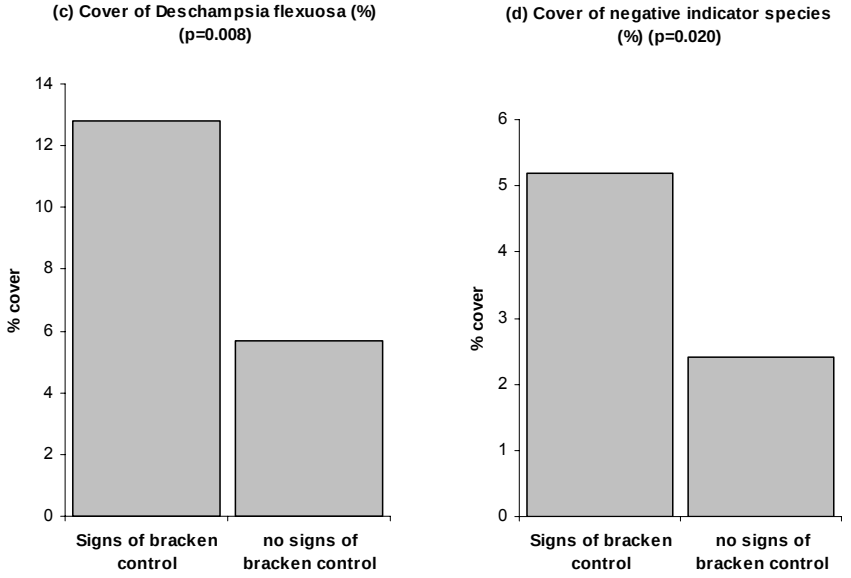
Figure 7. (a-f) Significant effects of heather cutting/mowing management on individual attributes

4.13 Stands with bracken management (Figure 8):

a) had a higher frequency of *Pteridium aquilinum* than on stands without bracken management (ie sites with bracken needed bracken management);
b) had a higher cover and frequency of *Deschampsia flexuosa*;
c) were less likely to pass targets for *Deschampsia flexuosa* frequency;
d) had a higher cover of negative indicator species than in stands without bracken control; and
e) had a higher cover of dense acrocarpous.


(a) Frequency of Pteridium aquilinum (stops) (p=0.016)
frequency (stops)
0
2
4
6
8
10
12
Signs of bracken control
no signs of bracken control

(b) Deschampsia flexuosa frequency pass rate (%) (p=0.021)
% pass rate
0
10
20
30
40
50
60
70
80
90
100
Signs of bracken control
no signs of bracken control


(c) Cover of Deschampsia flexuosa (%) (p=0.008)
% cover
0
2
4
6
8
10
12
14
Signs of bracken control
no signs of bracken control

(d) Cover of negative indicator species (%) (p=0.020)
% cover
0
1
2
3
4
5
6
Signs of bracken control
no signs of bracken control

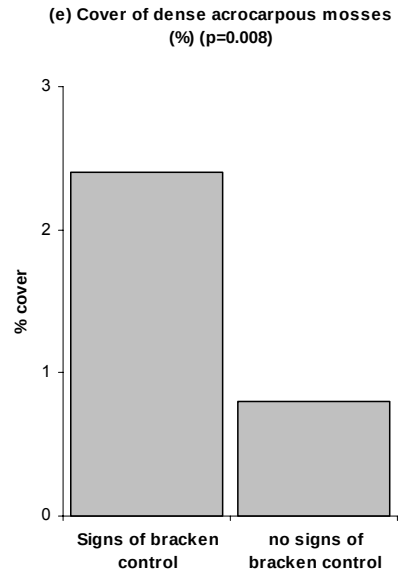

(e) Cover of dense acrocarpous mosses (%) (p=0.008)
% cover
0
1
2
3
Signs of bracken control
no signs of bracken control

Figure 8. (a-e) Significant effects of bracken control management on individual attributes

4.14 Stands with grazing management (Figure 9):

a) were twice as likely to pass targets for diversity of desirable forbs than those without grazing; and
b) were more likely to exceed upper limits for the proportion of the dwarf shrub component made up by dwarf *Ulex/Genista* species.

4.15 Stands with scrub management (Figure 10):

a) had a higher proportion of pioneer stage heather; and
b) had a lower proportion of building heather.

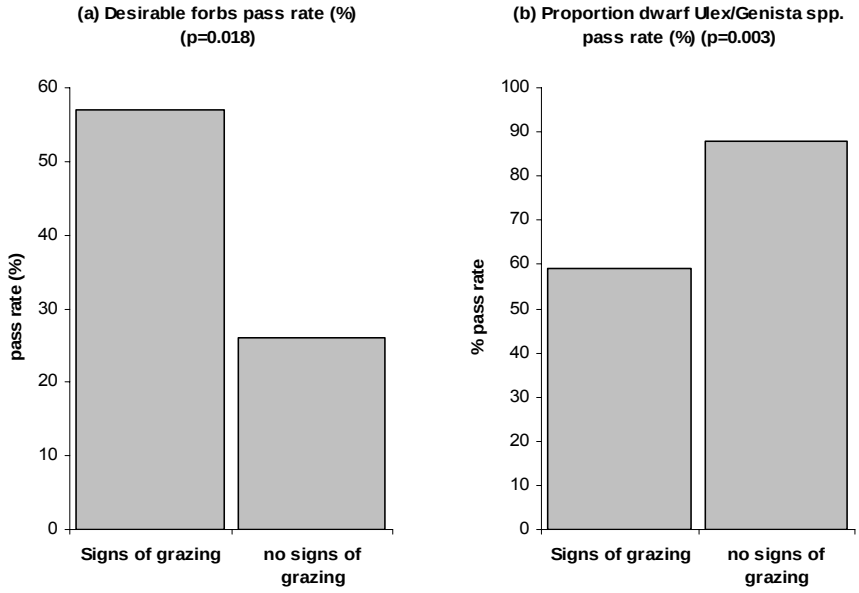


Figure 9. (a-b) Significant effects of grazing management on individual attributes

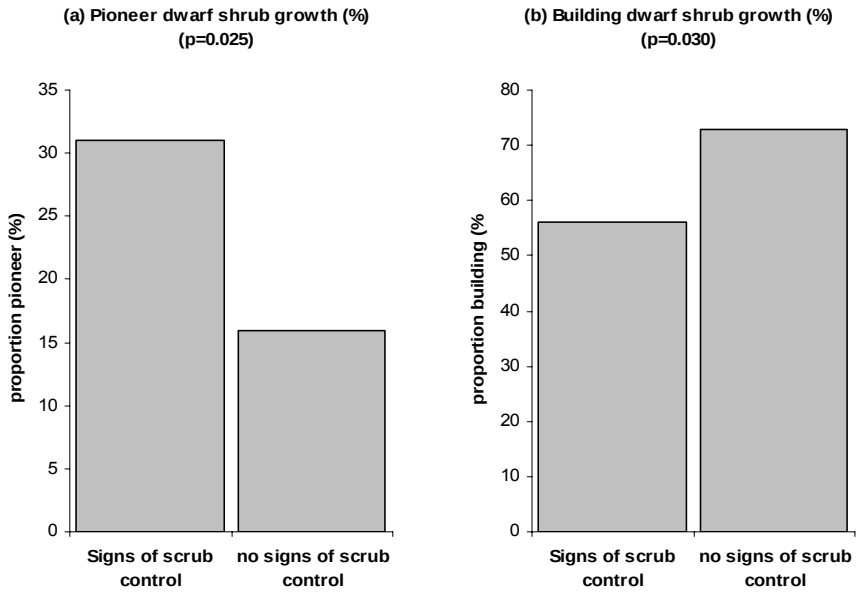


Figure 10. (a-b) Significant effects of scrub control management on individual attributes

Differences between wet and dry heaths

4.16 Differences in pass rates between wet and dry heathland stands are shown in Figure 5. In many cases, when the same attribute targets apply to both heath types, pass rates were similar. However, wet heaths were generally in better condition in terms of heavy grazing (mowing) impact, bracken invasion and negative indicator species. They were, however, more likely to fail targets for graminoid diversity and desirable forbs.

4.17 Differences in raw attribute values between wet and dry heathland stands were examined using t-tests. Wet heaths had higher cover of grasses (65% compared to 27% in dry heaths, p=0.000) and *Molinia caerulea* in particular (46% compared to 7%, p=0.000). However, the mean number of graminoid species of at least occasional frequency was lower in wet (1.5) than dry (2.4) heathland stands (p=0.030) and this resulted in a lower graminoid diversity pass rate in wet (13%) compared to dry (42%) heaths. Wet heaths also contained significantly less dwarf *Ulex/Genista* species with these species making up only 4% of the dwarf shrub cover, compared to 48% in dry heaths (p=0.032). Wet heaths were less prone to invasion by *Pteridium aquilinum* (a mean frequency of 2% (0.4 stops of 20), pass rate 100%), compared to dry heaths (32% (6.3 stops), pass rate 73%, p=0.006) and *Rubus* species (a mean frequency of 1.5% in wet heaths compared to 25% in dry heaths, p=0.018). Pools occurred rarely in both wet (1 stand) and dry (9 stand) heaths.

4.18 Figure 11 shows the differences in pass rates between wet and dry heathland stands using the species-poor sites CSM targets, where these differ from the standard CSM targets. This shows a similar pattern to when standard CSM targets are used.

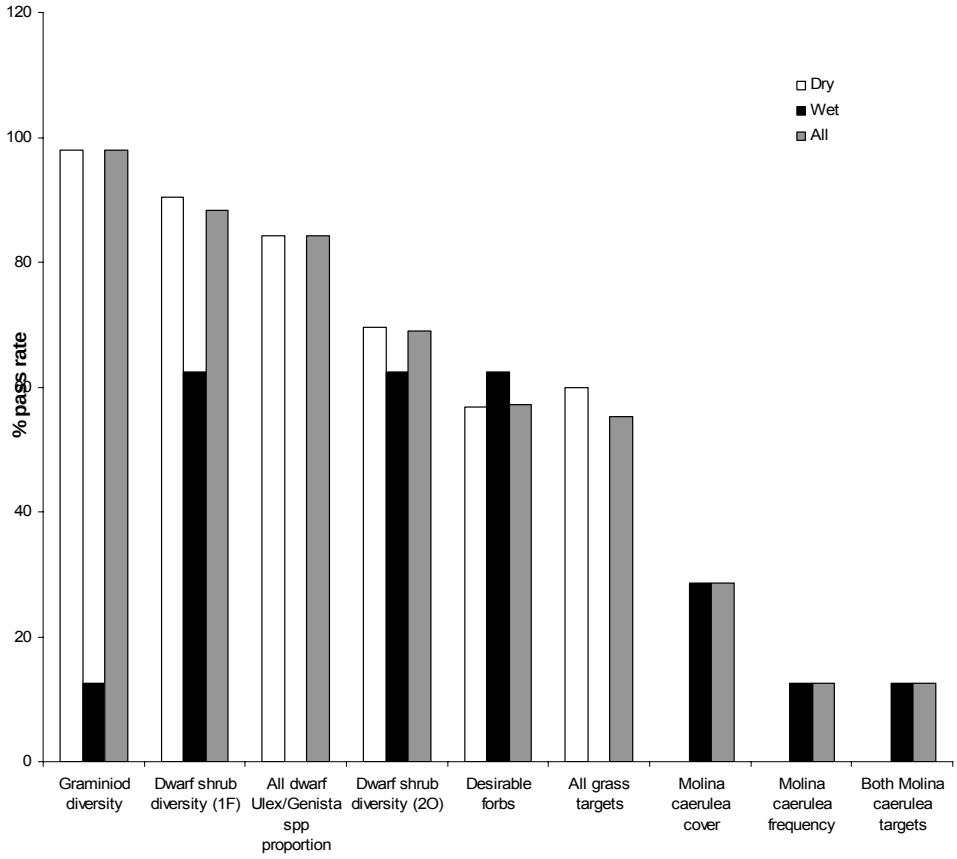


Figure 11. Pass rates using the species-poor CSM targets, for attributes where these differ from the standard CSM targets, for wet and dry heathland stands

Dry heaths

Effect of agri-environment agreements

4.19 Figure 12 shows a comparison of pass rates for individual attributes for the 95 dry heathland sites by agreement status. Chi-squared tests were used to explore the statistical significance of any differences between the two AE categories. No significant differences were found, regardless of whether standard or species-poor sites CSM targets were used.

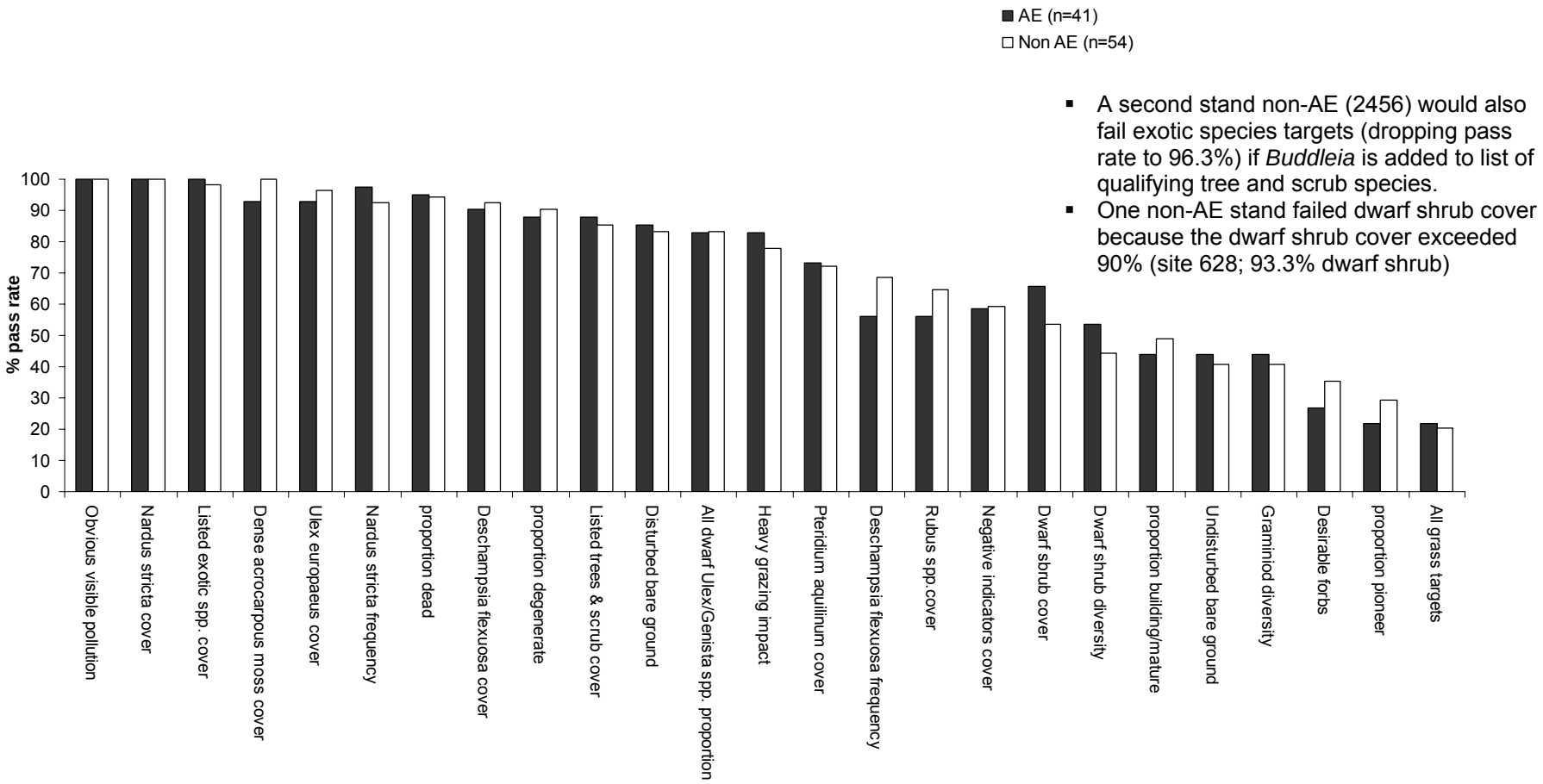


Figure 12. Pass rates for individual attributes for dry heathland stands inside and outside of agri-environment (AE) agreements

Condition assessment

4.20 No stand passed all attribute targets and therefore no stands could be considered to be in favourable condition. The most commonly failed target was the overall target for grasses (pass rate 21%), with the next most frequent being too low proportion of pioneer dwarf shrub growth stage (26%), too low frequency of desirable forbs (32%), too low diversity of target graminoid species (42%) and too little undisturbed bare ground (42%). Fifty-nine percent of all stands met the targets for cover of dwarf shrubs, though one exceeded the 90% upper limit.

4.21 Fifty-nine percent of dry heathland stands met the target for cover of negative herbaceous indicator species, 86% met the target for cover of scrub and trees and 73% for *Pteridium aquilinum* cover. *Ulex europaeus* represented less of a threat to favourable condition, with 95% of stands meeting the <25% cover target. Twenty-seven percent of stands failed to meet the target for the proportion of the dwarf shrub cover made up by dwarf *Ulex/Genista* species, all of which were in the south-west (three in Cornwall, three in Devon, three in Gloucestershire and one in Somerset).

4.22 Other pass rates were very high (>90%) for attributes including occurrence of visible pollution, frequency and cover of *Nardus stricta* and cover of exotic species, dense acrocarpous mosses and *Deschampsia flexuosa*.

4.23 Further examination of the data showed that of the 60% of stands which had >25% dwarf shrub cover ('DSH' stands), only 27% passed the 10-40% targets for (pseudo) pioneer growth forms. Examination of the raw data showed that this was mainly as a result of having too little (pseudo) pioneer growth (36 stands), rather than too much (5 stands, including three mown golf courses and two grazed sites).

4.24 The impact of revising some of the commonly-failed CSM targets was tested for dry heathland stands and in most cases resulted in increased pass rates (para. 2.43 for details of the revisions). Revision of the CSM target for cover of dwarf *Ulex* and *Genista* species had little impact on pass rates (83% to 84%). Revision of desirable forb and dwarf shrub diversity targets resulted in increased pass rates (32% to 57% and 48% to 91% when considering one species at least frequent; or 69% when considering two species at least occasional). But the largest difference was found in the revision of the graminoid diversity target (42% to 98%, resulting in an overall increase in the grass attribute pass rate from 21% to 60%).

4.25 Table 11 compares pass rates using the standard CSM targets and the less stringent HLS condition targets. When HLS targets were applied, overall pass rates improved only slightly to <5% (1.1 to 4.3%) of the dry heathland sample in good condition (depending on which structural diversity calculation method is used, para. 2.48). Most stands failed the HLS targets for dwarf shrub structural diversity; if this attribute is excluded the pass rate rises to 43%.

4.26 The targets for dwarf shrub cover and diversity and undisturbed bare ground were not met in the single chalk heath stand, though all other targets were met. Though the cover of dwarf shrubs was low, this is considered to be typical of chalk heathland and hence the stand was kept in the sample. This stand also failed the HLS FEP condition targets.

Table 11. Overall CSM and HLS FEP condition pass rates for dry heaths by agri-environment agreement status; 'Dwarf Shrub Heath' (DSH) and 'Other' heath stands, including and excluding targets for dwarf shrub structural diversity (number of stands in brackets)

Feature status	DSH & O	DSH & O		DSH		O	
	All	AE	Non-AE	AE	Non-AE	AE	Non-AE
condition assessment (n)	(95)	(41)	(54)	(27)	(30)	(14)	(24)
CSM (including structural targets)	0	0	0	0	0	0	0
CSM (excluding structural targets)	0	0	0	0	0	0	0
HLS (excluding structural targets)	43.2	46.3	40.7	70.4	73.3	0	0
HLS (inc dwarf shrub structure method A)	4.3	4.9	3.9	7.4	6.9	0	0
HLS (inc dwarf shrub structure method B)	1.1	0	2.0	0	3.4	0	0
HLS dwarf shrub structure: method A only	8.7	9.8	7.8	7.4	6.9	14.3	9.1
HLS dwarf shrub structure: method B only	2.2	0	3.9	0	3.4	0	4.5

A – pioneer = 10-15% and degenerate = 10-30%

B – pioneer = 10-15% and degenerate+ half of building/mature = 10-30%

Mean results for individual attributes

4.27 Appendix 5 (A and B) shows the mean (and SE) raw attribute results for the dry heaths and the only stand of chalk heath. The only statistically significant ($p<0.05$) difference in attribute results between agreement categories was that dry heathland stands under agri-environment agreement had significantly higher (but still low) cover of dense acrocarpous mosses (eg Plate M) than those outside of agreements (1.2% compared to 0.2%, $p=0.026$).

4.28 Figure 13 shows the range of results for key attributes recorded in individual dry heathland stands and a comparison with the condition assessment targets. This shows that on many sites attribute targets were failed by significant margins.

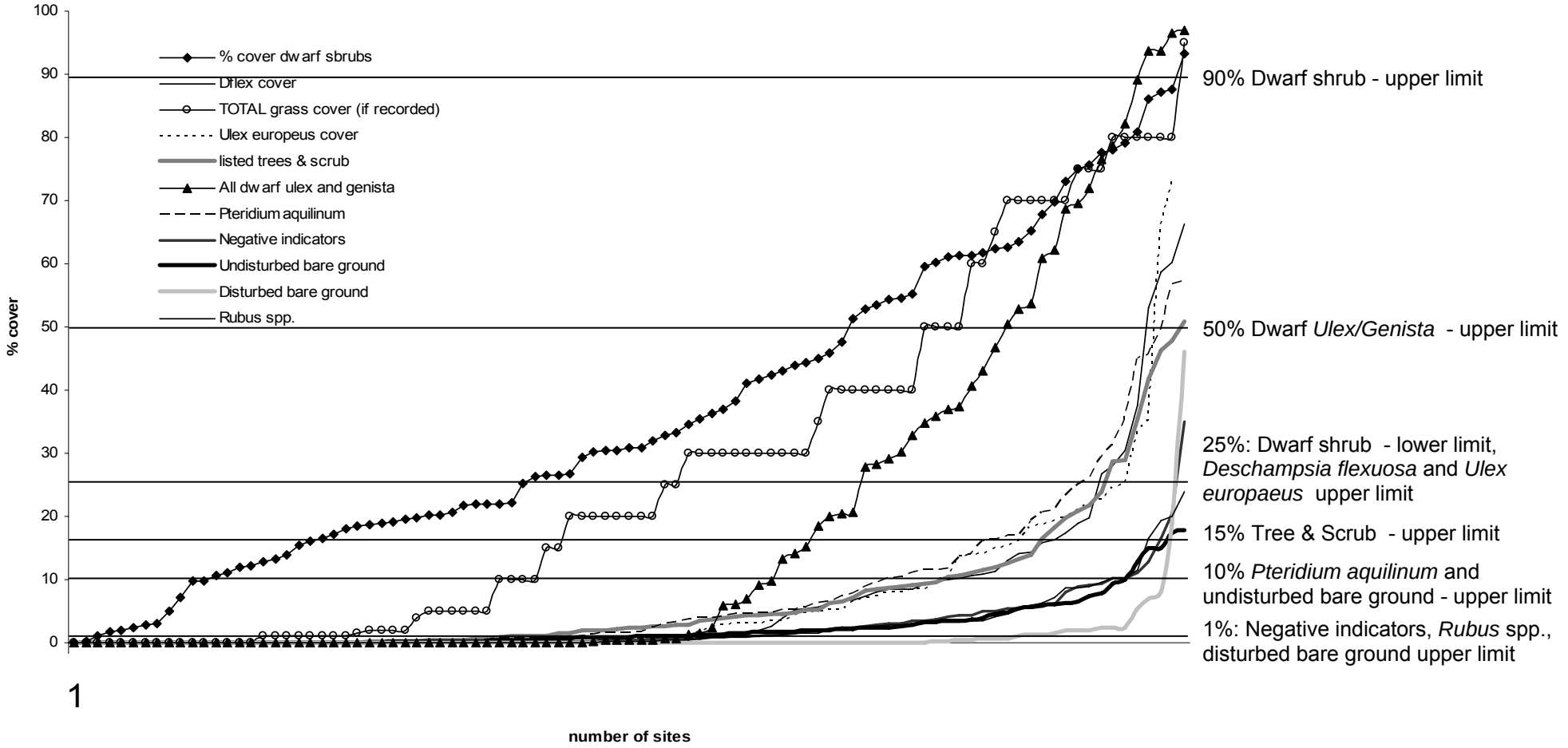


Figure 13. The range of results for key attributes recorded in individual dry heathland stands, with a comparison with the condition assessment targets

Wet heaths

Condition assessment

4.29 Figure 14 shows a comparison of pass rates for individual attributes by agreement status for the eight wet heathland stands. The statistical significance of differences between the results for the two categories could not be tested due to low sample sizes. Although some attribute targets had 100% pass rates (notably for disturbed bare ground, heavy grazing impact, trampling, drainage, silt or leachate, acrocarpous mosses, *Pteridium aquilinum* and exotic species), all stands failed to meet targets for grasses and dwarf shrub diversity. Many stands also fail due to low cover of dwarf shrubs (38% pass rate) and too high frequency/cover of *Molina caerulea* (13% pass rate). Pass rates were also low for frequency of desirable forbs (38% pass rate) and graminoid diversity (13%).

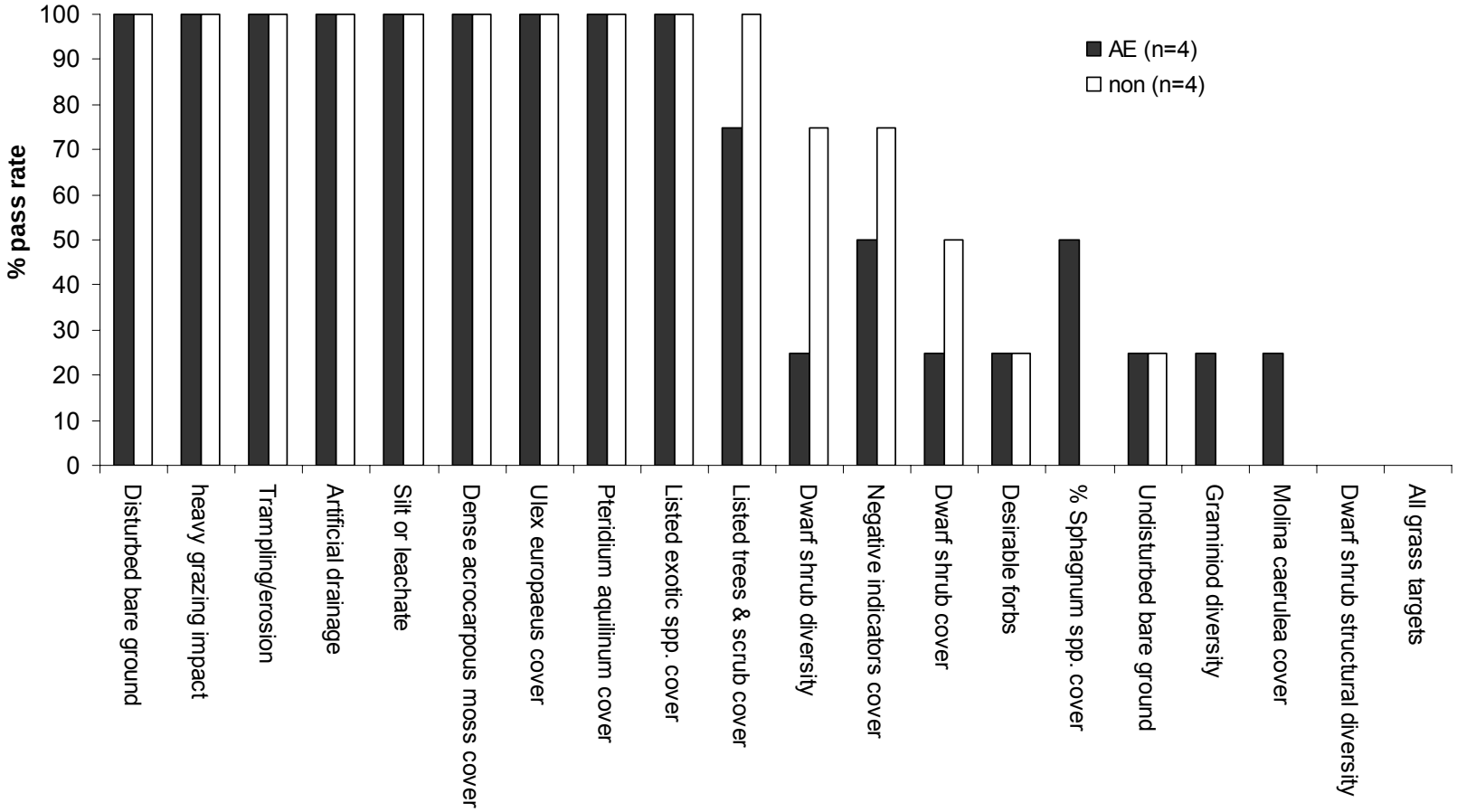
4.30 The use of species-poor site CSM targets for dwarf shrub diversity and frequency of *Molinia caerulea* had no effect on pass rates in wet heaths. The revision of the desirable forb target from at least two species at least occasional to just one species at least occasional resulted in an increase in pass rate from 38% to 63%. The pass rate for the proposed target of *Molinia caerulea* cover of <30% was 29%, but had no impact on the overall pass rate for the species.

4.31 In addition to failing the CSM targets, no stands passed the HLS condition targets either. If the HLS dwarf shrub structural diversity targets are excluded, two (25%) non-agreement wet heath stands passed the other targets.

Mean attribute results

4.32 Appendix 5 (C and D) shows the mean (and SE) raw attribute results for the wet heaths overall, whilst Appendix 5 (F) shows additional species for the individual stands. Statistical tests were not applied due to low sample sizes.

4.33 Figure 15 shows the range of results for key attributes recorded in individual wet heathland stands and a comparison with the condition assessment targets. This shows that on many sites attribute targets were failed by significant margins.



Sphagnum pass rate based on n=3 stands, rest did not have any Sphagnum so target does not apply.

Figure 14. Pass rate for individual attributes for wet heathland stands inside and outside of agri-environment (AE) agreements

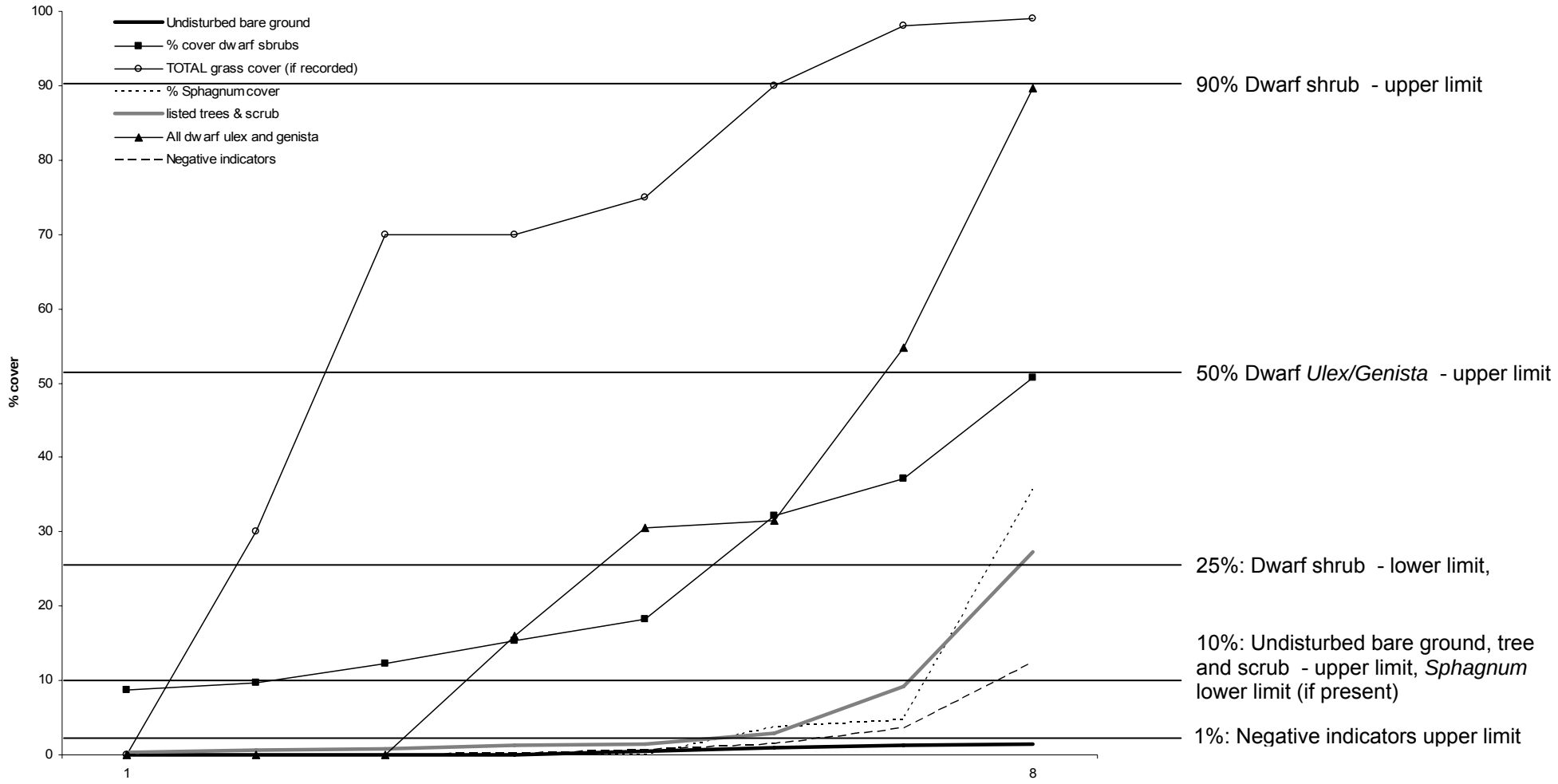


Figure 15. The range of results for key attributes recorded in individual wet heathland stands and a comparison with the condition assessment targets

‘Public’ and ‘private’ ownership

4.34 Differences in the percentage pass rates for each attribute for all surveyed dry heathland stands in ‘public’ ownership (for this analysis includes county, district, borough and parish councils, LNRs, National Trust, Wildlife Trust, other conservation and heritage trusts, race courses, commoners associations and Forestry Commission owned or managed land) and ‘private’ ownership is shown in Figure 16. Data for chalk and wet heaths are not shown due to low sample sizes. The only statistically significant difference in pass rates was for desirable forbs which was 20% in publicly owned stands and 43% in privately owned stands (Chi-squared test, p=0.031). However, more differences were found when the raw attribute data were examined. The publicly owned sites had higher cover of dense acrocarpous mosses (p=0.045) and disturbed bare ground (p=0.047), but lower desirable forb diversity (p=0.031).

4.35 Table 12 shows the relationship between the frequency of conservation management land ownership and agri-environment agreement status. Both within and outside of agri-environment schemes, publicly owned land was more likely to receive some kind of conservation management. Both public and private land was more likely to receive conservation management if it was under an agri-environment agreement.

Table 12. The frequency of conservation management (% of stands) in stands in private and public ownership and within and outside of agri-environment agreements

Ownership	AE	Non-AE	All
Private ownership	27.8	9.4	16.0
Public ownership	65.2	18.2	42.2
All	48.8	13.0	28.4

Stand size

4.36 Of the 95 dry heathland stands only 14 were greater than 8 ha in size. Thus, there was not a suitable sample distribution for meaningful analysis by size class. However, differences in pass rates for individual attributes between ‘large’ (>8 ha) and ‘small’ stands are shown in Figure 17. There were no statistically significant differences in pass rates (Chi-square analyses partly limited by low sample sizes). However, t-tests showed a strongly significant difference in dwarf shrub diversity (mean 3.9 species in ‘large’ stands c.f. only 2.7 species in ‘small’ stands, p=0.000) and in dwarf shrub frequency (mean 17.5 (88%) stops out of 20 in ‘large’ stands compared to 14.5 (73%) stops in ‘small’ stands, p=0.032). Hence larger sites had higher diversity and frequency of dwarf shrub species.

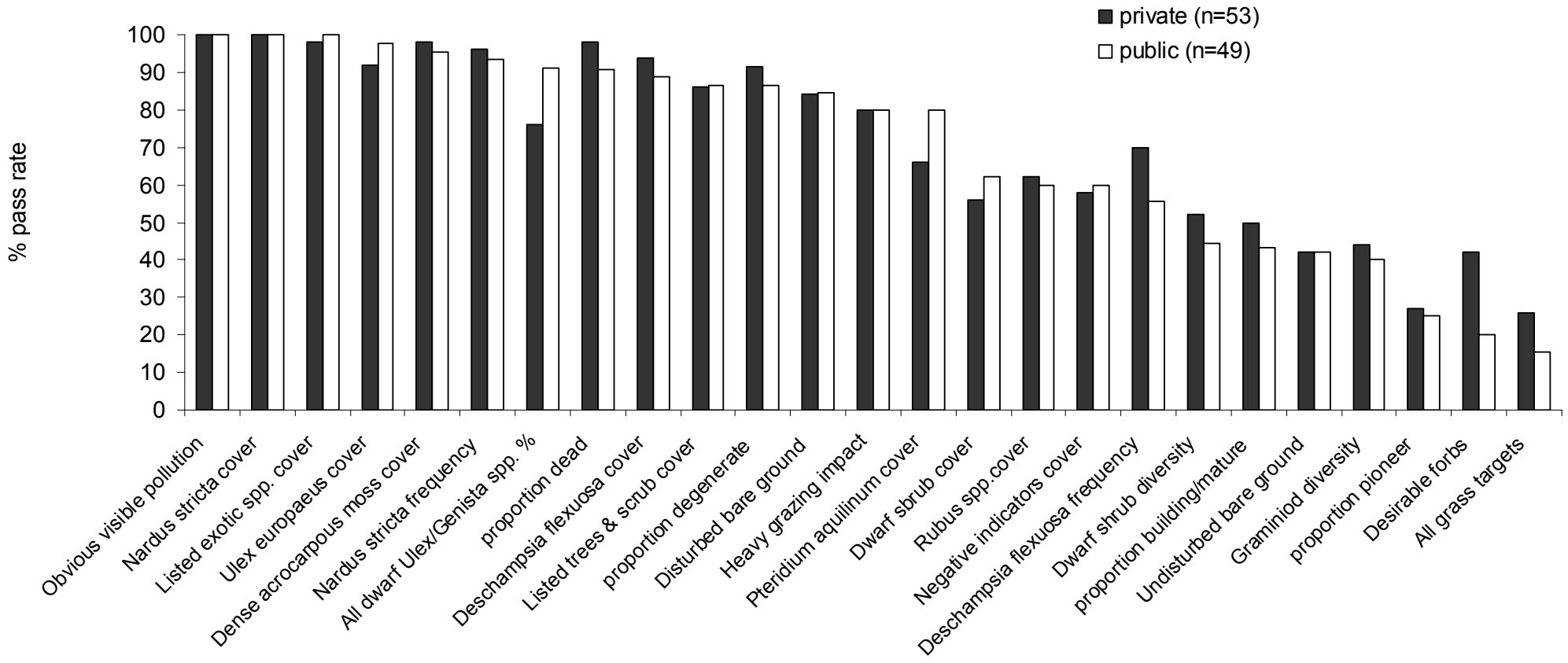


Figure 16. Pass rates for individual attributes for dry heathland stands in public and private ownership

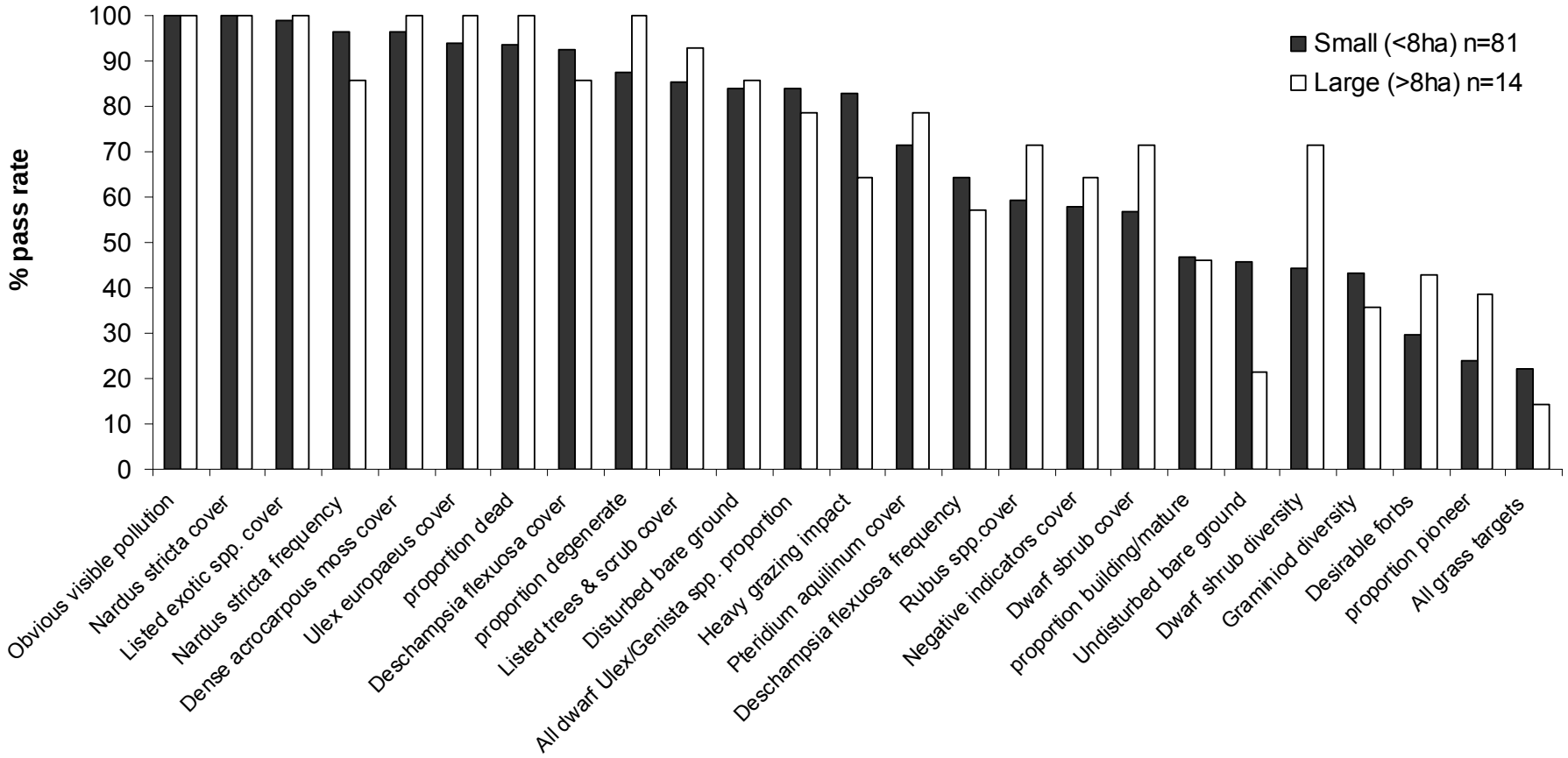


Figure 17. Pass rates for individual attributes for ‘large’ (>8 ha) and ‘small’ dry heathland stands

Regional variation

4.37 Table 13 shows pass rates for dry heaths in each Government Office Region (GOR). It should be noted that Dorset was included within the South East Region (due to the similarities of Dorset and SE heathlands) and that data for some of the regions is based on relatively small sample sizes. Data for wet and chalk heathland stands are not shown due to the low sample sizes. There was some regional variation in pass rates, though comparison is limited by low sample sizes in many regions. In particular, eastern heaths tended to have more bare ground and lower dwarf shrub cover. The heaths of the south west of England were the most diverse in terms of dwarf shrub species, but often failed particularly because of high cover of dwarf *Ulex/Genista* species (see Plates G and G). Heathlands in the south and east tended to have high pass rates for *Deschampsia flexuosa* frequency but those in the North West and West Midlands much lower rates. This may reflect geographical differences in vegetation types.

Correlations between attributes

4.38 Pearson correlation analyses were performed between the key numerical attribute data. However, few significant correlations were found (excluding for non-independent variables based on the same in-field variable) except:

- cover of dwarf shrubs was negatively correlated with the cover of grasses (r= -0.473, p=0.001);
- the proportion of pioneer dwarf shrub growth stage was positively correlated with graminoid diversity (r=0.427, p=0.032);
- cover of *Rubus* species was positively correlated with that of *Pteridium aquilinum* (r=0.380, p=0.026), and
- the proportion of dwarf *Ulex/Genista* species was positively correlated with dwarf shrub height (r=0.504, p=0.003).

Table 13. Pass rates for individual attributes for dry heaths by Government Office Region (number of stands in brackets)

Attribute	South West (38)	South East (34)	East of England (10)	North West (7)	West Midlands (6)	East Midlands (3)	North East (2)	London (1)	Yorkshire and the Humber (1)
Undisturbed bare ground	36.8	26.5	50.0	57.1	50.0	100	50.0	0.0	100
Disturbed bare ground	84.2	94.1	100	57.1	50.0	66.7	50.0	100	100
heavy grazing impact	94.7	64.7	70.0	85.7	100	100	50.0	100	100
Obvious visible pollution	100	100	100	100	100	100	100	100	100
Dwarf shrub cover	65.8	55.9	40.0	57.1	50.0	0	0	100	100
Proportion (pseudo) pioneer	28.9	26.5	30.0	14.3	16.7	0	0	0	0
Proportion building/mature	31.6	38.2	50.0	85.7	66.7	33.3	50.0	100	100
Proportion degenerate	89.5	88.2	90.0	71.4	50.0	33.3	100	0	100
Proportion dead	92.1	94.1	100	57.1	83.3	66.7	50.0	100	100
Dwarf shrub diversity	76.3	38.2	20.0	28.6	33.3	0	0	0	0
Graminoid diversity	34.2	41.2	50.0	85.7	33.3	0	100	0	0
Nardus stricta cover	100	100	100	100	100	100	100	100	100
Deschampsia flexuosa cover	100	94.1	100	85.7	83.3	0	100	0	100
Nardus stricta frequency	100	97.1	100	85.7	83.3	100	0	100	100
Deschampsia flexuosa frequency	81.6	73.5	90.0	14.3	16.7	0	0	0	0
All grass targets	23.7	26.5	40.0	0	0	0	0	0	0
Desirable forbs	36.8	38.2	20.0	28.6	16.7	0	100	0	0
Dense acrocarpous mosses	100	97.1	80.0	100	100	100	100	100	100
Ulex europaeus cover	94.7	97.1	100	85.7	83.3	100	100	100	100
Listed trees & scrub cover	92.1	82.4	100	71.4	83.3	33.3	100	100	100
Rubus spp. cover	52.6	76.5	40.0	42.9	66.7	100	50.0	100	0
Dwarf *Ulex/Genista* spp.	50.0	97.1	100	100	83.3	100	100	100	100
Pteridium aquilinum	73.7	79.4	70.0	42.9	83.3	33.3	100	100	0
Listed exotic spp. cover	100	97.1	100	100	100	100	100	100	100
Negative indicators cover	60.5	70.6	60.0	0	50.0	33.3	0	100	0

Note that Dorset has been included within South East Region.

5 Discussion

The sample

5.1 The 104 heathland stands in the final accepted sample were widely distributed, from Land's End in Cornwall to Cumbria and Northumberland, representing the full geographical spread of non-statutory heathland in England. As in the whole population, there was a concentration towards the south and west of the country, with stands in Cornwall making up 29% of the sample.

5.2 The majority of the sample (91%) was dry heathland, which is probably representative of the wider non-statutory heathland population. This has restricted the extent to which analyses could be performed on the wet (eight stands) and chalk (one stand) heathland samples and will also limit the usefulness of repeat monitoring visits in these heathland types. Unfortunately, higher levels of sample stratification were not possible within the available resources and in most cases heathland type was not know beforehand. The sample was stratified by agreement status, with 42 stands (40%) under agreement. This compares with a lower proportion (22%) of the total non-designated heathland resource under agreement (para. 2.14).

5.3 The ecological criteria for inclusion within the sample were broad. This approach was probably appropriate for the aims of the project and is consistent with the revised definition of the BAP priority habitat (para. 1.4). It allowed sites in poor condition but with heathland restoration potential to remain within the sample and also meant that the sample reflected the nature of the areas currently within the LHI/HEAP datasets (after definitely non-heathland sites were removed). A further advantage of the broad criteria is that a repeat survey will be able to report on progress on the sites in poor-condition. However, a more stringent stand selection criteria would have improved the condition of the sample (though perhaps not sufficiently to get many or any stands to favourable condition), though at the same time reducing the estimate of the extent of the habitat resource.

Condition assessment

5.4 No site-tailored conservation objectives existed or were known for the surveyed sites in this sample. Therefore, the targets they were measured against were the generic ones given in the CSM guidance for designated sites (with some revisions for species-poor sites). Bearing this in mind, strict objective application of the CSM guidance resulted in no stand passing all the targets (even when species-poor sites targets were used). Hence all of the non-statutory heathland sample can be considered to be in unfavourable condition. Furthermore, on average stands passed only 69% of the attribute targets (73% using the species-poor sites targets) and in many cases attributes fell short of targets by considerable margins. This compares with the still low figure of 17% of statutory (SSSI) lowland heathland features being in favourable condition in the UK (Williams 2006). This difference is not perhaps surprising, as non-statutory heathlands receive less of the attention and funding afforded to SSSIs. In addition, the best heathlands are likely to be designated and are thus perhaps more likely to be in good condition. It is also possible that because of the benefit of in-depth site knowledge, CSM targets may be more site-specific, or that stand selection protocol may differ in SSSI CSM. There may also be differences in how the condition assessment guidance has been applied in the field. In particular, the CSM lowland heathland guidance was only published in 2003 and would not have been applied to assessments before that date (and SSSIs are surveyed on a six-year cycle). Whether the strict, objective application of all current condition assessment targets was fully appropriate is discussed under Evaluation of the methodology.

5.5 Toogood and others (2006) recently monitored vegetation change in, and condition of, the 'Rough Land' management tier in West Penwith ESA which includes extensive heathland. None of the 13

heathland stands surveyed were in favourable condition, even when the lower species-poor targets were used. The nature of associated vegetation change recorded in permanent plots suggested that unfavourable condition generally reflected lack of active management. Thus, the condition results from Toogood and others (2006) are consistent with those in this report. Interestingly, though not representative of designated heathland as a whole, none of the 28 plots from nine SSSI/National Nature Reserve sites selected for inclusion in the heathland Validation Network baseline survey were in favourable condition (Ross and Bealey 2005). This was despite the fact that half the plots were "selected as an example of favourable condition". All the 'favourable' plots failed between one and seven out of up to 11 attribute targets with a mean of 3.6 attributes failed compared with 4.4 for the 'unfavourable' plots.

5.6 When the less stringent HLS FEP condition targets were applied, 1.1-4.3% of the dry heathland sample passed the assessment (depending on which structural diversity calculation method was used, para. 2.48). This slightly higher pass rate reflects the fact that fewer targets are used and hence need to be passed in the FEP condition assessment.

5.7 There were relatively low pass rates for a wide range of attribute targets. Some of this failure may perhaps be attributed to inappropriateness of some targets, at least at an individual site level (para. 5.44) and to the rather inclusive project sampling protocol which included any 'close to heath' vegetation. However, when combined with the high number of site rejections it nevertheless reflects the poor condition of heathland within the LHI and HEAP inventories outside of the national designated sites series. A concerning number of dry heathland stands (41%) failed to meet even the basic target of 25-90% cover of dwarf shrubs and many failed targets for cover of negative indicator species such as *Rubus* species, *Pteridium aquilinum* and others. (*Rubus* species and *Pteridium aquilinum* often occur together and their covers were positively correlated.) Whilst the dwarf shrub cover target is broad, the CSM guidance recommends that on statutory sites "the Conservation Objectives tables or the management plan for the site should however show a narrower range…" which reflects the local physiognomy (eg 25-50% or 50-75%).

5.8 Dwarf *Ulex/Genista* species were found to be most abundant in dry heaths, in heaths that were not cut or mown, or those with grazing. *Ulex gallii* forms a significant element of the heaths of the south-west of England (eg Plates F and G). The overall pass rate for the dwarf *Ulex/Genista* species attribute was 83% (and was unaffected by increasing the allowable proportion of these species from 50% to 60%). Those that failed were all in the far south-west. However, as this type of vegetation is geographically determined sites may have been declared in poor condition when they were just showing natural characteristics. It is recommended that this target is further reviewed for future assessment of both designated and non-designated sites.

5.9 Without repeat monitoring, 'recovering' status cannot easily be determined for stands in unfavourable condition, though it is likely that at least some of the sample, particularly those in the dwarf shrub heath 'feature' group, with active conservation management, are to a degree recovering. Furthermore, the recording of baseline heathland extent can, on repeat survey and using the field stand extent maps from this project, enable the determination of change in extent.

Agri-environment schemes

5.10 Most of the agri-environment agreement sample was within Countryside Stewardship Scheme (CSS) agreements, with other stands in Environmentally Sensitive Area (ESA) Schemes and one stand in the Wildlife Enhancement Scheme (WES). Unfortunately detailed information on most of these agreements was not available, though the ESA tiers involved were not specific to heathland, but included other rough or otherwise important land. Nevertheless, some of the ESA tiers included a requirement for agreeing management plans which should provide a mechanism for tailoring appropriate heathland management. For the oldest CSS agreements whole farm boundaries were used, but from c.1998 agreement areas were fully digitised.

5.11 There was some evidence to suggest that agri-environment agreements are associated with more positive conservation management (both on private and 'public' land), particularly relating to grazing and bracken management (eg Plate B), both of which were significantly more frequent

within agreements. However, there were few resulting relationships with individual pass rates and individual attribute results. In addition, it should be noted that conservation management activities were not restricted to agreement stands alone.

5.12 It is possible that the groupings 'agreement' and 'non-agreement' land used in this project were too coarse to detect differences and did not take full enough account of the full range of agreement-led objectives set for stands in the sample. For example, some of the ESA agreements related to general grassland tiers[7] which were not necessarily designed to promote good heathland management (though option information was not available for CSS sites). Furthermore, the length of time that sites had been in agreement was not known. Nevertheless, the presence of agri-environment agreements may at least indicate a level of conservation sympathy on the behalf of the landowner/manager and more non-agreement sites were rejected during early project stages than those within agreements, perhaps suggesting a larger non-heath element in the non-agreement category. It is likely that repeat monitoring will better elucidate the effects of agri-environment agreements through detection of changes over time.

Management activities

5.13 Management data were based only on visible signs of management at the time of survey and hence may not be comprehensive as the collection of management information was not a primary aim of the surveys. However, some useful conclusions can still be drawn from the data collected.

5.14 About a third of the sites in the sample were managed for conservation purposes (32%) and more were used for various forms of informal and formal recreation (38%). The most commonly encountered management activity was scrub management (24% of stands), followed by grazing (23%), heather mowing/cutting (20%), burning (12%) and bracken management (8%). There were some statistically significant relationships between some of these activities and the vegetation. For example, sites with heather mowing/cutting had a more diverse grass element, more desirable undisturbed bare ground and were less prone to domination by bracken or dwarf *Ulex/Genista* species. There was no statistical evidence to suggest that mowing or cutting led to reduction in dwarf shrub cover, with many of the golf course stands demonstrating that such management was associated with a good cover of pseudo-pioneer growth of *Calluna* and *Erica* species. One site was known to have been mown for over 100 years and still had 19% dwarf shrub cover, though not sufficiently high enough to pass the 25% target, even this extended period of mowing had not excluded dwarf shrubs altogether.

5.15 Those stands that were grazed had a higher diversity of desirable forbs, possibly because grazing resulted in a more heterogeneous or grassy vegetation. Also, grazed sites were more likely to exceed the targets for dwarf *Ulex/Genista* species. This may be because a pattern of dense *Ulex* species in mosaic with forb-rich grassier areas tends to arise in grazed situations, due to preferential grazing of the grassier areas and/or because grazing is more common in the south-west (where *Ulex gallii* heaths principally occur) and where 29% of stands were grazed, compared to only 12% elsewhere. Alternatively, the association may have arisen due to differences in grazing regimes between regions.

5.16 Bracken management, including spraying and targeted clearance, appeared to be associated with higher levels of bracken (ie sites with bracken need bracken management). *Deschampsia flexuosa*, dense acrocarpous mosses and other negative indicator species also tended to occur in stands where bracken management was necessary. High cover of such negative species is known to appear after bracken control and other types of active management, due to the disturbance to the top soil. These sites need to be revisited regularly to assess progress (ie decreases in the cover of negative indicators and increases in dwarf shrub species and characteristic grasses and forbs).

[7] Extensive permanent grassland and rough grazing, Permanent grassland on the chalk, Unimproved pasture and rough land, Low-input permanent grassland and Enclosed unimproved permanent grassland.

5.17 The positive relationship between scrub management and pioneer dwarf shrub growth possibly arose from new growth establishing on cleared areas, though other reasons, such as inter-correlation between management activities cannot be ruled out.

5.18 Unfortunately interpretation of the management data is limited by lack of detail and reliance only on field evidence. The results appear to indicate that the main effects of lack of appropriate management on heathlands, such as increased cover of scrub and trees, are being dealt with widely. However, attributes associated with appropriate grazing regimes (structural and diversity attributes) were failed in a high proportion of sites.

Ownership

5.19 There was an equal split in the sample between publicly and privately owned/managed land. 'Public' bodies tended to own the larger heathland stands (though note comments in para. 5.23) and also open access or common land. They also tend to have more positive conservation management. The high incidence of forestry and golf course stands may have in part been an artefact of both baseline inventories separating out various habitat patches within a single forest or golf course unit, thus increasing representation within the population.

5.20 Publicly owned sites tended to contain a lower diversity of desirable forb species, but had a higher cover of dense acrocarpous mosses and disturbed bare ground. The reason for this is not clear, though it is possible that higher levels of bare ground resulted from higher levels of public access.

Stand size

5.21 The size of the inventory polygons did not always coincide with the size of the surveyed heathland stand (due to the difficulties of mapping stands). The mean stand size was 4.26 ha and stands ranged from 0.13 ha to 23.51 ha in size. A preliminary examination of the non-statutory heathland inventory sites showed a mean polygon size of 7.65 ha with that only 6% of sites >25 ha in size, though some may have been part of wider SSSI or unmapped heathland stands. This compares with 8% of the sample stands >25 ha.

5.22 Interestingly, despite a bias in the sample towards small stands, it was found that larger stands had a higher frequency and diversity of dwarf shrubs.

5.23 It may not be possible to directly extrapolate from the results of this project to the small proportion of larger sites within the wider non-statutory heathland population, for a number of reasons. Firstly, the sample strategy imposed an upper stand size limit of 25 ha. It also excluded heathland which extended beyond the sometimes artificial boundaries of the two inventories and excluded areas of certain agri-environment agreement categories. Despite this, the sample is probably still representative of heathland inventory sites. Nevertheless, it should be borne in mind that large sites contribute a disproportionate area to the whole resource. As mentioned above there was a suggestion that large sites may be in better condition, at least with respect to some dwarf shrub attributes. Examination of heathland size distribution in the inventories is hampered by the inconsistent approach to mapping individual habitat patches within, and incompleteness of, the inventories (para. 5.30).

5.24 The smaller stands in the sample were below the minimal recommended area (5ha) for the condition assessment methodology given in Alonso and others (2003), though the assessment still proved practical for these stands.

Regional variation

5.25 There was a suggestion that in general southern heathlands (SW, SE and EoE) were in better condition than northern heathlands (Table 13). However, the results are not conclusive due to low sample sizes in the NW, W Midlands, E Midlands, NE, London and Yorkshire and the Humber.

5.26 Dwarf shrub cover and diversity were lower in the east, as expected, with most sites failing these attributes.

Habitat inventories and sampling strategy

5.27 The LHI and HEAP inventories together were reasonable at identifying the approximate locations of heathland habitat (although 32% of selected sites were rejected for habitat reasons alone, ie did not contain sufficient heath). It is considered that only a small proportion, if any, of these ecological site rejections were the result of recent habitat loss since the inventories were compiled, because of the inclusive nature of the habitat definition used in this project. Therefore most must have arisen from inaccuracy in the original datasets. Though significant overlap occurred between the LHI and HEAP inventories (51% of sample stands, 34% of the whole population), many areas were picked up by only one inventory. Thus, continuation of their combined use and/or the production of a comprehensive and updated dataset is recommended.

5.28 However, both data sources contained extensive areas of non-heathland habitats, particularly rush pasture, woodland, dense bracken and grassland, which resulted in site rejection and similar numbers of sampled HEAP and LHI derived polygons were found to definitely not contain heath. (Additional rejections occurred due to the strict sample protocol specific to this project.) Both data sources also appear to have incomplete coverage (and surveyors reported heathland extending beyond either data source). The extent of this issue is not known, but further investigation and correction of the inventory is warranted. Examination of aerial photographs may assist in some cases (and it was found that many pre-survey rejections could be made on the basis of aerial photographs alone). There was also significant overlap with the 'Moorland Line', which has been used to define the upland areas of England and a clearer split between upland and lowland heath, with their separate condition assessment methodologies, is required.

5.29 An examination of the overlap between surveyed stands and the lowland grassland inventories showed some overlap with the heathland and grassland inventories (for purple moor grass and rush pasture and lowland dry acid grassland) across a range of counties from Lancashire to Cornwall. In the majority of cases where overlap occurred, at least some dwarf shrub habitat (though sometimes at <25% cover) was present. Whilst some overlap may be legitimate, it is suggested that it could be reduced by improved resolution and cross referencing of all inventories.

5.30 It was noted that there was some inconsistency in how fragmented heathland had been mapped within both the LHI and HEAP datasets. In some cases individual patches had been mapped within a single large site, but in other cases the larger site itself had been mapped. This is something which should be examined, as this inconsistency limits analyses based on the number of polygon areas or on heathland size. It may have resulted in over-representation of forestry and golf course sites within the population (through subdivision of large sites) and hence the sample.

5.31 The GIS processing employed during preparation of the whole non-statutory heathland population may also have reduced mean site (polygon) size; in cases where LHI polygons overlapped with HEAP, the outer HEAP areas were included as a separate habitat polygon. Only the smallest of these 'slivers' were removed. This resulted in an overlap of the two inventories of only 34% in the unmodified source datasets but 51% of the sampled stands (which sampled within the population without regard to the boundaries of the two different data sources). The impact of this on the sampling strategy is not thought to be serious however, as it was a relatively small influence compared to the overall site rejection rate of 72%.

5.32 Though the Lowland Heathland Inventory has wide coverage, the completeness of this coverage is not known. HEAP polygons added significantly to the known heathland population. However, since they were based on aerial photograph interpretation, there may be some bias towards the more visually obvious heathland sites. It was not possible to obtain an estimate of the actual heath area in the country by extrapolating from the % of surveyed polygons that were heath to

the wider population, because, particularly in large polygons, not all heathland present was mapped and surveyed.

5.33 A high rate of success was achieved in identifying, contacting and getting access permission from landowners. This was fortunate, as the sample could otherwise have been biased, perhaps towards sites with sympathetic owners who might be more likely to undertake conservation management.

Evaluation of the methodology

5.34 The primary attributes and targets used in this project were those listed as standard in the Common Standards SSSI Condition Monitoring guidance (Alonso and others 2003; JNCC 2004), together with some revised targets based on those recommended for species-poor sites. These targets were applied to the field data set strictly and objectively, usually using the mean of values for all stops to determine whether attributes were passed or failed. However, Alonso and others (2003) and JNCC (2004) actually advocate a more flexible and site-specific approach to condition monitoring. The targets in these guidance documents are designed to be flexible and, where appropriate, to be tailored to a degree to suit particular site edaphic conditions and vegetation characteristics. In England, statutory sites monitored with this methodology will have individual conservation objectives set. Their condition is then assessed relative to these site-specific objectives and targets. However, such flexibility in assessing attributes targets was not possible in this project, as prior knowledge of the sites and their management was limited and no site management objectives existed or where known; instead the generic targets were applied consistently. Though this inevitably differs to an unknown degree to how targets are applied on designated sites, it allowed the assessments to be both repeatable and comparable and provided an overall assessment of condition of the resource within a common framework. Further development of this framework needs careful consideration and should seek to find a balance between the usefulness of generic targets and more specific targets for different heathland types. The framework should be applicable even where heathlands are heterogeneous or different heathland types occur in mosaic.

5.35 The HLS targets cover a much narrower range of attributes and appear to be designed to be applied more strictly (though tailored Indicators of Success selected from a longer list are also set to assess the performance of individual agreements). Their use slightly increases the number of stands in good condition, though targets for dwarf shrub structural diversity were still a major cause of condition assessment failure.

5.36 A discussion of the appropriateness of the attributes, their targets and the sampling strategy used in this project follows.

Attributes

5.37 In some cases attributes were assessed at both the whole stand level and at individual stops (eg dwarf shrubs, trees and scrub, bracken and negative species). Mostly the measurement of an attribute estimated at these two scales was closely matched. This suggests that the structured walk gave a representative estimate of the attribute for a stand, with the additional advantage of being more objective and repeatable than a whole-stand estimate. However, in cases where the whole-stand estimate was significantly different, this has been recorded and could be used to modify the overall attribute level in future surveys and reports. The extent to which both approaches are representative will also depend on the extent to which the structured walk and stand walkover are representative of the stand as a whole. This could perhaps be improved by introducing random sampling, though this would be problematic due to stand areas not being known beforehand (resulting in them being confirmed and if necessary remapped in the field) and would be likely to increase fieldwork time.

5.38 The attribute results for the overall stand calculated from the mean of the individual stop data was used as the default value in this project. However, it should be noted that a single abnormally high or low result for an attribute at a single stop may result in the mean result for the whole stand

exceeding a target (eg 90% cover at one of 20 stops alone results in a mean value of 4.5% overall). This is potentially a problem with the relatively small sample size (20) where such abnormal results, which occur by chance, can have a significant effect on whether individual attributes are passed or not. Results were also discussed for median values in the 2005 interim report (Hewins & Toogood 2005), but generally showed no strong difference in pass rates compared with using means.

5.39 During the survey, a number of variables were recorded in addition to those needed for the condition assessment. These included overall percentage grass cover (at the whole stand level) and frequency (and sometimes cover) of species which, while not listed in the standard methodology, were thought by the surveyor to be of relevance and could be used as contextual data in the assessment.

5.40 There is some confusion in the existing methodological guidance as to the status of *Myrica gale*. In both Alonso and others (2003) and JNCC (2004), it is included as dwarf shrub in the field form, but a desirable forb in the attribute summary table. In the current project and report was included as a dwarf shrub.

5.41 The 'heavy grazing impact' attribute has included mat form (pseudo-pioneer) heather growth, which often arises from mowing rather than grazing. Consideration needs to be given to how acceptable mowing (eg on golf courses) might be separated from damaging overgrazing within this target.

5.42 It is important to note that the cover of *Pteridium aquilinum* changes throughout the year. In this project an attempt was made to predict the high summer cover of this species for sites surveyed earlier in the year.

5.43 Finally some species, particularly of trees and exotic species, were occasionally recorded in addition to those listed within CSM guidance. However their inclusion in the relevant attribute did not generally affect pass rates (except in two cases, as indicated in the results), suggesting that the standard lists are reasonably comprehensive. Nevertheless, surveyors sometimes recorded other significant species including some which could be considered to be positive/negative indicators, at least in the local context and the use of this extra data should be considered in any future review of the methodology.

Targets

5.44 Field experience of a wide geographical and ecological range of English heathlands has shown that many (but not all) of the standard condition assessment targets are probably fully appropriate across this range. These include cover of *Pteridium aquilinum*, exotic species, *Ulex europaeus*, *Rubus* species and dense acrocarpous mosses. However, a number of other targets are of more questionable appropriateness when applied universally.

5.45 Interestingly, the standard CSM targets for graminoid and desirable forb species diversity, are more frequently passed by heathlands in poor condition, with a large acid grassland element, than by stands with higher dwarf shrub cover. This may question the suitability of these targets, at least in the poor to intermediate condition heathlands. Only the very 'best condition' heathlands may pass this attribute and it is separating out such heathlands that the attribute may be most useful. Furthermore, the fact that the poorest sites may pass these attributes will influence the interpretation that is placed on the examination of percentage of attributes passed by each stand, as attribute passes are correlated (paras. 4.5 and 4.6). However, as Figure 7 indicates, there is also a link to management, in particular grazing. It is therefore very difficult to separate out when the lack of a suite of species is due to natural conditions or lack of appropriate management for long periods of time. Revision of the targets to lower thresholds for both graminoid and desirable forbs increased pass rates has helped to make the attribute more applicable across a wider range of heathland types.

5.46 The target for *Molina caerulea* in wet heath is more than occasional in the sward. Only one of the eight wet heathlands stands passed this target; the others all had a significant *Molina caerulea* element. Indeed the target even failed when applied to dry heath stands. This issue has also been identified in other studies that have suggested that this target (present in <33% of stops) may be too low (Ross & Bealey 2005). However, raising the threshold to 'no more than frequent' had no impact on pass rates in the current sample (12.5%), as the species was abundant in all stands which failed the target. In the west in particular, *Molinia* may occur at high frequency (but not necessarily high cover) even in dry/humid heaths (eg Glaves & Lakin 2004). Testing of a cover target (≤ 30%) resulted in a higher pass rate (29%) and is perhaps more appropriate for this species. Similarly there is some indication that, at least in some regions, sites may fail the *Deschampsia flexuosa* frequency dry heath target even though the cover target is met. This target was also failed in a survey of four SSSI Site Units on the large Quantock Common CSS agri-environment agreement (Nisbet 2005). However, in that case it had been decided not to apply this target.

5.47 All of the sites which exceeded the 50% upper threshold for dwarf *Ulex/Genista* species were in the far south-west where *Ulex gallii* heaths are found and are often grazed. Though this attribute was failed, these sites were often relatively species-rich, passing key targets for dwarf shrub cover, diversity, negative species and even positive indicator species. Increasing the upper threshold to 60% had little effect. The dwarf *Ulex/Genista* species target may need further review, particularly with regard to what is natural and acceptable in the different forms of western heath.

5.48 The estimates of growth stages which have been used to assess the dwarf shrub structural diversity targets were based only on *Calluna vulgaris* and *Erica cinerea*, though these species sometimes formed only a relatively small proportion of the total dwarf shrub cover, particularly in wet heathlands (where they only made up on average 9% of the total dwarf shrub cover) and south-western *Ulex gallii* heaths. Furthermore, given the extremely low pass rates, even for apparently 'good' sites, the targets themselves may not be appropriate and broader targets may be more suitable. However, this attribute is clearly related to heath management (by burning, cutting or restoration treatments) and the low pass rates to may some extent reflect a lack of active management. It should be noted that the dwarf shrub structural data collected for CSM condition assessment could not be directly related to HLS targets as different age-classes were used (para. 2.48). Consideration should perhaps be given to revision of the HLS targets.

5.49 In this project, targets were not applied for bryophyte and *Cladonia* species cover in dry heaths. The guidance suggests that these are usually site specific and should only be applied when 'naturally present' and be set by surveyors with detailed knowledge of a site (which was not the case in this project). The CSM guidance suggests dry heath targets of >10% cover for bryophytes and >5% for *Cladonia* species ('if specific to the site'). *Cladonia* species were rarely recorded in this survey. However, the average bryophyte cover was 5.5% and 17% of dry heathland stands exceeded 10% bryophyte cover (though the conservation value of the bryophyte species contributing to this cover is unknown). The target for *Sphagnum* species (>10%) was only applied in three of the wet heaths where this species group was present. Lichens were not recorded in any wet heath and so targets were not applied.

5.50 It may be useful for any review of the condition assessment methodology to consider a hierarchy of attributes, condition targets which perhaps only apply in certain types of heathland, additional attributes, or perhaps even more than one type of condition category. Finally it might be sensible to reduce the total number of attributes, since there are relatively high numbers of heathland targets (17; comprising 25 sub-targets) in dry heaths, compared to some other priority habitats (only eight in lowland meadow) and most sites failed those considered to be basic (eg dwarf shrub structure or cover).

5.51 Because this was only a baseline survey, that the length of time the agreement stands have been under agri-environment agreements was not known and because both change in extent and 'recovery' status of unfavourable stands cannot easily be shown by a single survey, a repeat survey is recommended to enable proper assessment of BAP targets. At this time it may be possible to apply more sophisticated analysis techniques, including examination of trends in

individual species and to examine further the condition within sub-sets of heathland types. Interpretation of findings could be improved by recording management information for the stands in more detail and would also allow application of a ‘favourable-recovering’ condition category based on management in place. Consideration could be given to the addition of new sites on a rolling programme.

6 Recommendations

Monitoring methods, attributes and targets

6.1 Consideration should be given to:

- the dwarf gorse *Ulex minor/U.gallii/Genista* species target, in particular in the South West where these species are naturally more abundant;
- the frequency/cover of *Molinia caerulea* in wet heaths, which may occur in high frequency without outcompeting other species; and similarly the frequency/cover of *Deschampsia flexuosa* in some dry heaths;
- the number of forb and graminoid species required;
- the convenience of adding further negative indicators (eg *Brachypodium sylvaticum* and *Phragmites australis* to the list of coarse grasses; *Ilex aquifolium* and *Sorbus aucuparia* to the list of tree/shrub species; *Buddleia* to the list of invasive exotic species);
- the status of *Myrica gale* as dwarf shrub or desirable forb;
- how acceptable mowing (eg on golf courses) might be separated from damaging overgrazing within overgrazing attribute;
- the inclusion of *Eriophorum vaginatum* with *E. angustifolium* in the list of wet heath graminoids;
- the addition of other species of *Carex* in the list of wet heath graminoids;
- clarification of the definition of 'acrocarpous mosses' (which in this project this was taken to mean just those mosses forming a dense impenetrable mat, rather than all mosses with an acrocarpous growth form in the strictest sense);
- a hierarchy of attributes and condition targets to only apply in certain types of heathland;
- a reduction in the total number of attributes; and
- CSM guidance providing more detailed guidance on stand selection, as choice of stand impacts greatly on the resulting condition assessment.

Updating the Lowland Heathland Inventory

6.2 In addition to providing an understanding of the condition of lowland heathland sites outside of SSSIs, this project has also identified concerns about the quality of the habitat inventories used to underpin this work.

6.3 The Lowland Heathland Inventory is based on the 1994 English Nature and RSPB original paper inventory. Where SSSIs were known to include heathland the entire site was included in the inventory. In the South West, data from Local Record Centres collated as part of the NBN South West Pilot has been used to update original records. The total extent of the LHI is 94,139 ha, which may represent an overestimate of the heathland resource as some of the areas have other habitats present. The UK BAP initial estimate of the extent of lowland heathland was 58,000 ha of which 55% was found in England. The RSPB HEAP inventory is based on soils data and analysis of aerial photography. The HEAP estimate of heathland is around 55,000 ha in England.

6.4 There is considerable overlap between the LHI and some of the other priority habitat inventories. In particular with fens (29,000 ha), undetermined grassland (26,418 ha), lowland dry acid grassland (7,341 ha) and upland heathland (6,418 ha). In all cases the vast majority of these overlaps (>90%) occur within SSSIs. Subsequent to the preparation of the LHI the main habitats for each SSSI management unit have now been attributed. Using site unit boundaries where lowland dwarf shrub heath is the main habitat reduces the extent of inventory heathland on SSSIs from 70,454 ha to 48,765 ha. The overlap of the LHI and the lowland dwarf shrub heath site units

is around 20,000ha. This shows strong coincidence with the Land Cover Map 2000 (LCM2000) dwarf shrub heath class which has around 18,000 ha overlap with the dwarf shrub heath site units.

6.5 The population of heathland sites outside of SSSIs was taken from English Nature's LHI with additional sites from RSPB's HEAP inventory since neither of these inventories provided full coverage of known heathland sites. Once slivers have been removed, 3,738 polygons covering 33,403 ha exist in the combined inventories outside of SSSIs. As discussed earlier in this report, of the 347 sample sites selected 187 were rejected at the mapping stage, 25 pre-survey and 44 on survey or post survey. This suggests that a high proportion of the area in the combined inventories may not be lowland heathland according to the BAP definition.

6.6 The correlation between LCM2000 and the lowland heathland inventory outside of SSSIs was quite poor. Although only one of the rejected sites was coincidental with a LCM heath polygon, only one third of known sites were coincidental. Comparing soil data for known heathland and non-heathland sites the range of associated habitat types is not dissimilar. However looking at the soil data for all lowland heathland inventory sites, around one quarter occur on soils not associated with lowland heathland.

6.7 This project has demonstrated that a large proportion of non-heathland sites can be identified through interpretation of aerial photographs, knowledge of specific sites and third party datasets. It does not, however, appear that outside of designated sites such sites can be identified accurately through an automated process.

6.8 In summary the following recommendations are made regarding the inventories:

- For the lowland heathland inventory within SSSIs the boundaries should be refined based on site unit data, LCM2000 and aerial photography.
- Where lowland heathland polygons overlap with upland heathland polygons/inventories then decisions should be made as to which habitat is present. Equally, decisions should also be made for lowland heathland polygons occurring within the moorland boundary, taking into consideration slope and altitude.
- Outside of SSSIs, it is recommended that the inventories are updated based on a process similar to that of the South West Pilot and Grassland Inventory process. The inventories would be updated based on recent survey data, knowledge of sites and aerial photograph interpretation. This process would be most effective if undertaken as part of a process of updating all the habitat inventories for an area. This would help to address overlaps between habitat inventories.
- A rule base for the interpretation of data sources should be created to ensure consistent application. In particular, this should define the reliability of different sources of data for updating the inventories and the priority considering the age of data sources.

Repeat survey

6.9 It is recommended that the survey is repeated at regular intervals, possibly with the rolling addition of new sites, to enable proper assessment of BAP targets.

Policy developments

6.10 Policy developments and approaches to policy implementation could be used to facilitate improvements in heathland condition, for example:

- Continuation of raising awareness of the importance of lowland heathland.

- Protection of lowland heathlands from further loss and damage through appropriate legislation, including a program for the designation of more heathland sites.
- Ensuring appropriate monitoring of lowland heathland, both within and outside of SSSIs.
- Targeting agri-environment agreement initiatives to lowland heathland sites. Having a reliable and up to date heathland inventory would facilitate this.
- Improving uptake of lowland heathland sites into agri-environment agreements and ensuring that the tiers/options are appropriate for restoration of heathland towards favourable condition.
- Monitoring the way agri-environment scheme options are being applied.
- Providing financial support to local schemes that aim to advise and support land managers, particularly those outside of agri-environment agreements. This should be effectively targeted to be most cost-effective.
- Funding and encouraging further research into the best management practices for lowland heathland, particularly in the face of future threats (climate change, atmospheric nutrient enrichment, etc).

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Appendix 1 Heathland types included in the sample

Plate A. Heathland with good dwarf cover and managed primarily for conservation objectives

This stand is large and though varied, the dwarf shrub cover is consistently high. *Calluna vulgaris* and *Vaccinium myrtillus* dominate in varying proportions, but *Erica cinerea* and *Ulex minor* are also present at low cover locally. Bracken, though frequent, is of lower cover. Birch and pine saplings invasion occurs patchily, dense in places.

Plate B. Heathland undergoing conservation bracken management

The site has been actively managed for at least the past 10 years. Management has included annual cutting of bracken, which is said to have successfully weakened the bracken which was previously over 2m tall. In the year previous to this photograph the bracken was also sprayed with Asulox. Subsequent

regeneration of pioneer heather has occurred since then. Substantial amounts of Rhododendron have been removed. The site was being grazed at the time of survey.

Plate C. Heathland associated with rotational forestry management

The site was essentially forestry plantation, comprised of various aged stands. Heathland habitat occurred as a dwarf scrub layer on the forest floor, ericoid cover tended to vary with the maturity of the forestry stand. The cover of *Calluna vulgaris*, *Molinia caerulea* and *Erica tetralix* was typically highest beneath recently planted forestry stands, with vigorous regeneration of *Calluna vulgaris* which reached over 1m tall and lowest under more heavily shaded mature stands.

Plate D. Heathland under extensive heathland restoration schemes

The stand was completely (or nearly) cleared of scrub during August 2005 as part of a heath restoration scheme. Consequently, excluding two oak trees and some scattered leggy *Ulex europaeus* bushes, the stand was mostly bare ground, oak/birch stumps, bracken litter and occasional weeds. In a few places a few leggy *Calluna vulgaris* bushes persist and *Molinia caerulea* occurred locally too – in areas which were not previously scrub.

Plate E. Heathland associated with golf courses and racecourses

This course had significant patches of heathland. Most had fairly high cover of *Calluna vulgaris*, apparently mown to a low height. *Calluna vulgaris* occurs elsewhere in mown *Molinia caerulea* stands but at low cover, so not included as part of the stand.

Plate F. Grazed *Ulex gallii*-rich heaths in the south-west of the country

The stand had a very high dwarf shrub cover, though this varies in the relative proportion of the component species and in height. Bracken (and bramble) were invading only very locally.

Plate G. Un-grazed *Ulex gallii*-rich heaths in the south-west of the country

The stands of *Ulex gallii* contained remnants of heathers (*Calluna vulgaris* and *Erica cinerea*). Elsewhere *Ulex europaeus* was dominant.

Plate H. Lichen heath with relatively low cover of dwarf shrubs

The stand was very varied. Half was a mosaic of clumps of bramble and short grazed rabbit lawns, with little heather present (though tiny plants are present very rarely). The other half contains some significant patches of heather, but also rabbit lawns with abundant lichen and scrub dense locally.

Plate I. Wet heath with *Myrica gale*

Wet heath with *Myrica gale*. The stand was very tussocky and wet, dominated by Molinia caerulea with *Erica tetralix* and *Myrica gale*. The whole area is crossed with peaty streams.

Plate J. Wet heath without *Myrica gale*

Plate K. Damage by recreational driving

The many wide gravel tracks were excluded from the stand. The heath areas in between these tracks were fairly short and grassy.

Plate L. Damage by arson

This area had almost all been burnt (*Ulex europaeus* and Cytisus scoparius). The areas in between had *U. europaeus*, *Rubus fruticosus* and *Pteridium aquilinum* (under management) and heathers (*Erica cinerea* and *Calluna vulgaris*, much of which was mature/degenerate). Litter was thick (which could be problematic for regeneration) and bare ground was only present on paths.

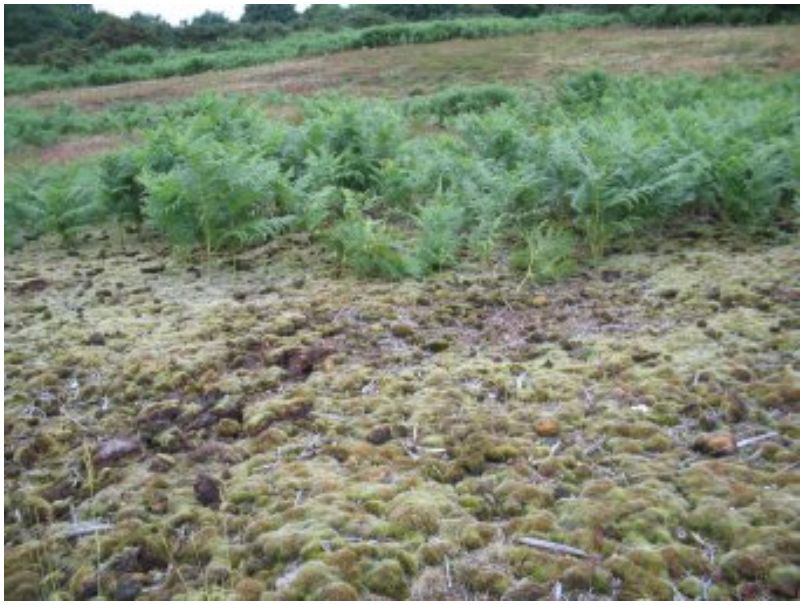

Plate M. Heathland with dominance of dense acrocarpous mosses

Plate N. Heathland invaded by exotic species (bamboo)

Plate O. Heathland invaded by *Deschampsia flexuosa*

Plate P. Heathland invaded by scrub

The stand was dominated by *Ulex gallii* with abundant scrub species including *Salix triandra*, *Betula pendula* and *Rubus fruticosus agg*., the latter, dense in places. The sparse heathers (*Calluna vulgaris* and *Erica tetralix*) recorded, occurred at the gorse dominated peripheries of the habitat patch. Some small patches of pioneer heather were recorded in the grassier areas. Cattle have created paths through the habitat and some rolling /cutting has occurred, presumably to provide a route for farm vehicles through the site.

Plate Q. Grassland maintained by rabbit grazing and recreational trampling (showing positive impact of rabbit exclusion on heather growth)

There was only localised heather, all is rabbit grazed stunted mats (1-5cm tall), in an acid grassland matrix with lots of *Rumex acetosella*. There was one exclosure, where sward heights were 10-20cm.

Appendix 2 Landowner letter

Rural Development Service
Technical Advice Unit
Woodthorne,
Wergs Road,
Wolverhampton.
WV6 8TQ
Website: www.defra.gov.uk/rds/wm/

DAT

Dear

ENVIRONMENTAL MONITORING OF HEATHLANDS (SITE ID)

You might be aware that, from time to time, Defra monitors the environmental impact of its policies on landscape, wildlife and the historic environment.

Defra is currently supporting a project (jointly with English Nature) to establish the extent and condition of heathland habitats. This involves looking at a sample of sites that have been identified as potentially containing heathland vegetation, some under agri-environment agreement and some not under agreement. The objective of the project is to obtain data from a representative sample of sites and use this to look at the changes that have occurred on heathland in the countryside as a whole as well as comparing trends on land in agri-environment schemes with land not in agreement. It will also provide a baseline for looking at future changes.

The land shown on the attached map has been selected as part of the non agri-environment scheme sample, and our records indicate that you may be the owner or occupier of this land. We would be very grateful if you would allow our contract surveyors (from Just Ecology Environmental Consultancy) to access the land and undertake a brief survey of the vegetation present. This would involve the surveyors walking 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 list of all the plant species found by the surveyors on your land will be prepared and sent to you in the autumn.

We would also be grateful if you could also use the enclosed form to provide some simple information, to confirm that you are the owner/occupier of the land, and to enable the Just Ecology surveyors to arrange access more easily. A SAE is enclosed for the purpose of returning this form. This will be followed up by a brief telephone call to arrange a mutually convenient survey date.

I can assure you that any information gathered will remain strictly confidential. Individual field data will not be published or made available to any third party. Only aggregated results and conclusions will be reported.

If there are any points you wish to discuss about this request, please do not hesitate to contact me.

Yours sincerely

Andrew Cooke
RDS Technical Advice Unit
Direct Line: 01902 693390
Email: Andrew.i.cooke@defra.gsi.gov.uk

ENVIRONMENTAL MONITORING OF HEATHLANDS (site ID)

We would be grateful if you complete and return the following brief form. Alternatively, please call the surveyors direct on 01454 269650, Fax 01454 269651, or email eleanor@justecology.co.uk.
Thank you!

Are you the owner of the land shown on the enclosed map? **Yes/no**

If no, please give the contact details of who you think might own the land:

……

……

……

If yes, are you happy for the land to be included in the survey? **Yes/no**

If you **do** own the land, and **are** happy for it to be included in the survey, please confirm the details below so that we will be able to contact you to arrange our visit:

Are the following address details correct? **Yes/no**

If no, please give correct details:

……

……

……

Do we need to phone you to let you know when we are coming? **Yes/no**

If yes, please give the best telephone number to contact you on:

……

When is the best time to contact you?

……

Is the land shown in an agri-environment scheme? **Yes/no**

If yes, when did the agreement start?

……

Is the land heathland, or is there heather growing on the land shown? **Yes/no**

Please let us know if there are any special access or bio-security arrangements for the land:

……

……

……

……

Appendix 3 Field form

Lowland Heathland - Condition Assessment field form *Project FST 20-32-065. Just Ecology 2005-2006.*

Site Name/N°: County/nearest town:…… (N° stands:……..)		**Grid reference:**	**Assessed by:**
Date:……/……../……	**Time on site** (hours)	**Photographs taken. P…….. to P…….**	**NVC type (if available)**

Key management activities affecting condition (circle):		**Other activities likely to have an impact (? or + or -)**	
Grazing	Rolling and chain harrowing	Farming/agriculture events	Natural
Burning (management /accidental)	Bracken management	Conservation activities	Military activities
weed control	Heather cutting/mowing	Urban development	Mineral extraction
Scrub control	Functioning artificial drainage	Recreation/tourism	Forestry
Recent forest clearance	Other (specify):	Infrastructure/transport	Water abstraction
Active Management	Yes/No		
Agri-env. schemes/grants	Yes/No (type: CSS/ESA/WES)		

Type of heath Wet Dry Limestone Dune Lichen

Comments
Including general site description, NVC type(s) if known, rationale for stand selection, site boundaries, notes of important species, management information, information from the landowners etc.

Whole stand: (*only give if different from average cover of the stops on the structured walk (ie walk not representative)

Attribute		**% Cover**	**DAFOR**	**Comments** *(including justification of why whole stand estimate is different from the sum of the average cover of the stops)*
Total dwarf shrubs*				
Calluna / Erica growth phases* (add up to 100%)	Pioneer			
	Building/mature			
	Degenerate			
	Dead			
	Undifferentiated			
Negative species*				
Undisturbed bare ground*				
Disturbed bare ground*				
Trees and scrub*				
Bracken*				*Note if % cover is likely to be equal to or greater than 10% in high summer.*
*Ulex europaeus**				
Obvious visible pollution (eg run-off)				
Average dwarf shrub height (cm)*				
heavy grazed/mown dwarf shrubs (carpet, topiary drumstick) as % total DShrub cover.				
Total grass cover				
Pools				

Structured 'W' walk NB: Record absolute values for % cover**.** An A4 sheet is approx. 1.5% of a 2x2m quadrat. 6.32 x 6.32cm is 0.1%.

Attribute	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
% cover bare ground (not rock or litter, but including tracks/paths and peat)																				
Undisturbed(include small paths)*****																				
Disturbed ground/erosion/poached*****																				
% cover vegetation structure																				
TOTAL % cover dwarf shrubs*****•																				
Dwarf shrub heavy grazing impact♥																				
Average height of dwarf shrub (cm)																				
% of total *Calluna /Erica* Building/Mature (add Degenerate to 100%) Undifferentiated — Pioneer																				
—																				
—																				
— Dead																				
—																				
Vegetation composition See lists below, cover or presence as requested.. Include any other species if relevant to the site.																				

Dwarf shrubs* % cover of any of the following species: *Arctostaphylos uva-ursi, Calluna vulgaris, Erica ciliaris, Erica cinerea, Erica tetralix, Erica vagans, Ulex gallii, Ulex minor, Vaccinium myrtillus, V. vitis-idaea, Genista anglica (G. pilosa), Empetrum nigrum* Wet heaths: *Myrica gale, Salix repens.* Also record *Ulex* & *Genista* spp. combined (not *U. europaeus*). RECORD SEPARATELY BUT ALSO GIVE A COMBINED %.•

Graminoids(*) Presence or % cover***** of any of the following species: *Agrostis* spp.*, Ammophila arenaria, Carex* spp., *Danthonia decumbens, Deschampsia flexuosa*, Eleocharis* spp.*, Eriophorum angustifolium, Festuca* spp., *Molinia caerulea*, Nardus stricta*, Trichophorum cespitosum.* Wet heaths: *Carex panicea, Carex pulicaris, Juncus acutiflorus, Juncus articulatus, Rhynchospora alba, Schoenus nigricans*.*

Desirable forbs Presence of any of the following species (record others if appropriate).*Armeria maritima, Galium saxatile, Genista anglica, Hypochaeris radicata, Lotus corniculatus, Plantago lanceolata, Plantago maritima, Polygala serpyllifolia, Potentilla erecta, Rumex acetosella, Scilla verna, Serratula tinctoria, Thymus praecox, Viola riviniana.* Limestone heath*: Filipendula vulgaris, Galium verum, Helianthemum nummularium, Sanguisorba minor.* Dune heath: *Aira praecox, Corynephorus canescens, Phleum arenarium, Erodium cicutarium, Filago minima, Sedum acre, Peltigera.* Wet heath: *Anagallis tenella, Drosera* spp, *Narthecium ossifragum, Pinguicula* spp, *Succisa pratensis.*

Bryophytes* Grouped % cover of all spp. (except dense acrocarpous spp. and *Sphagnum* spp.) eg, *Dicranum scoparium, Hylocomium splendens, Hypnum cupressiforme, Pleurozium schreberi, Polytrichum* spp.*, Racomitrium lanuginosum*

Sphagnum spp. * Grouped % cover of all spp.

Dense mats of acrocarpous mosses* Grouped % cover of mats of all spp. eg *Campylopus introflexus*

Lichens * Grouped % cover of all spp. Grouped % cover of ***Cladonia* spp***

Negative species* % cover of the following species: *Cirsium arvense, Digitalis purpurea, Epilobium spp. (excl. E. palustre), Chamerion angustifolium, Juncus effusus, J. squarrosus*, *Ranunculus repens,* other *Ranunculus* spp. *Rumex obtusifolius, Senecio* spp, *Urtica dioica,* "coarse grasses"♦, Wet heaths: *Apium nodiflorum, Glyceria fluitans, Oenanthe crocata, Phragmites* spp, *Typha* spp.

Invasive exotic species* % cover of the following species: *Rhododendron ponticum, Gaultheria shallon, Fallopia japonica* and others (list).

Trees and scrub* % cover of eg: *Alnus glutinosa, Betula* spp.*, Prunus spinosa, Pinus* spp.*, Rubus* spp.*, Cytisus scoparius, Quercus* spp.*, Hippophae rhamnoides, Salix* spp. **and others** (list).

Pteridium aquilinum* % cover. ***Ulex europaeus**** % cover

Indicators of local distinctiveness - Rare species, pools, edges
Eg. *Cicendia filiformis, Cladonia arbuscula, Cladonia incrassata, Cornicularia* spp., *Gentiana pneumonanthe, Hammarbya paludosa, Lycopodiella inundata, Radiola linoides, Rhynchospora fusca, Viola lactea*, etc. (see lists for individual natural areas)

Appendix 4 Supporting data

The following supporting data will be supplied with the final version of this report:

MapInfo GIS

Stand_boundary polygons.TAB

Attributed with site number, site name, survey data, area (ha), stand number, heathland type, AE status, comments and survey details (Heathland Sample Survey 2005/2006. Just Ecology Environmental Consultancy. FST20-32-065).

Routeofwalk polyline.TAB

Attributed with site number, comments and survey details (Heathland Sample Survey 2005/2006. Just Ecology Environmental Consultancy. FST20-32-065).

Photo_points points.TAB

Attributed with site number, photo number, comments and survey details (Heathland Sample Survey 2005/2006. Just Ecology Environmental Consultancy. FST20-32-065).

Target_notes points, polygons and polylines.TAB

Attributed with site number, comments and survey details (Heathland Sample Survey 2005/2006. Just Ecology Environmental Consultancy. FST20-32-065).

Excel

Raw data spreadsheets:

Including all raw data, including counts at individual stops, pass rates, other information including additional species records and comments and group summaries.

Landowner contact and site rejection spreadsheets:

Details of sites written to, pre-survey and on-survey rejection, landowner details.

MS Word

Final report:

This report in electronic format.

Site descriptions

Site descriptions and photographs.

Image files

All site photographs in electronic format, named by site ID and photo number.

Paper

Dossiers:

Folders for all surveyed, including basemaps, aerial photographs field maps, field survey forms, GIS print out of final survey map, all landowner correspondence and any other relevant information.

Labelled showing site ID, agreement category, county, government region etc.

Appendix 5 Sampled sites

The surveyed stands, showing heathland type, agri-environment agreement (AE) category, designations/ownership, feature status and other self-explanatory headings (* two stands at this site).

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
916	dry	2006	Cornwall	CSS	Open Access	LHI	DSH	17.741	Council
791	dry	2006	Cornwall	CSS	Open Access	BOTH	DSH	0.84	Council
2397	dry	2006	Cornwall	CSS	Open Access	HEAP	DSH	11.63	Council
2579	dry	2005	Devon	CSS	Common land	HEAP	DSH	3.312	LNR
4771	dry	2006	Dorset	CSS	Open Access	HEAP	DSH	13.53	National Trust
4753	dry	2005	East Sussex	CSS		HEAP	DSH	4.252	Private
1201	dry	2006	East Sussex	CSS		HEAP	DSH	4.824	Golf course
2140	dry	2006	East Sussex	CSS		HEAP	DSH	4.59	Golf course
171*	dry	2006	Halton (Cheshire)	CSS	Open Access	LHI	DSH	3.92	Council
437	dry	2006	London (Bromley)	CSS		LHI	DSH	0.54	Commoners Association
2127	dry	2006	Sheffield (S. Yorkshire)	CSS	Open Access (part), Common land (part)	HEAP	DSH	20.52	Council
297	dry	2006	Shropshire	CSS		LHI	DSH	1.78	Council
1117	dry	2005	Somerset	CSS		BOTH	DSH	2.792	Private
153	dry	2006	Staffordshire	CSS	Common land	BOTH	DSH	5.47	Council
368	dry	2006	Suffolk	CSS	Common land	LHI	DSH	2.71	Council

Table continued …

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
2701	dry	2006	Suffolk	CSS		HEAP	DSH	0.2	Private
440	dry	2006	Surrey	CSS		BOTH	DSH	5.3	Private
4809	dry	2006	Surrey	CSS	Common land	HEAP	DSH	7.46	Wildlife Trust
442	dry	2006	Surrey	CSS		LHI	DSH	2.8	Private
2315	dry	2005	West Sussex	CSS	Common land	BOTH	DSH	23.508	National Trust
1247	dry	2005	West Sussex	CSS	Common land	BOTH	DSH	7.506	National Trust
65	dry	2006	Cumbria	CSS	Open Access	BOTH	DSH	14.92	Private
716	dry	2006	Cornwall	ESA		BOTH	DSH	0.82	Private
737	dry	2006	Cornwall	ESA		BOTH	DSH	0.52	Private
2514*	dry	2006	Cornwall	ESA		BOTH	DSH	4.97	Private
1178	dry	2006	Devon	ESA		LHI	DSH	2.27	Private
1189	dry	2005	Somerset	ESA	Open Access	LHI	DSH	0.758	FC managed
2387*	dry	2006	Berkshire	non	Common land	BOTH	DSH	12.9	Commoners Association
1410	dry	2006	Berkshire	non		HEAP	DSH	2.95	Private
75	dry	2006	Bolton	non		LHI	DSH	0.78	Golf course
844	dry	2006	Cornwall	non	Open Access (part)	BOTH	DSH	2.99	Minerals Company
628	dry	2006	Cornwall	non	Open Access	BOTH	DSH	10.3	Private
1654	dry	2006	Cornwall	non		HEAP	DSH	0.79	Private
2456	dry	2006	Cornwall	non	Open Access	BOTH	DSH	1.09	Council(/private)
5059	dry	2006	Cornwall	non		BOTH	DSH	0.78	Parish council
808	dry	2006	Cornwall	non		BOTH	DSH	1.96	Parish council
881	dry	2006	Cornwall	non	Common land	BOTH	DSH	0.94	Private

Table continued …

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
604	dry	2006	Cornwall	non	Open Access	BOTH	DSH	5.56	Private
2267	dry	2006	Cumbria	non		HEAP	DSH	1.96	Private
4283	dry	2006	Devon	non		BOTH	DSH	12.04	Racecourse
4319	dry	2006	Devon	non		BOTH	DSH	12.743	Golf course
1056	dry	2006	Devon	non	Common land	LHI	DSH	6.73	Private
2355	dry	2006	Dorset	non		BOTH	DSH	1.83	FC
1034	dry	2006	Dorset	non		LHI	DSH	0.58	Private
4479	dry	2006	Dorset	non		HEAP	DSH	0.45	Private
2663	dry	2005	Gloucestershire	non		HEAP	DSH	3.403	FC owned
565*	dry	2006	Gloucestershire	non		BOTH	DSH	10	FC
4664	dry	2006	Gloucestershire	non		HEAP	DSH	3.7	FC
1345	dry	2005	Hampshire	non		HEAP	DSH	4.492	FC managed
156	dry	2006	N. Staffs	non		BOTH	DSH	0.78	Golf course
330	dry	2006	Norfolk	non		BOTH	DSH	2.31	FC
2336	dry	2006	Poole	non	Open Access	BOTH	DSH	7.03	Golf course
2245	dry	2006	Suffolk	non	Common land	BOTH	DSH	6.27	Golf course
478	dry	2005	Surrey	non	Common land	LHI	DSH	0.715	National Trust
457	dry	2006	Surrey	non	Common land	LHI	DSH	0.79	Golf course
2217*	dry	2006	West Sussex	non		HEAP	DSH	0.29	Private
497	dry	2006	Wokingham	non		BOTH	DSH	1.53	National Trust
233	dry	2005	Cannock (Staffordshire)	CSS	Common land	BOTH	O	22.299	LNR

Table continued …

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
178	dry	2006	Cheshire	CSS	Common land	LHI	O	0.73	Wildlife Trust
893	dry	2006	Cornwall	CSS	Common land	LHI	O	3.812	Private
3924	dry	2006	Cornwall	CSS	Open Access	BOTH	O	0.71	Private
1379*	dry	2006	Dorset	CSS		HEAP	O	2.08	Private
171*	dry	2006	Halton (Cheshire)	CSS	Open Access	LHI	O	3.92	Council
2761	dry	2005	Hampshire	CSS	Open Access	BOTH	O	0.514	Private
1976	dry	2006	Norfolk	CSS		BOTH	O	1.93	Council
1914	dry	2006	Suffolk	CSS	Common land	HEAP	O	0.36	Council
371	dry	2006	Suffolk	CSS	Common land	BOTH	O	0.5	Council
2292	dry	2005	Surrey	CSS	Common land	BOTH	O	8.076	Wildlife Trust
694	dry	2006	Cornwall	ESA		LHI	O	1.66	Private
304	dry	2005	Shropshire	ESA		LHI	O	1.54	Private
364	dry	2006	Suffolk	ESA	Open Access	BOTH	O	4.56	Wildlife Trust
2387*	dry	2006	Berkshire	non		HEAP	O	1.89	Commoners Association
30	dry	2006	Co Durham	non		LHI	O	2.06	Part council (part private)
5068	dry	2006	Cornwall	non	Open Access	HEAP	O	1.02	Private
2503	dry	2006	Cornwall	non	Open Access	BOTH	O	2.35	Private
1620	dry	2006	Cornwall	non		HEAP	O	2.04	Private
2514*	dry	2006	Cornwall	non	Open Access	BOTH	O	6.336	Private
1583	dry	2006	Cornwall	non		HEAP	O	3	Private
2095	dry	2006	Cumbria	non		HEAP	O	2.28	Private
4112	dry	2006	Dorset	non		BOTH	O	2.39	MOD

Table continued …

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
4542	dry	2006	Dorset	non	Common land	HEAP	O	0.37	Minerals Company
383	dry	2006	Essex	non		LHI	O	0.42	Golf course
565*	dry	2006	Gloucestershire	non		BOTH	O	0.937	FC
541	dry	2005	Hampshire	non	Common land	LHI	O	3.205	Council
1343	dry	2005	Hampshire	non		HEAP	O	4.019	Private
8	dry	2005	Hampshire	non	Common land	BOTH	O	1.804	Parish Council
2312	dry	2006	Hampshire	non	Common land	BOTH	O	1.49	Private
2823	dry	2006	Northumberland	non		LHI	O	7.98	Golf course
2650	dry	2006	Nottinghamshire	non		BOTH	O	1.9	FC
250	dry	2006	Nottinghamshire	non	Open Access	BOTH	O	4	Private
2648	dry	2006	Nottinghamshire	non		BOTH	O	2.17	Private
3502	dry	2005	Surrey	non		BOTH	O	22.4	MOD
2218	dry	2005	West Sussex	non		HEAP	O	3.85	Private
2217*	dry	2006	West Sussex	non		HEAP	O	0.75	Private
629	dry	2006	Cornwall	CSS	Open Access & Common land	BOTH	X	2.43	Heritage Trust
2428	dry	2006	Cornwall	CSS	Open Access	BOTH	X	3.04	Private
1163	dry	2005	Devon	CSS		HEAP	X	0.579	Private
1850	dry	2005	Surrey	CSS		HEAP	X	1.95	Council
2719	dry	2005	Somerset	ESA		BOTH	X	11.205	Private
545	dry	2006	Hampshire	Non		LHI	X	3.08	FC

Table continued …

Site	Type	Survey Year	County/Unitary Authority/ Metropolitan District	AE	Access	Data source	Feature status	Area (ha)	Designations/ ownership
2078	dry	2005	Shropshire	Non	Common land	HEAP	X	1.673	Council
2598	Dry (lichen)	2006	Suffolk	Non		BOTH	R	1.46	Private
1379*	wet	2006	Dorset	CSS		HEAP	R	1.1	Private
2570	wet	2005	Somerset	ESA		BOTH	DSH	0.594	Private
1613	wet	2006	Cornwall	non		HEAP	DSH	1.12	Private
3912	wet	2006	Cornwall	non		LHI	O	0.13	Private
2572	wet	2005	Devon	non	Common land	BOTH	DSH	4.361	Private
989	wet	2006	Dorset	non		BOTH	O	0.36	FC
146	wet	2006	Staffordshire	CSS	Common land	BOTH	O	7.3	Council
2786	wet	2005	Hampshire	WES		BOTH	O	12.434	Private
534	chalk	2005	West Sussex	ESA		LHI	O	0.16	Conservation Trust
***=6**	Dry=101 Wet=8 Lichen =1 Chalk =1			**CSS=39** **ESA=11** **WES=1** **Non=60**	**Common land = 25 %** **Open Access =23 %**	Both=53 LHI=25 HEAP=33	DSH=63 O=41 X=7	Min: 0.13 Max: 23.51 Mean: 4.26	**Council = 18** **Commons Assoc. = 3** **FC = 11** **Golf Course = 10** **Heritage Trust = 1** **LNR = 2** **Minerals Company = 2** **MOD = 1** **NT = 5** **Conservation/ Wildlife Trust = 5** **Parish Council = 3** **Private = 49** **Racecourse = 1**

Appendix 6 Raw attribute data

Table A. Mean (SE) attribute levels for the dry heath sample (all stands), both overall and within and outside of agri-environment agreements (number of stands in brackets)

Attribute	(nos.)	Target	Chalk O AE (1)	All (95)	Dry DSH&O AE (41)	Non-AE (54)
Undisturbed bare ground %		1-10%	0	2.4 (0.39)	2.3 (0.53)	2.4 (0.56)
Disturbed bare ground %		<1%	0	1.1 (0.53)	0.4 (0.19)	1.6 (0.92)
Heavy grazing impact %		<1%	0	9.8 (2.59)	9.2 (4.12)	10.2 (3.36)
Dwarf shrub height (if recorded) (cm)			n/a	40.8 (2.52)	40.5 (4.47)	41.1 (2.96)
Dwarf shrub cover %		25-90%	1.015	36.4 (2.52)	38.5 (3.71)	34.7 (3.44)
Proportion pioneer %		10-40%	n/a	19.1 (2.98)	22.1 (4.88)	16.7 (3.70)
Proportion building/mature %		20-80%	n/a	69.2 (2.95)	66.2 (4.62)	71.5 (3.83)
Proportion degenerate %		<30%	n/a	9.1 (1.47)	9.3 (2.09)	9.0 (2.08)
Proportion dead %		<10%	n/a	2.4 (0.80)	2.2 (0.69)	2.6 (1.35)
% of dwarf shrubs contributing to estimate of structural diversity			100	70.5 (3.37)	66.6 (5.41)	73.5 (4.26)
Nardus stricta cover %		<25%	0	0.4 (0.20)	0.3 (0.27)	0.5 (0.30)
Deschampsia flexuosa cover %		≤O	0	6.8 (1.38)	7.3 (1.73)	6.5 (2.05)
Total grass cover %			50	27. (2.81)	25. (3.82)	28. (4.04)
Ulex europaeus cover %		<25%	0	6.1 (1.29)	7.9 (2.16)	4.8 (1.57)
Listed trees & scrub cover %		<15%	0.49	6.9 (1.14)	6.6 (1.67)	7.2 (1.56)
Rubus spp. cover %		<1%	0	2.4 (0.47)	3.5 (0.93)	1.6 (0.41)
Dwarf *Ulex/ Genista* spp. (% of total dwarf shrubs)		<50%	0	18.8 (2.94)	20.5 (4.92)	17.5 (3.62)
Pteridium aquilinum cover %		<10%	0.49	8.0 (1.33)	7.4 (2.05)	8.5 (1.77)
Listed exotic spp. cover %		<1%	0	0.1 (0.12)	0.0 (0.02)	0.2 (0.21)
Negative indicators cover %		<1%	0	2.6 (0.52)	2.3 (0.57)	2.9 (0.81)
All injurious weeds cover %			0.49	10.8 (1.42)	9.7 (2.09)	11.6 (1.94)

Table continued …

Attribute (nos.)	Target	Chalk O AE (1)	All (95)	Dry DSH&O AE (41)	Non-AE (54)
Dense acrocarpous mosses cover %	<O	0	0.70 (0.28)	1.19 (0.61)	0.32 (0.17)
Dense acrocarpous mosses frequency (stops)		0	1 (0.23)	1.58 (0.49)	0.55 (0.15)
Bryophyte frequency (stops)		5	8.61 (0.59)	9.14 (0.93)	8.20 (0.77)
Bryophyte cover %		0.25	5.82 (0.78)	6.78 (1.46)	5.08 (0.82)
Deschampsia flexuosa frequency (stops)		0	5.41 (0.69)	6.19 (1.04)	4.81 (0.93)
Dwarf shrub diversity (number of spp.)		1	2.86 (0.12)	3.04 (0.18)	2.72 (0.15)
Exotics frequency (stops)		0	0.13 (0.07)	0.17 (0.10)	0.11 (0.09)
Number of listed desirable forbs at least Occ (number of spp.)		5	1.01 (0.11)	0.90 (0.15)	1.09 (0.15)
Lichen cover %		0	0.68 (0.41)	0.08 (0.05)	1.13 (0.72)
Lichen frequency (stops)		0	1.44 (0.30)	1.31 (0.38)	1.53 (0.44)
Listed desirable forb diversity (number of spp.)		5	1.93 (0.16)	1.78 (0.21)	2.05 (0.23)
Listed graminoid diversity (number of spp.)		3	3.15 (0.12)	3.34 (0.15)	3.01 (0.17)
Molinia caerulea frequency (stops)		0	6.33 (0.74)	5.75 (1.17)	6.77 (0.96)
Molinia caerulea cover %		0	7.15 (1.19)	5.76 (1.92)	8.17 (1.51)
Negative species frequency (stops)		18	4.88 (0.50)	4.78 (0.68)	4.96 (0.72)
Number of dwarf shrub spp. at least frequent		1	1.66 (0.10)	1.75 (0.14)	1.59 (0.14)
Number of listed graminoid spp. at least occasional		3	2.36 (0.11)	2.41 (0.16)	2.33 (0.15)
Frequency of all dwarf shrubs (stops)		9	14.9 (0.48)	15.2 (0.66)	14.6 (0.68)
Frequency of all trees/scrub (stops)		13	8.12 (0.66)	8.58 (1.02)	7.77 (0.88)
Pteridium aquilinum frequency (stops)		0	6.30 (0.60)	7.09 (0.97)	5.70 (0.77)
Rubus spp frequency (stops)		13	5 (0.57)	5.41 (0.95)	4.68 (0.70)

Table B. Mean (SE) attribute levels for the dry heath sample, for 'Dwarf Shrub' Heath and 'Other' heath stands (number of stands in brackets)

		Dry			
		AE		Non-AE	
Attribute (nos.)	Target	DSH (27)	O (14)	DSH (30)	O (24)
Undisturbed bare ground %	1-10%	2.6 (0.75)	1.9 (0.60)	2.5 (0.78)	2.3 (0.84)
Disturbed bare ground %	<1%	0.2 (0.12)	0.8 (0.50)	0.1 (0.09)	3.5 (2.03)
Heavy grazing impact %	<1%	6.5 (3.80)	14. (9.70)	7.5 (3.52)	13. (6.18)
Dwarf shrub height (if recorded) (cm)		48.7 (5.46)	23.1 (4.23)	45.4 (3.52)	34.6 (4.92)
Dwarf shrub cover %	25-90%	50.7 (3.84)	15.2 (1.84)	53.0 (3.39)	11.9 (1.53)
Proportion pioneer %	10-40%	14.9 (4.88)	36.0 (10.0)	11.7 (3.15)	23.4 (7.37)
Proportion building/mature %	20-80%	75.1 (5.15)	49.1 (7.46)	78.5 (3.65)	62.4 (7.11)
Proportion degenerate %	<30%	7.9 (2.07)	11. (4.73)	9.0 (2.20)	8.9 (3.93)
Proportion dead %	<10%	1.9 (0.69)	2.9 (1.56)	0.7 (0.26)	5.1 (3.06)
% of dwarf shrubs contributing to estimate of structural diversity		61.5 (6.75)	76.3 (8.78)	71.0 (5.43)	76.7 (6.88)
Nardus stricta cover %	<25%	0.1 (0.06)	0.8 (0.81)	0.1 (0.10)	1.0 (0.66)
Deschampsia flexuosa cover %	≤O	7.3 (1.83)	7.4 (3.76)	2.5 (0.87)	11.4 (4.33)
Total grass cover %		22. (4.40)	32. (7.20)	18. (4.85)	41. (5.98)
Ulex europaeus cover %	<25%	2.9 (1.02)	17.5 (5.21)	4.1 (1.38)	5.6 (3.09)
Listed trees & scrub cover %	<15%	6.1 (2.35)	7.4 (1.98)	6.3 (2.03)	8.4 (2.45)
Rubus spp. cover %	<1%	2.7 (1.07)	5.0 (1.78)	0.8 (0.30)	2.6 (0.82)
Dwarf *Ulex/ Genista* spp. (% of total dwarf shrubs)	<50%	24.4 (6.45)	13.0 (7.19)	22.3 (5.21)	11.6 (4.74)
Pteridium aquilinum cover %	<10%	5.7 (1.82)	10.8 (4.86)	5.1 (1.46)	12.7 (3.39)
Listed exotic spp. cover %	<1%	0.0 (0.03)	0 (0)	0.3 (0.39)	0 (0)
Negative indicators cover %	<1%	2.0 (0.70)	2.8 (0.98)	1.4 (0.72)	4.7 (1.53)
All injurious weeds cover %		7.7 (2.05)	13.6 (4.64)	7.0 (1.61)	17.4 (3.59)
Dense acrocarpous mosses cover %	<O	1.27 (0.88)	1.05 (0.64)	0.21 (0.11)	0.46 (0.37)
Dense acrocarpous mosses frequency (stops)		1.66 (0.67)	1.42 (0.67)	0.53 (0.21)	0.58 (0.23)
Bryophyte frequency (stops)		9.92 (1.08)	7.64 (1.75)	9.46 (0.92)	6.62 (1.24)
Bryophyte cover %		7.75 (2.05)	4.91 (1.63)	6.50 (1.23)	3.32 (0.93)
Deschampsia flexuosa frequency (stops)		6.55 (1.35)	5.5 (1.64)	3.8 (1.04)	6.08 (1.63)
Dwarf shrub diversity (number of spp.)		3.40 (0.22)	2.35 (0.22)	3.13 (0.19)	2.20 (0.23)
Exotics frequency (stops)		0.25 (0.16)	0 (0)	0.2 (0.16)	0 (0)

Table continued …

Attribute	Target (nos.)	Dry			
		AE		Non-AE	
		DSH	O	DSH	O
		(27)	(14)	(30)	(24)
Number of listed desirable forbs at least Occ (number of spp.)		0.85 (0.19)	1 (0.25)	0.76 (0.17)	1.5 (0.26)
Lichen cover %		0.11 (0.08)	0.03 (0.02)	0.31 (0.20)	2.15 (1.60)
Lichen frequency (stops)		1.62 (0.56)	0.71 (0.26)	1.33 (0.39)	1.79 (0.88)
Listed desirable forb diversity (number of spp.)		1.48 (0.22)	2.35 (0.40)	1.6 (0.27)	2.62 (0.38)
Listed graminoid diversity (number of spp.)		3.18 (0.19)	3.64 (0.24)	2.93 (0.21)	3.12 (0.29)
Molinia caerulea frequency (stops)		6.55 (1.48)	4.21 (1.90)	8.3 (1.39)	4.87 (1.18)
Molinia caerulea cover %		3.95 (1.56)	9.13 (4.64)	10.1 (2.24)	5.66 (1.87)
Negative species frequency (stops)		3.85 (0.85)	6.57 (0.99)	3.1 (0.77)	7.29 (1.17)
Number of dwarf shrub spp. at least frequent		2.03 (0.18)	1.21 (0.18)	2.13 (0.18)	0.91 (0.15)
Number of listed graminoid spp. at least occasional		2.29 (0.19)	2.64 (0.28)	2.16 (0.20)	2.54 (0.23)
Frequency of all dwarf shrubs (stops)		17.4 (0.42)	11.1 (1.12)	18.0 (0.29)	10.4 (0.96)
Frequency of all trees/scrub (stops)		7.55 (1.25)	10.5 (1.72)	7.8 (1.23)	7.75 (1.28)
Pteridium aquilinum frequency (stops)		7 (1.09)	7.28 (1.98)	4.83 (0.82)	6.79 (1.37)
Rubus spp frequency (stops)		4.14 (1.07)	7.85 (1.76)	3.43 (0.82)	6.25 (1.13)

Table C. Mean (SE) attribute levels for the wet heath sample (all stands), both overall and within and outside of agri-environment agreements (number of stands in brackets)

Attribute	Target (nos.)	All	AE	Non-AE
		(8)	(4)	(4)
Undisturbed bare ground %	1-10%	0.51 (0.21)	0.71 (0.30)	0.31 (0.31)
Disturbed bare ground %	<1%	0.05 (0.05)	0.11 (0.11)	0 (0)
Heavy grazing impact %	<1%	0 (0)	0 (0)	0 (0)
Trampling/erosion %	<1%	0 (0)	0 (0)	0 (0)
Artificial drainage %	None	0 (0)	0 (0)	0 (0)
Silt or leachate %	None	0 (0)	0 (0)	0 (0)
Dwarf shrub height (if recorded) (cm)		49.4 (12.9)	28 (9.77)	63.8 (16.5)
Dwarf shrub cover %	25-90%	23.0 (5.39)	18.6 (4.94)	27.4 (9.91)
% of dwarf shrubs contributing to estimate of structural diversity		8.73 (5.52)	12.1 (11.1)	5.28 (3.09)
TOTAL grass cover &		66 (13.2)	54.5 (23.6)	81.3 (7.75)
Sphagnum spp. cover % (if present)	>10%	5.53 (4.37)	9.87 (8.67)	1.18 (1.18)

Table continued …

Attribute (nos.)	Target	All (8)	AE (4)	Non-AE (4)
Lichens cover % (if present)	>5%	0 (0)	0 (0)	0 (0)
Dense acrocarpous moss cover %	<O	0 (0)	0 (0)	0 (0)
Ulex europaeus cover %	<10%	0.34 (0.18)	0.56 (0.32)	0.12 (0.12)
Listed trees & scrub cover %	<10%	5.48 (3.28)	7.67 (6.56)	3.30 (2.05)
Rubus spp. cover %		0.15 (0.15)	0.31 (0.31)	0 (0)
All dwarf *Ulex* and *Genista* spp. (% of total dwarf shrubs)		27.8 (11.2)	30.3 (21.1)	25.3 (11.6)
Pteridium aquilinum cover %	<10%	0.21 (0.18)	0.06 (0.06)	0.37 (0.37)
Listed exotic spp. cover %	<1%	0 (0)	0 (0)	0 (0)
Negative indicators cover %	<1%	2.26 (1.51)	4.12 (2.86)	0.39 (0.35)
All injurious weeds cover %		2.47 (1.47)	4.18 (2.83)	0.77 (0.41)
Dense acrocarpous moss cover %		0 (0)	0 (0)	0 (0)
Dense acrocarpous moss frequency (stops)		0 (0)	0 (0)	0 (0)
Bryophyte frequency (stops)		0 (0)	0 (0)	0 (0)
Bryophyte cover %		0 (0)	0 (0)	0 (0)
Deschampsia flexuosa cover %		0 (0)	0 (0)	0 (0)
Deschampsia flexuosa frequency (stops)		0 (0)	0 (0)	0 (0)
Dwarf shrub diversity (number of spp.)		3.5 (0.18)	3.25 (0.25)	3.75 (0.25)
Exotic spp. frequency (number of species)		0 (0)	0 (0)	0 (0)
Number of listed desirable forbs at least occasional		1.25 (0.49)	1.25 (0.94)	1.25 (0.47)
Lichen cover %		0 (0)	0 (0)	0 (0)
Lichen frequency (stops)		0 (0)	0 (0)	0 (0)
Listed desirable forb diversity (number of species)		2 (0.53)	2.5 (0.86)	1.5 (0.64)
Listed graminoid diversity (number of species)		2.5 (0.32)	2.5 (0.28)	2.5 (0.64)
Molinia caerulea frequency (stops)		18 (2)	16 (4)	20 (0)
Molinia caerulea cover %		46.5 (13.1)	43.4 (19.9)	49.6 (20.1)
Negative species frequency (number of stops)		4.75 (2.13)	5.75 (3.83)	3.75 (2.42)
Number of dwarf shrubs at least frequent		1.87 (0.39)	1 (0.40)	2.75 (0.25)
Number of listed graminoid spp. at least occasional		1.5 (0.26)	1.75 (0.47)	1.25 (0.25)
Frequency of all dwarf shrubs (stops)		17.2 (1.29)	15.7 (2.39)	18.7 (0.75)
Frequency of all trees/scrub (stops)		7.37 (1.75)	8.5 (3.52)	6.25 (1.03)
Pteridium aquilinum frequency (stops)		0.37 (0.26)	0.25 (0.25)	0.5 (0.5)
Rubus spp frequency (stops)		0.25 (0.16)	0.5 (0.28)	0 (0)

Table D. Mean (SE) attribute levels for the wet heath sample, for 'Dwarf Shrub' Heath and 'Other' heath stands (number of stands in brackets)

		DSH			O	
		Target	AE	Non-AE	AE	Non-AE
Attribute	**(nos.)**		**(1)**	**(2)**	**(2)**	**(3)**
Undisturbed bare ground %		1-10%	0.5	0.62 (0.62)	0.78 (0.42)	0.00 (0.00)
Disturbed bare ground %		<1%	0.45	0 (0)	0 (0)	0 (0)
Heavy grazing impact %		<1%	0	0 (0)	0 (0)	0 (0)
Trampling/erosion %		<1%	0	0 (0)	0 (0)	0 (0)
Artificial drainage %		None	0	0 (0)	0 (0)	0 (0)
Silt or leachate %		None	0	0 (0)	0 (0)	0 (0)
Dwarf shrub height (if recorded) (cm)			n/a	96.5	28 ()	47.4
Dwarf shrub cover %		25-90%	32.2	43.9 (6.74)	14.1 (2.81)	10.9 (1.30)
% of dwarf shrubs contributing to estimate of structural diversity			0	4.68 (4.68)	16.2 (14.7)	5.88 (5.88)
TOTAL grass cover &			30	72.5 (2.5)	62.6 (31.4)	99
Sphagnum spp. cover % (if present)		>10%	3.75	2.37 (2.37)	11.9 (11.9)	0 (0)
Lichens cover % (if present)		>5%	0	0 (0)	0 (0)	0 (0)
Dense acrocarpous moss cover %		<O	0	0 (0)	0 (0)	0 (0)
Ulex europaeus cover %		<10%	0	0.25 (0.25)	0.75 (0.38)	0 (0)
Listed trees & scrub cover %		<10%	27.3	6.05 (3.19)	1.11 (0.25)	0.55 (0.25)
Rubus spp. cover %			0	0 (0)	0.41 (0.41)	0 (0)
All dwarf *Ulex* and *Genista* spp. (% of total dwarf shrubs)			89.7	42.6 (12.0)	10.4 (10.4)	7.95 (7.95)
Pteridium aquilinum cover %		<10%	0	0 (0)	0.08 (0.08)	0.75 (0.75)
Listed exotic spp. cover %		<1%	0	0 (0)	0 (0)	0 (0)
Negative indicators cover %		<1%	12.4	0.05 (0.04)	1.36 (1.08)	0.73 (0.71)
All injurious weeds cover %			12.4	0.05 (0.04)	1.45 (1.05)	1.48 (0.03)
Dense acrocarpous moss cover %			0	0 (0)	0 (0)	0 (0)
Dense acrocarpous moss frequency (stops)			0	0 (0)	0 (0)	0 (0)
Bryophyte frequency (stops)			0	0 (0)	0 (0)	0 (0)
Bryophyte cover %			0	0 (0)	0 (0)	0 (0)
Deschampsia flexuosa cover %			0	0 (0)	0 (0)	0 (0)
Deschampsia flexuosa frequency (stops)			0	0 (0)	0 (0)	0 (0)
Dwarf shrub diversity (number of spp.)			3	4 (0.5)	3.33 (0.33)	3.5 (0.5)
Exotic spp. frequency (number of species)			0	0 (0)	0 (0)	0 (0)

Table continued …

		DSH		O	
Attribute	Target (nos.)	AE (1)	Non-AE (2)	AE (2)	Non-AE (3)
Number of listed desirable forbs at least occasional		1	1.5 (1)	1.33 (1.33)	1 (1)
Lichen cover %		0	0 (0)	0 (0)	0 (0)
Lichen frequency (stops)		0	0 (0)	0 (0)	0 (0)
Listed desirable forb diversity (number of species)		3	2 (1)	2.33 (1.20)	1 (1)
Listed graminoid diversity (number of species)		3	3 (1)	2.33 (0.33)	2 (1)
Molinia caerulea frequency (stops)		4	20 (0)	20 (0)	20 (0)
Molinia caerulea cover %		1.8	20.3 (17.3)	57.3 (20.2)	78.8 (17.3)
Negative species frequency (number of stops)		17	1.5 (5)	2 (1.15)	6 (5)
Number of dwarf shrubs at least frequent		1	3 (0.5)	1 (0.57)	2.5 (0.5)
Number of listed graminoid spp. at least occasional		2	1 (0.5)	1.66 (0.66)	1.5 (0.5)
Frequency of all dwarf shrubs (stops)		16	20 (0.5)	15.6 (3.38)	17.5 (0.5)
Frequency of all trees/scrub (stops)		19	6.5 (0)	5 (0.57)	6 (0)
Pteridium aquilinum frequency (stops)		0	0 (1)	0.33 (0.33)	1 (1)
Rubus spp frequency (stops)		0	0 (0)	0.66 (0.33)	0 (0)

Table E. Dry heaths – additional species

Site	Other species
534	*Campanula rotundifolia (O), Galium mollugo (O), Linum catharticum (O), Teucrium scorodonia (O), Clinopodium vulgare (0), Crataegus monogyna (O), Leontodon hispidus (A), Achillea millefolium (F),*
30	*Clinopodium calamintha (0.05%, R), Dryopteris dilatata (0.05%, R), Equisetum sylvaticum (3.45%, O), Rumex acetosa (0.25%, R), Anthoxanthum odoratum (0.5%, R), Trifolium repens (0.5%, R), Plantago media (0.25%, R), Poa* spp. *(0.5%, R), Sorbus aucuparia (0.05%, R),*
65	*Sorbus aucuparia (0.18%, R), Trifolium repens (0.18%, O), Cerastium fontanum (0.18%, O), Rumex* spp. *(0.06%, R), Poa* spp. *(0.06%, R), Cirsium vulgare (0.41%, R), Carex nigra (1.41%, F), Veronica chamaedrys (1.18%, R), Corydalis claviculata (0.18%, O), Stellaria graminea (0%, -),*
75	*Anthoxanthum odoratum (R), Sorbus aucuparia (1.1%, R), Juncus conglomeratus (1%, R),* Litter (1.35%, O)*, Stachys palustre (0.03%, R), Impatiens glandulifera (0.06%, R), Phragmites australis (0.03%, R), Equisetum* spp. *(0.01%, R), Lathyrus pratensis (1%, R),*
153	*Arctium* spp. *(0.1%, R),*
156	*Luzula multiflora (O), Anthoxanthum odoratum (O), Sorbus aucuparia (1%, R),*
178	*Sorbus aucuparia (0.5%, R),* Litter (2%, R)*, Aesculus hippocastanum (0.15%, R), Dryopteris felix-mas (0.05%, R),*
233	*Sorbus aucuparia (0.2%, R),*
250	*Ornithopus perpusillus (0.05%, R),* Litter (1.25%, R)*,*
297	*Ilex aquifolium (0.03%, R), Sorbus aucuparia (0.26%, R), Centaurea nigra (0.01%, R),* Litter (26.5%, F)*, Crataegus monogyna (3.9%, O), Pilosella officinalis (0.01%, R), Malus pumila (1.5%, R), Lapsana communis (0.05%, R), Dryopteris* spp. *(2%, R), Acer pseudoplatanus (3.75%, R),*
330	*Ilex aquifolium (1.5%, R),*
364	Litter (9.01%, F)*, Ceratocapnos claviculata (2.12%, F), Aira praecox (0.11%, O), Sorbus aucuparia (0.5%, R),*
371	*Teucrium scorodonia (O), Anthoxanthum odoratum (O),* Litter (7.6%, F)*, Pilosella officinalis (0.05%, R),*
383	*Juncus acut/artic (O),* Litter (2.45%, F)*, Cirsium palustre (0.05%, R),*
440	*Broom (0.05%, R),*
442	*Ilex aquifolium (0.05%, R), Sorbus aucuparia (0.01%, R),*
457	*Luzula* spp. *(A),*
497	*Sorbus aucuparia (0.03%, R),*
541	*Lonicera periclymen (O), Polygonum* spp. *(R),*
604	*Silene vulgaris (R), Sedum (R),* Litter (5.5%, R)*, Salix* spp. *(5.5%, R),*
628	*Agrostis curtisii (0.31%, O),*
694	*Silene dioica (1.45%, F), Rumex acetosa (1.3%, F), Anthoxanthum odoratum (3.5%, O), Sedum anglicum (0.05%, R), Leontodon hispidus (0.05%, R), Lonicera periclymenum (3.05%, F), Viola* spp. *(0.6%, O), Galium aparine (0.05%, R),*
716	*Agrostis curtisii (2.2%, F),* Dodder (R)*,*
737	Litter (26.4%, A)*,*
791	*Agrostis curtisii (3.28%, A), Salix* spp. *(0.05%, R),*
808	Stones (16.45%, O)*, Cotoneaster (0.01%, R),*

Table continued …

Site	Other species
844	Litter (12%, A), *Hyacinthoides* spp. *(0.1%, R), Polystichum* spp. *(1.75%, R), Dryopteris* spp. *(0.65%, O),*
881	*Anthoxanthum odoratum (F), Agrostis curtisii (1.05%, O),* Litter (12.45%, F), *Viola* spp. *(0.1%, R),*
893	*Pilosella officinalis (R), Anthoxanthum odoratum (O), Agrostis curtisii (8.5%, F),* Orchid (O), Fern (R), *Pedicularis* spp. *(R),*
916	*Anthoxanthum odoratum (O), Agrostis curtisii (10.95%, F), Polystichum* spp. *(0.05%, R),*
1034	*Agrostis curtisii (3.21%, O),*
1056	*Sphagnum (0.01%, R), Holcus mollis (R),*
1117	*Juncus acutiflorus (0.61%, O),*
1178	*Polystichum* spp. *(O),* Litter (9.3%, F), *Crataegus monogyna (4%, R),*
1201	*Anthoxanthum odoratum (F),* Orchid (R), *Luzula (R),*
1247	All TREES (35.25%, A), *Ilex aquifolium (0.05%, R), Dryopteris dilatata (0.02%, O), Lonicera pericyclemem (0.01%, R),*
1343	*Teucrium scorodonia (F), Cirsium vulgare (0.01%, R),*
1410	*Sphagnum* spp. *(0.25%, R), Salix* spp. *(0.1%, O),*
1583	*Hyacinthoides non-scripta (O),* Litter (4.9%, A), *Salix* spp. *(3.25%, O), Crataegus monogyna (0.6%, R), Pedicularis sylvaticum (O),*
1620	Litter (36.95%, A), *Crataegus monogyna (2.6%, R), Salix* spp. *(0.5%, R), Succisa pratensis (R),*
1654	*Agrostis curtisii (7.06%, A),*
1914	*Plantago coronopus (R), Cirsium vulgare (0.03%, R), Aira praecox (F), Luzula* spp. *(F),*
1976	Litter and bryophyte (28.3%, A), *Sorbus aucuparia (2.25%, O), Cytisus scoparius (0.5%, R),*
2095	*Dryopteris dilatata (1.4%, O), Juncus articulatus (0.75%, R), Sphagnum* spp. *(1%, R), Viola* spp. *(0.05%, R), Veronica chamaedrys (0.1%, R), Galium aparine (0.35%, O), Lamium album (0.1%, R),*
2127	Litter (7%, O), *Anthoxanthum odoratum (R),*
2218	Litter (4.5%, R), *Genista tinctoria (0.01%, R),*
2245	*Anthoxanthum odoratum (R), Pilosella officinalis (R), Arrhenatherum elatius (0.25%, R), Luzula* spp. *(R),*
2267	*Lonicera periclymenum (2.05%, F), Dryopteris dilatata (6.35%, A), Oxalis acetosella (0.05%, R), Crataegus monogyna (0.2%, R), Rosa* spp. *(0.05%, R), Taraxacum officinale (0.05%, R), Galium* spp. *(0.15%, O), Sorbus aucuparia (0.55%, F),*
2292	*Genista tinctoria (R), Succisa pratensis (R),*
2312	*Veronica serpyllifolia (F), Dodder (R), Anthoxanthum odoratum (O),*
2315	*Ilex aquifolium (0.01%, R),*
2336	*Agrostis curtisii (3.05%, O),*
2355	*Sphagnum (0.35%, R), Agrostis curtisii (1.25%, R),*
2397	*Anthoxanthum odoratum (O), Crataegus monogyna (2.5%, R), Sorbus aucuparia (3%, R),*
2456	*Agrostis curtisii (0.4%, O), Acer pseudoplatanus (0.05%, R), Buddleia (1.3%, O), Fern (0.1%, R), Blechnum spicatum (0.05%, R),*
2503	*Hedera helix (2.5%, R), Agrostis curtisii (0.31%, O), Buddleia (0.5%, R),*
2648	Litter (39.4%, A), *Fagus sylvatica (5.5%, R), Acer campestre (2.5%, R),*
2650	Litter (6.9%, A),

Table continued …

Site	Other species
2663	*Centaurium erythraea (0.01%, R), Sphagnum (1.25%, R),*
2701	*Luzula* spp. *(A), Anthoxanthum odoratum (F), Pilosella officinalis (R),*
2823	*Anthoxanthum odoratum (9.85%, A), Rumex acetosa (0.5%, O), Juncus articulatus (0.2%, R), Trifolium repens (1.1%, O), Cerastium fontanum (0.1%, R), Deschampsia caespitosa (0.4%, O), Jasione montana (2.85%, R),*
3502	*Succisa pratensis (R),*
3924	*Ranunculus flammula (0.06%, R), Sanguisorba officinalis (0.18%, O),* Litter (1.3%, F)*, Juncus bufonius (0.16%, O), Juncus articulatus (0.1%, R), Phragmites australis (0.01%, R), Galium verum (0.26%, O), Dactylorhiza fuchsii (0.01%, R),* Medium Rush (0.2%, R)*,*
4112	*Cirsium vulgare (0.01%, R), Agrostis curtisii (0.8%, O),*
4283	*Agrostis curtisii (2.25%, O),*
4319	*Agrostis curtisii (1.5%, O),* Bracken litter (R)*,*
4479	*Cirsium vulgare (0.01%, R),*
4542	*Pilosella officinalis (R), Euphrasia* spp. *(R), Hedera helix (R),*
4664	*Ilex aquifolium (0.05%, R), Sorbus aucuparia (0.1%, R), Anthoxanthum odoratum (O), Crataegus monogyna (0.01%, R), Deschampsia cespitosa (0.6%, O), Fagus sylvatica (0.01%, R), Sambucus nigra (0.25%, R),*
4753	*Sphagnum spp (2%, R),*
4771	*Hypericum* spp. *(O), Crataegus mongyna (0.5%, R), Euphrasia* spp. *(0.03%, O), Rosa (0.04%, R),*
5059	*Agrostis curtisii (1.355%, A),*
5068	*Anthoxanthum odoratum (O), Cynosurus cristatus (O), Sanguisorba officinalis (F), Centaurea nigra (R), Ranunculus flammula (R), Pedicularis* spp. *(R), Succisa pratensis (R),*
1379 (1)	Litter (9.4%, F)*, Luzula* spp. *(0.37%, F), Sorbus aucuparia (0.05%, R),*
171 (1)	Litter *(10.6%, O),*
171 (2)	Litter (7%, F)*, Cytisus scoparius (4.75%, R), Crataegus monogyna (0.05%, R), Galium aparine (0.05%, R),*
2217 (1)	*Picea* spp. *(4.3%, O),*
2217 (2)	*Crataegus monogyna (0.55%, O),*
2387 (1)	flint/stone (20.05%, F)*, 0 (0%, -),*
2514 (1)	*Salix cinerea (0.15%, R), Cuscuta epithymum (0.3%, O), Teucrium scorodonia (0.2%, R), Anthoxanthum odoratum (0.2%, R), Brachypodium sylvaticum (0.5%, R), Rumex acetosa (0.1%, R),*
2514 (2)	*Teucrium scorodonia (0.45%, O), Dryopteris dilatata (0.15%, R), Brachypodium sylvaticum (1.3%, F), Jasione montana (0.05%, R), Silene dioica (0.05%, R), Anthoxanthum odoratum (1.05%, O), Stellaria graminea (0.05%, R), Hyacinthoides non-scripta (0.15%, O), Rumex acetosa (0.35%, O), Hedera helix (0.2%, R),*
565 (1)	*Sorbus aucuparia (0.01%, R), Hyacinthoides non-scripta (R),*
565 (2)	*Crataegus monogyna (0.13%, R), Sorbus aucuparia (0.01%, R),*
2598	*Aira praecox (0.3%, R),*

Table F. Wet heaths – Additional species

Site	Other species
146	*Deschampsia flexuosa (18.8%, A), Chamerion angustifolium (0.25%, R), Agrostis* spp. *(R), Holcus lanatus (0.55%, O),* Bryophyte (1.05%, O), Litter (5.25%, O), *Carex nigra (0.05%, R), Polystichum* spp. *(0.28%, O),*
989	*Juncus conglomeratus (0.1%, R), Sphagnum (0.13%, O),*
1613	Litter (11.75%, A), *Agrostis curtisii (0.1%, R), Agrostis* spp. *(0.55%, R), Carex echinata (0.05%, R),*
2570	*Agrostis spp (A), Lotus corniculatus/uliginosus (A),* Bryophytes (12.8%, A), Coarse grasses (5.2%, F), *Pedicularis* spp. *(O), Luzula* spp. *(O), Hypochaeris radicata (O),*
2572	Bryophytes (9.01%, F), *Agrostis curtisii (R),*
3912	*Phragmites australis (1.45%, A), Pulicaria dysenterica (4.5%, F), Mentha aquaticum (0.7%, O), Equisetum fluviatile (0.7%, F), Cirsium palustre (0.5%, O), Scutellaria minor (0.3%, O), Festuca rubra (3%, F), Lotus pedunculatus (1.9%, F), Prunella vulgaris (0.2%, O), Ranunculus flammula (0.75%, F), Dactylis/Holcus (0.7%, F), Anthoxanthum odoratum (1.05%, F), Sanguisorba officinalis (0.35%, O), Plantago lanceolata (0.05%, R), Silene dioica (0.15%, O), Ranunculus acris (0.2%, O), Agrostis* spp. *(0.8%, O), Populus* spp. *(0.9%, R), Lythrum salicaria (0.05%, R),*
1379 (2)	*Eriophorum* spp. *(3.15%, A),* Open water (10.4%, A), *Carex* spp. *(5.51%, A),* Orchid (0.07%, O), *Pedicularis (0.91%, F),* Bryophytes (3.05%, O), *Potamogeton* spp. *(0.86%, F), Menyanthes trifoliata (0.05%, R), Agrostis* spp. *(O),*

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