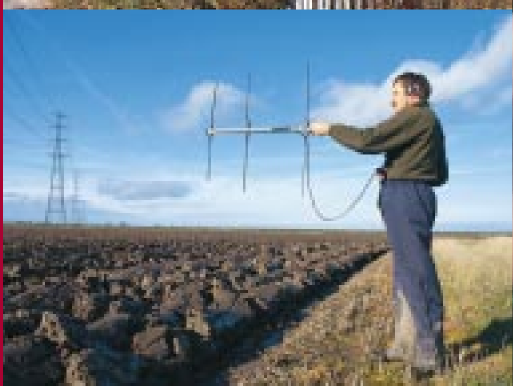
Report Number
564

Validation Network Project

Upland habitats covering: blanket bog, dry dwarf shrub heath, wet dwarf shrub heath and *Ulex gallii* dwarf shrub heath

English Nature Research Reports



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Upland habitats covering: blanket bog, dry dwarf shrub heath, wet dwarf shrub heath and *Ulex gallii* dwarf shrub heath

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ISSN 0967-876X

Summary

1. English Nature together with the other UK statutory nature conservation agencies are committed to monitoring condition on designated sites under the Common Standards framework. This sets out the timing and broad structure for monitoring approaches in each agency. English Nature is committed to establish a system for assessing the condition of SSSI features in order to meet the Government's Public Service Agreement target of 95% of SSSI features in favourable condition by 2010. Information on the trends in feature condition is needed to identify obstacles that are preventing favourable condition being achieved for all SSSI features.

2. The Validation Network project has an overall objective to ensure that data on the condition of individual features on SSSIs is accurate, consistent and scientifically robust. The means to achieve this outcome is through a sample of sites on which quantitative monitoring is undertaken on a regular basis in parallel with the cycles of condition assessment for SSSIs.

3. This document reports on part of the first tranche of Validation Network monitoring on key upland habitats. These are: blanket and upland raised mires within the blanket bog Priority Habitat and sub-montane dry dwarf shrub heath and wet heath within the upland heathland Priority Habitat. In addition, a sub-category of dry dwarf shrub heath was selected – *Ulex gallii* dry heath. The upland habitats were represented by NVC types H4, H8, H12, H18, U2-U20, M15, M17, M18 and M19.

4. Plots representing pre-selected habitat types were located within areas of relatively favourable and unfavourable condition according to CO/Site Managers' previous assessments and field assessments by the project officer. These paired plots were located as close together as possible within sites in order to minimise geographical variations in community types. Both detailed botanical recording (all vascular plant species) and recording of variables relating to other attributes was carried out within 30 1x1 metre quadrats located within each plot. These data were then used to compare with condition assessments carried out by independent observers.

5. For the dwarf shrub cover and diversity attributes, the level of agreement between condition assessment categories and quantitative assessments was generally quite good. The greatest disagreement was seen on the *U. gallii* plots, which contained a large amount of mature *U. gallii* but not much *U. europaeus*. This would be expected to cause problems in assessing 'allowable' dwarf shrub cover if the two species were highly aggregated. For the dwarf shrub diversity assessment, agreement was good in most habitats apart from blanket bog where agreement was less than forty percent. Generally, although the assessment of dwarf shrubs gave satisfactory results, there would appear to be some inaccuracies which may arise from the rapid condition assessment method. While it is obviously difficult to assess mature dwarf shrub species and cover from above, this needs to be stressed in the guidance as there is clearly some inherent error in the 'rapid assessment' method.

6. The level of agreement between condition assessment categories and quantitative assessments was fairly good for bryophyte abundance with only three out of thirteen assessments disagreeing. This attribute applies to both blanket bog and wet heath

which are often more open habitats with lower or more patchy dwarf shrub cover. Visual assessment of bryophyte cover among the sward is probably facilitated by this structure. For bryophyte and lichen cover, all but one of the assessments did not agree although the degree of error was only one category in all cases.

7. The level of agreement between condition assessment categories and quantitative assessments for the graminoid cover attribute was reasonable, with five (including one marginal), of the thirteen plots being mis-classified. All of these were only one category out. The analysis revealed a possible difference in perception of favourable condition at each site by the assessor

8. The level of agreement between condition assessment categories and quantitative assessment for the *Calluna* age structure attribute was extremely good with only one marginal mis-classification. It is interesting to note that this is one of the few attributes which has pictorial guidance.

9. There was a reasonably good level of agreement between condition assessment categories and quantitative assessments for grazing impacts, with the proportion of flowering dwarf shrubs and presence of stock dung being the best attributes. Several of the attributes were either not recordable or were recorded so rarely that they were of limited value in determining grazing impacts.

10. There was only a small number of significant differences between favourable and unfavourable plots across habitats for C-S-R (Competitive, Stress and Ruderal strategy) radii. Two sets of plots showed a consistently higher score for the R-radius on the unfavourable plots. These were on the blanket bog and wet heath habitats which show a good deal of similarity in botanical composition and functional ecology. This points to some disturbance factor acting on these plots, perhaps due to higher grazing pressure. On the dry dwarf shrub heath, one favourable plot showed a higher C-radius and lower S-radius score than its paired unfavourable plot. This was due to the presence of high stress-tolerators and low competitors, that are adapted to higher grazing levels, on the unfavourable plot. Grazing appears to be the driving force for communities containing species of different C-S-R strategies among some plots.

11. There was a clear tendency for unfavourable plots to score highest for grazing suited species, although only one habitat, blanket bog, showed a statistically significant difference. Mean grazing suited species scores for most blanket bog plots (negative), showed that this habitat is particularly intolerance to anything but light grazing pressure. There was a tendency for favourable wet heath plots to score more highly on wet suited species although this was not significant. This could be due to a degradation of the characteristic suite of species of wet heath communities due to drainage and/or other features of management associated with unfavourable condition.

12. The multivariate analysis of botanical data proved extremely successful in separating favourable and unfavourable plots using community data. Both pairs of plots and all plots combined within habitat types showed good separation along the main DCA (Decorana) axis which accounted for most variation in the data. The only exception was in the *U. gallii* heaths, where community types (and therefore composition), were

distinctly different between the two sites in the study. Independent environmental variables showed that favourable plots tended to be associated with healthy mature *Calluna* and flowering dwarf shrubs in general while unfavourable plots tended to be associated with young *Calluna*, *Calluna* showing signs of grazing or browsing plus signs of contemporary stock activity. This combination of attributes explained nearly all of the differences associated with favourability along the most important DCA axis.

13. Results of the analysis of whole plot vegetation communities and soil/whole site data showed some worrying trends where the potentially toxic element Aluminium appears to be mobilising, although levels may not yet be serious. However, the mechanisms behind this are not known apart from an association with more acidic conditions, possibly arising from external sources in ombrogenous water, or possibly where peat soil is becoming more acid due to continuous burning cycles. Recent work has also suggested that where stock levels are higher, increased biological activity in the peat may lead to higher levels of acidity. Some, or a combination of these factors may be at work at the sites in this study and would warrant further investigation.

14. Overall, the validation exercise on upland habitats showed that the condition assessment methodology was accurate in assessing attributes relating to dwarf shrubs but there were mixed results for other attributes. Inconsistencies were probably due to differences in measuring field attributes (e.g. oblique viewing of graminoid and sub-canopy vegetation compared to vertical viewing under detailed assessments, although there were also inconsistencies between habitat types. Some attributes may not add value to the overall condition assessment due to their general rarity. Confusion between types of measure (e.g. frequency and cover) may not help consistency. Clear differences between vegetation communities on favourable and unfavourable plots showed that pressures resulting in unfavourable condition also caused changes in community composition. Grazing pressure was generally the strongest driver of unfavourable condition. Further research, particularly on grouse moors (e.g. on Dartmoor and the East Pennines), is needed to look into the mechanisms associated with the widespread practice of burning.

15. New guidance, currently submitted in draft to the JNCC (A. Crowle pers. comm.), has revised some of the methods of measuring many of the attributes discussed here and may provide a more simplified approach. Further testing may be required.

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1. Introduction

1.1 Background to the Validation Network

English Nature is committed to establishing a system for assessing the condition of SSSI features in order to meet the Government's Public Service Agreement target of all SSSI features in favourable condition by 2010. Information on the trends in feature condition is needed to identify obstacles that are preventing favourable condition being achieved for all SSSI features.

The wider needs of UK reporting require consistency of approaches across the country agencies in Scotland, Wales, Northern Ireland and England. This issue has been addressed through agreement on "a Statement of Common Standards Monitoring" published by the JNCC in 1998. This statement sets out the timing and broad structure for monitoring approaches in each agency. English Nature has developed an approach of condition assessment to support these standards and we use ENSIS as the database to hold and report the condition of SSSI features.

There are over 8,240 features distributed on 21,578 units across English SSSIs (as of 12/2/02). This number of individual assessment units cannot be assessed by traditional quantitative monitoring methods given the resources available to English Nature. The condition assessment approach that is being implemented does no more than standardise a rapid, visual assessment technique, focusing on key attributes of each feature. Given the importance of this information it is important that this approach is quality assured and validated in order to give us, and others, confidence in this statistic.

The 'validation network' concept has its origins in the 1992 SSSI Monitoring Strategy and work to date takes its lead from that strategy. Given the new Programme Board structure for planning within English Nature the validation network project is being reviewed to ensure that it meets our needs and is properly resourced.

1.2 Project aims

The overall objective of the Validation Network project is to ensure that data on the condition of individual features on SSSIs are accurate, consistent and scientifically robust. The means to achieve this outcome were through a sample of sites on which quantitative monitoring is undertaken on a regular basis. The project will establish such a system and this system will operate in parallel with the cycles of condition assessment for SSSIs.

The aims of the project are:

- to validate the condition assessment methodology in England through testing the suitability of attributes and associated targets in assessing quality and trend in condition;

- to establish a set of control sites to ensure that individual site assessments match regional or national changes in feature condition over time;

- to contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change.

1.3 Habitats and species covered by the Validation Network

1.3.1 Habitats

The Validation Network will need to be structured reflecting the way in which the Common Standards monitoring programme is structured. For example, methods devised for habitat condition monitoring in the uplands is stratified according to three broadly defined habitats within two Priority Habitats (Anon. 2000). These are: blanket and upland raised mires within the blanket bog Priority Habitat and sub-montane dry dwarf shrub heath and wet heath within the upland heathland Priority Habitat. There is also montane moss and lichen heath within the montane-subalpine-alpine Broad Habitat category which is not sub-categorised into Priority Habitats. On the other hand, methods devised for habitat condition monitoring on lowland grasslands are stratified by NVC type – a much finer classification than the uplands.

For this part of the project, three of the broadly defined habitat types within the blanket bog and upland heathland Priority Habitats were selected for study. These were blanket and upland raised mires, dry dwarf shrub heath and wet heath. In addition, a sub-category of dry dwarf shrub heath was selected – *Ulex gallii* dry heath. Montane moss and lichen heath was not selected as it was considered to be a rare habitat in England and more identified with other montane habitats. The upland habitats were represented by NVC types H4, H8, H12, H18, U2-U20, M15, M17, M18 and M19.

1.3.2 Species

As an extension to the validation of Common Standards monitoring on habitats, research on invertebrate assemblage quality was carried out on selected plots. This sub-project was designed to see whether habitat ‘quality’ is correlated with the ‘quality’ of animal communities supported by the habitat. Clearly, if this is not the case, then measures of habitat ‘quality’ will need to be reassessed to reflect the requirements of both invertebrates and vertebrates.

This sub-project will be reported on at a later date.

2. Methods

2.1 Selection of sites

A number of candidate sites were identified during the scoping and pilot phases of the project. Suitability for selection was assessed from information on the English Nature Site Information System (ENSIS), plus other data provided by the NNR management co-ordinator and site management staff. There was also a database of previous/current monitoring and research available within SST. After an initial selection, candidate sites were visited over summer 2001 (during the pilot phase) and winter 2001-2002, where closer inspection and further discussions took place.

The following upland sites were selected:

Yarner Wood NNR, Devon
Stiperstones NNR, Shropshire
Ingleborough NNR, N. Yorkshire
Kielderhead NNR & Whitelee SSSI, Northumberland
Moorhouse & Upper Teesedale NNR, Cumbria & Northumberland
Dunkery & Horner NNR, Somerset

Details of sites and NVC communities covered are shown in Appendix 1.

Methods for habitat monitoring have been derived from a combination of traditional quantitative methodologies, results of the Pilot programme and specialist advice.

2.1.1 Selection of sample plots

For all habitat types, monitoring plots were paired (Unfavourable and Favourable) and representing the target habitat type within each site. A fully 'factorized' series of plots representing the seven states of condition, all sub-communities and all possible types of management relating to the target habitat would result in a huge number of plots and samples can only therefore be drawn from a few combinations of 'treatments' within the series. Plots were also selected from within site condition monitoring units where vegetation was reasonably homogeneous (in terms of community and structure). In practice, this is much easier on the lowland sites where intensive management often results in uniformity. Information on the overall condition of units from ENSIS data within which monitoring plots were placed, together with their types of management are shown in Appendix 2. Also indicated are sites/plots where there are or have been historical or current compatible vegetation monitoring projects.

For most upland sites, ENSIS data refer to large heterogeneous units or compartments and are therefore of limited use as the initial aim of Validation Network monitoring is to test the methodologies targeted at particular habitat types or Priority Habitats. Monitoring plots were therefore delineated within fairly homogeneous vegetation within the survey/management unit. Plot size was variable according to the scale of the target habitat and local topography and were at least 0.5 ha with a maximum of 3.4 ha.

Monitoring plots were marked with re-locatable transponders or Feno markers and mapped. All major positions were recorded using a hand-held GPS system.

2.2 Detailed field methodologies

2.2.1 Blanket & upland raised mire

2.2.1.1 Botanical composition and associated measures

Attributes assessed under this heading were:

- Bryophyte abundance
- Dwarf-shrub cover
- Dwarf-shrub diversity
- Graminoid cover

These were assessed using the following methods:

Bryophyte abundance, dwarf-shrub cover, dwarf-shrub diversity and graminoid cover - These were assessed using the same method as in the dwarf-shrub heath category. Overall group total cover estimates were made for dwarf-shrub, bryophyte (excluding *Polytrichum* spp *Campylopus* spp and *Racomitrium lanuginosum* except in hummocks) and graminoid cover for each quadrat. *Sphagnum* spp were also assessed as an overall group cover estimate within the quadrat.

Environmental and structural variables - Environmental and structural variables were sampled at each quadrat location.

Attributes assessed under this heading were:

- Bare ground
- Grazing impact
- Erosion/disturbance/anthropogenic problematical features.
- Soil condition and nutrients: pH, extractable PO_4-P, H, Na, K, Ca, Mg, Fe, Al & Mn, total N.
- Physical features: aspect and slope.
- Climate.

These were assessed using the following methods:

Bare ground – This was categorized as natural, resulting from fire or resulting from disturbance by stock. Recently recolonised bare ground will be assessed from indicator species recorded from the botanical survey (see Anon. 2000).

Grazing impact – This was assessed by 5 methods:

- Proportion of *Calluna* of flowering age (late Pioneer onwards), flowering during August-September
- Proportion of *Calluna* showing ‘normal’, ‘drumstick’, ‘topiary’, ‘carpet’ or ‘prostrate’ growth forms. Pictorial aids assisted in this assessment

- Grazing of *Empetrum nigrum, Vaccinium vitis-idea, Erica tetralix* or *Nardus stricta*
- Uprooted dwarf-shrubs
- Trampling damage to *Sphagnum* hummocks or carpets
- Presence of stock dung

Erosion/disturbance/anthropogenic problematical features – This was assessed at a whole plot level and recorded active peat extraction and other features such as enhanced hagging, stock paths, vehicle damage etc.

Soil condition and nutrients – This was assessed on a whole plot basis. Soil samples from the uppermost 75mm only were collected from each quadrat location using a 'pot auger' soil sampler (Steve Peel, ADAS *pers. comm*.). pH was tested on fresh samples. Bulked samples were sent for analysis for the following determinands:

Loss on Ignition, pH, extractable PO_4-P, H, Na, K, Ca, Mg, Fe, Al & Mn, CEC, total N.

Data from other sources, eg the CEH Critical Load models, will add information to this set.

Aspect and slope – Aspect was measured at each quadrat location using a hand-held compass while slope was measured using a clinometer at each quadrat location.

Climate – Meteorological data from external sources will, where obtainable, help explain variation among plot condition and composition. Sources will include the Meteorological Office web-site and local weather stations.

2.2.2 Sub-montane dry dwarf-shrub heath: Typical *Calluna* dry dwarf-shrub heath and *Ulex gallii* dry heath

2.2.2.1 Botanical composition & associated measures

Attributes assessed under this heading were:

- Dwarf-shrub cover
- Dwarf-shrub diversity
- Bryophyte/lichen abundance

These were assessed using the following methods:

Dwarf-shrub cover, dwarf-shrub diversity and bryophyte/lichen abundance - Botanical composition were recorded by using 1x1m square quadrats, placed within the plot at randomly selected x and y co-ordinates. All higher plants together with bryophytes and lichens where these are identifiable in the field were recorded. Nests at 10, 20, 30, 40, 50 and 100cm were used to record the first occurrence of each species and an overall percentage cover estimate made for each species in the whole quadrat. A minimum of 30 and a maximum of 40 quadrats were recorded on each plot (40 being the recommended number by Hodgson and Colanti, 1995). Quadrat numbers were kept constant for paired plots.

Overall total cover estimates for the two categories dwarf-shrubs and bryophytes/lichens were also estimated.

2.2.2.2 Environmental and structural variables

Environmental and structural variables were sampled at each quadrat location. These can significantly contribute to explaining variation in botanical composition and presence/absence of positive and negative indicators over the entire within-plot sample.

Attributes assessed under this heading were:

- Age structure
- Grazing impact
- Bare ground.
- Soil condition and nutrients: pH, extractable PO_4-P, H, Na, K, Ca, Mg, Fe, Al & Mn, total N.
- Physical features: aspect and slope.
- Climate.
- Disturbance/anthropomorphic problematical features.

These were assessed using the following methods:

Age structure – This were assessed as the proportion of each quadrat containing Calluna belonging to the four age classes: Pioneer, Building, Mature or Degenerate phase. Pictorial aids will assist in this assessment. Time since the last burn were recorded where burning is a management tool.

Grazing impact – This were assessed by 5 methods:

- Proportion of *Calluna* of flowering age (late Pioneer onwards), flowering during August-September
- Proportion of *Calluna* showing 'normal', 'drumstick', 'topiary', 'carpet' or 'prostrate' growth forms. Pictorial aids assisted in this assessment
- Grazing of *Empetrum nigrum, Vaccinium vitis-idea, Erica tetralix* or *Nardus stricta*
- Uprooted dwarf-shrubs
- Presence of stock dung

Bare ground – The proportion of bare ground attributable to natural causes or to disturbance by stock aided the assessment of grazing pressure.

Soil condition and nutrients – This was assessed on a whole plot basis. Soil samples from the uppermost 75mm only were collected from each quadrat location using a 'pot auger' soil sampler (Steve Peel, ADAS *pers. comm*.). pH was tested on fresh samples. Bulked samples were sent for analysis for the following determinands:

Loss on Ignition, pH, extractable PO_4-P, H, Na, K, Ca, Mg, Fe, Al & Mn, CEC, total N.

Data from other sources, eg the CEH Critical Load models, will add information to this set.

Aspect and slope – Aspect was measured at each quadrat location using a hand-held compass while slope was measured using a clinometer at each quadrat location.

Climate – Meteorological data from external sources will, where obtainable, help explain variation among plot condition and composition. Sources include the Meteorological Office web-site and local weather stations.

Disturbance/anthropomorphic problematical features – Indicative features such as vehicle tracks, accidental/unplanned fires, dumping of farm waste and other disturbance were assessed on a whole plot basis. This was assessed semi-quantatively in the field.

2.2.3 Wet dwarf-shrub heath

2.2.3.1 Botanical composition & associated measures

Dwarf-shrub cover, dwarf-shrub diversity and bryophyte abundance - These were assessed using the same method as in the dry dwarf-shrub heath category. Overall cover estimates were made for total dwarf-shrub and bryophyte cover for each quadrat (excluding *Polytrichum* spp and/or *Campylopus* spp).

Graminoid cover – This will also be assessed using the botanical survey method as above and will include an overall cover estimate for this group for each quadrat.

2.2.3.2 Environmental and structural variables

These were assessed as in dry dwarf-shrub heath above.

2.3 Plot condition

Plot condition was assessed independently by local staff (usually Site Management staff), with a working knowledge of the habitats and species being assessed. In all cases, guidance and field sheets from EN's upland guidance were used together with sheets to aid assessment of *Calluna* age and growth form.

The area assessed was the validation plot together with a 'buffer' zone of variable width which gave an indication of condition of the wider area within which the plot was situated, but not the entire ENSIS unit which was usually much larger and contained a wide variety of habitat types.

2.4 Analytical and interpretive methods

2.4.1 Comparison of qualitative condition data with quantitative data

All relevant attributes within each habitat type had a 'value' assigned from the condition monitoring exercise which could be compared with the average value calculated from quantitative assessments.

For plant species and species groups (eg bryophytes), percentage cover values were arcsine transformed, averaged and back transformed to obtain an overall mean value. Other 'composite' measures were slightly more complicated and were calculated in the following ways:

***Calluna* age structure**: proportions in the late mature/degenerate age classes were added and used as the 'favourable' proportion.

Overall grazing impact: grazing impact is assessed on condition forms using up to nine measures such as flowering of dwarf shrubs and frequency of herbivore dung. A method of scoring these was devised such that individual measures would score 0 if grazing was absent, 1 where grazing was light, 2 moderate and 3 heavy. These scores were then added to give an overall quantitative grazing score for each plot in each habitat. Categories and scoring are shown in Appendix 3.

Where the guidance uses semi-quantitative measures as targets for attributes, the definitions published in the guidance for lowland heathland assessment have been followed. These are:

- **Dominant**: the species appears at most (>60%) stops and it covers more than 50% of each sampling unit.
- **Abundant**: species occurs regularly throughout the stand, at most (>60%) stops and its cover is less than 50% of each sampling unit.
- **Frequent**: species recorded from 31-60% of stops.
- **Occasional**: species recorded from 11-30% of stops.
- **Rare**: species recorded from up to 10% of stops.

Final comparisons of qualitative (condition) and quantitative assessments were made by comparing membership of favourable or unfavourable categories. Scoring of favourable/unfavourable grades follows that published in the guidance (Anon. 2000).

2.4.2 Botanical composition

For each defined Habitat Feature, species and species groupings have been analysed according to membership of the following:

a. C (competitor), S (stress-tolerator) and R (ruderal) strategy scores per plot according to the Grime *et al* (1988) strategy types.

b. Suited species scores according to the scheme developed by Critchley (2000) relating to soil nutrient status, grazing and soil moisture.

Mean group 'radii' (C-S-R) or scores (suited species scores), per plot were used to assess whether species' group membership reflect condition between plots. Analysis of C-S-R strategies was carried out using the MAVIS computer package provided by CEH (S. Smart pers. comm.). Previous analyses have used the FIBS package (Hodgson and Colasanti 1995), but this has proven to be rather tedious as data have to be input by hand.

Suited species scores (Critchley 2000), were used in preference to Ellenburg species scores according to the revised definitions for British plants (Hill 1999) as the latter does not incorporate values for bryophytes. This would result in a large reduction in the number of utilizable species as in many cases most recorded species in upland habitats are bryophytes and where total species number is low this becomes even more critical. Acid, grazing, nutrient and wet scores for all species were kindly provided by John Fowbert and Nigel Critchley of ADAS.

2.4.3 Vegetation community composition

Detrended Correspondence Analysis (DCA) (Hill, 1979) was used to analyse community data. The statistical package CANOCO (**CANO**nical **C**ommunity **O**rdination) (ter Braak and Smilauer, 1998) was used to compare quadrat and plot data. This was done by 'passively' running the ordination analysis on pooled plot data (favourable and unfavourable), and then superimposing plot condition on within-plot quadrat scores. Rare species were downweighted in the analysis to reduce their influence on community ordinations. Species scores were used to partly explain site (quadrat) scores and ordination axes.

Environmental variables were used to help explain ordination axes indirectly using regression analysis on DCA site scores and this process, in turn, determined the most important of these variables according to statistical probability levels. It was not possible to use Canonical Community Analysis (CCA), which is a more statistically robust way of relating environmental variables to community data, as there were missing data (either unrecorded by field workers or because the variable concerned was not relevant to the target recording unit).

2.4.4 Other tests

Where necessary, all percentage data were arcsine transformed before performing calculations involving means and normal errors. Nonparametric tests were used for group tests and regressions where there was no assumption of normality of the data. It was not possible to adjust for multiple statistical tests (by using Bonferroni adjusted probabilities for example), as most data sets contained varying numbers of missing values and were therefore tested as paired variables and also most tests were non-parametric. Individual, significant results with low probability among a number of non-significant results were treated with caution (Moran 2003).

3. Results and analysis

3.1 Comparison of qualitative condition data with quantitative data

3.1.1 Attributes covering all habitats

Dwarf shrub cover

Target for attribute:

Blanket Bog: Except in wetter areas where *Sphagnum* spp are abundant and forming lawns, cover of dwarf shrubs must be greater than 33%.

Dry dwarf shrub and *U. gallii* heaths: Dwarf shrubs (*Calluna, Erica* spp, *Vaccinium* spp, *Empetrum* and *Ulex gallii*) are dominant over grass species. Minimum of 75% cover of dwarf shrubs, excluding recently burnt stands.

Wet heath: Dwarf shrubs should not dominate the sward and there should be a minimum of 25% cover of species other than dwarf shrubs.

Table 1 shows the results of the comparison for dwarf shrub cover with mean values from quadrats and estimates from condition assessments. The column showing percentage point error gives the figure for how far above or below the quantitative measure the condition category was assigned.

For most habitats, there is a reasonably good agreement between the quantitative data and condition assessment. In all cases, errors in condition assessment was towards the more favourable category. Only on the *U. gallii* dry heath habitat was there a large discrepancy on two plots (38 and 28% respectively). These were both plots with a relatively large amount of mature *U. gallii* and this may have been a factor in over-estimating dwarf shrub cover.

Dwarf shrub diversity

Target for attribute:

At least two dwarf shrub species frequent and widespread in the sward. No one dwarf shrub species dominant to the exclusion of all others. Where there is a dominant species, one or more species must be frequent and widespread. Where three or more species are present, but only one is frequent and widespread, the abundances of the less abundant species may be combined and treated as a single species.

Table 2 shows the results of the comparison for dwarf shrub diversity with overall values from quadrats and estimates from condition assessments. The column "direction of error" shows the direction of tendency for the condition assessment away from the quantitative assessment ("+" is favourable condition awarded on unfavourable data).
The results show a good level of agreement across all habitats except for blanket bog where agreement was poor (<40% in the correct category). Neither was there consistency in the direction of error in this habitat which involved three different observers.

On the two sites where condition was judged to be more favourable than the supporting data, three or more dwarf shrubs were present but with one dominant and others only occasional at most. The observer's perception here may have been that the combination of the non-dominant species (as allowed in the guidance), produced a higher frequency than there actually was.

On two of the three sites where condition was judged to be less favourable than the supporting data, dwarf shrubs were well mixed within the general sward (with little clumping) and this may have led to the perception that their frequency was lower. The third of these sites was well grazed and in overall poor condition so this may have influenced the observer.

3.1.2 Attributes covering selected habitats

Bryophyte abundance

Target for attribute:

Blanket Bog: Bryophytes should be abundant and must include *Sphagnum* spp. *Sphagnum* spp must be both frequent and widespread in the stand and not restricted to hollows, forming at least occasional lawns or hummocks.

Wet Heath: Bryophytes (excluding *Polytrichum* spp and/or *Campylopus* spp) should be at least frequent and forming patches below or, in more open swards, between the dwarf shrubs.

Table 3 shows the results of the comparison for bryophyte abundance (cover and frequency) with overall values from quadrats and estimates from condition assessments. The assessment of abundance in both habitats is clearly more related to cover values than frequency of occurrence and this is therefore the measure used for comparison. Only one comparison in the blanket bog and two in the wet heath habitat disagreed between the assessment and quantitative measure. The blanket bog condition assessment was towards a less favourable score while wet heath tended towards the more favourable. Percentage point errors are not given as limits to values are not given in the guidance.

Bryophyte/lichen abundance

Target for attribute:

Dry dwarf shrub heath only: Bryophytes (excluding *Polytrichum* spp and/or *Campylopus* spp) and /or 'bushy' *Cladonia* spp lichens (eg *C. impexa* and *C. arbuscula*) should be at least frequent and forming patches below or, in more open swards, between the dwarf shrubs.

Table 4 shows the results of the comparison for bryophyte/lichen abundance (cover and frequency) with overall values from quadrats and estimates from condition assessments. All but one of the six assessments disagreed with mean cover values, with four (including one marginal) tending towards more favourable and one less favourable. The perception of the surveyor here generally is that bryophyte and lichen abundance is higher than it actually is and this may be a function of assessing cover between the dwarf shrubs although this did not appear to give such discrepancies in the bryophyte (only) measure previously.

Graminoid cover

Target for attribute:

Blanket bog: Hare's-tail cotton grass *Eriophorum vaginatum*, purple moor-grass *Molinia caerulea*, deer grass *Trichophorum cespitosum*, wavy hair-grass *Deschampsia flexuosa*, heath rush *Juncus squarrosus* or other graminoids should not dominate over dwarf shrubs. The cover of graminoids should not exceed 50%, unless Sphagnum spp are abundant/co-dominant and forming lawns below the graminoids.

Wet heath: Purple moor-grass *Molinia caerulea*, deer grass *Trichophorum cespitosum*, wavy hair-grass *Deschampsia flexuosa*, heath rush *Juncus squarrosus* or other graminoids should not dominate over other species. Total cover of graminoids should not exceed 50%.

Table 5 shows the results of the comparison for graminoid cover with overall values from quadrats and estimates from condition assessments. On the blanket bog plots, the only under-estimated assessment in terms of condition was on an area which had experienced heavy stock usage for many years but still had a high dwarf shrub cover (see Table 1), which was growing in patches. The 'unfavourable' appearance and the assessor's knowledge of the grazing problems in and around the plot may have led to an over-estimation of the graminoid cover. The two plots where over-estimation of condition occurred were fairly marginal and probably within allowable bounds of error.

There was only one plot where condition was strongly under-estimated on the wet heaths. This was an area of a probable sever burn 20 years ago and subsequent over-grazing which had led to a very 'grassy' look with *Molinia caerulea* being frequent and widespread. However, the cover of *Molinia* was quite low leading to an over-estimation when assessing the plot from a lateral view.

***Calluna* age structure**

Target for attribute:

Dry dwarf shrub heath/Ulex gallii heath: Either: all age classes of *Calluna* present with at least 25% of the management unit in the late mature/degenerate age class or 25% or more excluded from the burning rotation

or: the whole management unit is unburnt.

Stands which are never burnt should be present on level or gently sloping ground, not entirely confined to steep slopes.

[**Note** that in stands which are never or infrequently burnt *Calluna* may regenerate through layering. Where this occurs the pioneer phase may not be present and it may be difficult to distinguish between the building, mature and degenerate phases. Stands where layering of *Calluna* is frequent and widespread should be included in the late mature/degenerate age class].

Wet heath: Either: all age classes of *Calluna* present with at least 33% of the management unit in the late mature/degenerate age class or 33% or more excluded from the burning rotation

or: the whole management unit is unburnt.

Stands which are never burnt should be present on level or gently sloping ground, not entirely confined to steep slopes.

[**Note** that in stands which are never or infrequently burnt may regenerate through layering. Where this occurs the pioneer phase may not be present and it may be difficult to distinguish between the building, mature and degenerate phases. Stands where layering of *Calluna* is frequent and widespread should be included in the late mature/degenerate age class].

This attribute is a difficult one to express in an easy to interpret quantitative manner due to the possible complexities involved in determining condition above. In some cases, the monitoring plot size was too small to represent all the age classes present in the management unit as a whole, and therefore this would have increased the likelihood of an unfavourable score. Evidence of burning within recent years was also difficult to ascertain from field inspection and site records on some sites and therefore this was not uniformly applicable. As a simple measure, therefore, the proportion of *Calluna* in the late mature/degenerate age class or excluded from burning was calculated and compared to the assessment. This is the simplified method of assessment used in the guidance with the addition of area excluded from burning.

Table 6 shows the results of this comparison. From these results, the attribute would seem an efficient and simple measure of *Calluna* age structure. It is not possible, however, to gauge the relative importance of the other measures (see above) in the assessment carried out by the observer.

Grazing impact

Target for attribute:

Blanket bog: Grazing impacts should be light.

(An absolute maximum of 5% of the grazing unit may show signs of current moderate or heavy grazing).

Indicators of light grazing:

- Widespread and abundant flowering of cotton grasses *Eriophorum* spp. [Note that this indicator may only be reliable in spring].
- No evidence of encroachment by graminoid species such as *Juncus squarrosus, Deschampsia flexuosa* or *Nardus stricta*.
- Upright growth of *Calluna vulgaris*. Bush canopy open, not a tightly packed mass of contorted shoots. Very few or no instances of 'drumstick', 'topiary' or 'carpet' growth forms.
- No obvious grazing of *Calluna vulgaris* or *Vaccinium myrtillus*. Grazed shoots difficult to find without both intensive and extensive searching.
- Little or no signs of grazing of *Erica tetralix*, *Empetrum nigrum* or *Vaccinium vitis-idaea* if present.
- Little or no evidence of trampling of *Sphagnum* hummocks or carpets.
- At most only very localised occurrence of trampled bare ground, including animal paths and enhanced hagging.

Field indicators taken from MacDonald *et al* (1998).

Dry dwarf shrub heath: Grazing impacts should be light.

(An absolute maximum of 5% of the grazing unit may show signs of current moderate or heavy grazing).

Indicators of light grazing:

- Where stands of dwarf shrubs lie adjacent to stands of preferentially grazed vegetation such as grassland, flushes, or recently burnt heath, any marginal band of distinctly grazed dwarf shrubs should not exceed 1m in width.

- <33% of long shoots of *Calluna vulgaris* or *Vaccinium myrtillus* showing signs of having been grazed where average shoot growth is >4cm.

- or, where average shoot growth is <4cm then <16% of shoots grazed.

- [Note that this indicator may only be reliable in late winter and early spring as *Calluna* in particular is mainly grazed in autumn and winter].

- Only shoot tips (most recent year's growth) removed by grazing.

- Abundant and conspicuous flowering of *Calluna* and/or *Vaccinium myrtillus*.

- Upright growth of *Calluna vulgaris*. Bush canopy open, not a tightly packed mass of contorted shoots. Very few or no instances of 'drumstick', 'topiary' or 'carpet' growth forms.

- Little or no signs of grazing of *Empetrum nigrum*, *Vaccinium vitis-idaea* or *Nardus stricta* if present.

- No uprooted dwarf shrub seedlings in areas regenerating after fire.

- Herbivore dung should be rare and very difficult to find in short vegetation.

- Negligible bare ground attributable to grazing pressure.

Field indicators taken from MacDonald *et al* (1998).

Wet heath:

As dry dwarf shrub heath above with the following variation:

- Abundant and conspicuous flowering of *Calluna.*

- Little or no signs of grazing of Erica tetralix, Empetrum nigrum, *Vaccinium vitis-idaea* or *Nardus stricta* if present.

***Ulex gallii* heath:**

As dry dwarf shrub heath with the following variation:

- Little or no signs of grazing of *Erica tetralix, Empetrum nigrum, Vaccinium vitis-idaea* or *Nardus stricta* if present.

Some of these measures were not applicable to the season when the validation monitoring was undertaken and assessments were therefore not attempted. These include: flowering of *Eriophorum* spp on blanket bog (flowers are only conspicuous in spring/early summer) and annual shoot growth and grazing signs on *Calluna* which again is only a reliable indicator in early spring (March/April). However, other measures compensate for not being able to record the Calluna *shoot growth* attributes and the attribute measuring *flowering of dwarf shrubs* has been added to the list of blanket bog attributes to compensate for the flowering of *Eriophorum spp* attribute (this is not included in the guidance). *Presence of large herbivore dung* was also added to the blanket bog attributes as it was felt to be a useful additional measure of current grazing pressure (this is also not included in the guidance).

Flowering dwarf shrubs

Table 7 shows the results of the comparison for flowering dwarf shrubs with overall values from quadrats and estimates from condition assessments. Generally, there is a good level of agreement between condition categories and mean proportion of flowering shoots except for two plots in the dry dwarf shrub heath habitat where the “obvious but patchy” category is probably mis-classified. However, these two plots could be viewed as being at the two limits of the category in terms of qualitative filed perception.

Grazed growth forms of *Calluna*

This measure was applied using the same categories on all the habitats. Table 8 shows that one plot in each of the blanket bog and dry dwarf shrub heath habitats appeared to be mis-classified, one being graded too high, one too low. Otherwise, there appears to be a good level of agreement here.

Grazing of unpalatable species

Only three plots recorded quantitative signs of grazing of unpalatable species. Table 9 shows that two of these agreed with the condition assessment, while another three plots recorded signs under the condition assessment but not in quantitative recording. Overall, however, the agreement appears to be good between the two measures.

Uprooted dwarf shrub seedlings in recent burns

No plots recorded this by either method as shown in Table 10, although there is no condition category for complete absence of this attribute.

Large herbivore dung

The agreement between quantitative recording and condition categories appears to be good as shown in Table 11 for all habitats except *U. gallii* heath. The fact that roe deer would have been the large herbivores involved at Yarner may have influenced the lack of quantitative records as droppings would have been highly clumped and therefore easily missed by the sampling methodology.

Trampled bare ground

The attribute for blanket bog includes “paths and enhanced hagging”. Only one plot recorded trampled bare ground in the quantitative recording as shown in Table 12. This was, however, at a very low level and may have been missed or interpreted as insignificant under the condition assessment.

Trampling damage to *Sphagnum* hummocks

As with the bare ground attribute, this was detected at a very low rate at one site as shown in Table 13. This low level could be interpreted as being in the correct condition category.

Width of heavy grazing zone

This was assessed as being absent in the quantitative monitoring which was carried out on a whole plot basis rather than through a series of samples. Table 14 shows that the condition assessments agreed with this, where dwarf shrubs were present.

3.2 Botanical composition

3.2.1 C-S-R strategies

3.2.1.1 Blanket bog

There were no differences between plots at any site for either C or S strategies. There was a difference between plots at Ingleborough for the R strategies where the favourable plot had a lower score which approached significance (Mann-Whitney U = 135.5, P = 0.052). The unfavourable plot at this site contained high ruderal-scoring species such as *Cerastium fontanum* and *Achillea millefolium* plus a larger number of semi-ruderal species reflecting the highly degraded and over-grazed nature of this plot.

3.2.1.2 Dry dwarf shrub heath

Only one site showed significant differences among values between plots, Stiperstones. Here, the favourable plot had a higher C-radius and lower S-radius score (Mann-Whitney U = 89.5, P = 0.045 and U = 30.5, P = 0.045) respectively. This reflects the presence of species adapted to higher grazing levels characterized by low competitors and high stress-tolerators such as *Festuca ovina*, *Nardus stricta* and *Galium saxatile* in the unfavourable plot.

3.2.1.3 Wet heath

Only one site showed significant differences among values between plots, Kielderhead & Whitelee. Here, the favourable plot had a lower R-radius score (Mann-Whitney U = 91.5, P = 0.039). This reflects the much ‘grassier’ community of the unfavourable plot which contained a number of graminoids such as *Poa annua* which have high R-radius scores.

3.2.1.4 *U. gallii* heath

There were no significant differences between any pairs of plots for any of the categories.

3.2.2 Suited species scores

3.2.2.1 Blanket bog

Although there were differences among plots for acid, nutrient and wet mean scores, there were no overall significant differences between favourable and unfavourable plots. There was, however, a significant difference for grazing suited species scores between favourable and unfavourable plots overall (T-test, t = 3.18, df = 6, P = 0.019). The mean score for the unfavourable plots was near to neutral while that of the favourable plots was –0.24, showing that there were probably only a few species contributing to the grazing suited species count. Figure 1 shows the mean suited species scores for all blanket bog sites and plots arranged according to their condition scores. The three plots with the 'highest' mean scores all scored highest in unfavourability in the condition monitoring excercise, with Ingleborough Fenwick Lot (mean grazing suited species score of 0.0507) scoring 11 out of 23 on this scale. This plot had a history of over-grazing and was dominated by graminoids such as *Juncus squarrosus* and *Luzula multiflora*, but also had grazing-tolerant herbs such as *Galium saxatile* as common associates.

3.2.2.2 Dry dwarf shrub heath

There were no significant differences between grouped favourable and unfavourable plots for acid, grazing, nutrient or wet suited species scores. However, the two plots scoring highest on unfavourability also scored highest for mean grazing suited species scores as shown in Figure 2. The highest score, for Kielderhead Compt. 2, was 0.176 which was much higher than the highest score on the blanket bog plots. This plot was also dominated by graminoids such as *Juncus squarrosus* and *Luzula multiflora*, with grazing-tolerant herbs such as *Galium saxatile* abundant. One plot, Ingleborough South House Moor Trig. Point, also scored unusually low on the mean wet suited species score compared to all the other plots which were either neutral or slightly positive.

3.2.2.3 Wet heath

There were no significant differences between grouped favourable and unfavourable plots for acid, grazing, nutrient or wet suited species scores. The biggest differences again occurred among the mean grazing suited species scores. Here, one of the plots scoring highly on unfavourability (Kielderhead Compt. 1) also scored highly for mean grazing suited score at 0.13 as shown in Figure 3. Interestingly, the other high scoring plot on unfavourability, Exford East, had the lowest mean grazing suited score at –0.189. However, the condition assessment was for moderate grazing pressure and the plot scored highest (for unfavourability), on dwarf shrub cover, bryophytes and graminoids. Clearly, if grazing pressure is an issue here, it has not had time to affect the species composition and perhaps some other circumstance, such as a hot burn has affected the vegetation. Kielderhead Compt. 1 had graminoids such as *Juncus squarrosus* and *Agrostis canina*, with grazing-tolerant herb species such as *Galium saxatile* indicating that this plot was fairly degraded.

Apart from one site, Kielderhead Compt. 105, relative favourability seems to be associated with the mean wet suited species score as shown in Figure 4. This suggests that either some wet heath plots are scored more unfavourable due to not having species characteristic of the community types or that the communities are degraded due to drainage or other mechanisms which are changing the characteristic wet heath communities.

3.2.2.4 *U. gallii* heath

There were no significant differences between grouped favourable and unfavourable plots for acid, grazing, nutrient or wet suited species scores. There were however, fairly large differences in mean grazing suited species scores between the favourable and unfavourable plots at each site (unfavourable having higher scores see Figure 5), although no plots scored positively. One plot (Perkins Beech) also scored much lower than the others on mean wet suited species scores, possibly indicating the negative effect of high cover of *Ulex* species on the dwarf shrub heath communities.

3.3 Vegetation community composition

3.3.1 Blanket bog

The results of the DECORANA analyses for blanket bog plots are shown in Figure 6 for Moorhouse & Upper Teesedale, Figure 7 for Kielderhead & Whitelee and Figure 8 for Ingleborough. Quadrat data for all four plots were pooled for analysis with the Moorhouse & Upper Teesedale data as there were no clear 'pairs' of plots in terms of condition for comparison. Quadrats from the more unfavourable plots are clearly located towards the right hand portion of DCA axis 1 on all the graphs. Quadrat scores were significantly different between 'favourable' and 'unfavourable' plots on DCA axis 1 for Moorhouse & Upper Teesedale (Mann-Whitney U = 559.5, P << 0.001), Kielderhead & Whitelee (Mann-Whitney U = 130.0, P << 0.001) and Ingleborough (Mann-Whitney U = 19.0, P << 0.001). There was also a significant difference along DCA axis 2 for Kielderhead & Whitelee (Mann-Whitney U = 224.0, P = 0.001).

Figures 10 to 12 show the DECORANA species plots for Moorhouse & Upper Teesedale, Kielderhead & Whitelee and Ingleborough respectively. The latter two plots clearly show species of degraded or over-grazed blanket bog, such as the common grasses and mesotrophic species such as *Trifolium repens*, appearing at the unfavourable end of the main axis. The picture at Moorhouse & Upper Teesedale is more complicated. Figure 10 shows most of the M19 constants (*Eriophorum vaginatum, Calluna vulgaris, Pleurozium schreberi, Sphagnum capillifolium* and *Rubus chamaemorus*) lying in the left sector of the species ordination. In addition, *Empetrum nigrum* and *Cladonia impexa*, two preferentials for M19b, are also situated with this group. The species lying in the 'unfavourable' part of axis 1 are more akin to communities of more waterlogged ombrogenous peats, such as the M18a raised and blanket mire. These species include *Eriophorum angustifolium, Sphagnum papillosum, Erica tetralix* and *Sphagnum tenellum.* Only two grazing-associated species (*Agrostis canina* and *Nardus stricta*) occur, both at this end of axis 1. It is difficult to say whether the methodology is tending to favour the M19 type of blanket mire over the M18 type here or whether the methodology is showing itself to be very sensitive to distinguishing between blanket bog in favourable and unfavourable condition.

Figure 9 and 13 show the DECORANA quadrat and species scores for all sites pooled. In this case, the ordination is reversed (a common occurrence with DECORANA), with unfavourable plots located towards the lower score end of axis 1. Quadrat scores were significantly different between 'favourable' and 'unfavourable' plots on DCA axis 1 (Mann-Whitney U = 2889.5, P << 0.001) and on DCA axis 2 (Mann-Whitney U = 9121.0, P << 0.001). The position of species indicative of degraded blanket bog, particularly graminoids and mesotrophic species, are again clearly located towards the unfavourable part of axis 1 (the left end) and axis 2 (bottom end) in Figure 13.

Table 15a shows the results of Spearman rank regression (all variables except dung presence) or Mann-Whitney analysis of environmental variables against DECORANA quadrat scores on blanket bog sites. It can be seen that there is consistency among the three within-site analyses for deeper peat and older *Calluna* to be present on the more favourable plots and building *Calluna* and stock dung to be present on the more unfavourable plots. The variable flowering dwarf shrubs is only significantly related to favourable vegetation at one site, Ingleborough. The row of results for the all sites analysis shows that only one significant variable has reversed its direction of relationship as might be expected from the combination of within-site analyses. This variable, flowering dwarf shrubs, may therefore be the only consistent indicator of favourable condition among the attributes tested.

3.3.2 Dry dwarf shrub heath

The results of the DECORANA analyses for dry dwarf shrub heath plots are shown in Figure 14 for Stiperstones, Figure 15 for Ingleborough and Figure 16 for Kielderhead & Whitelee. The striking thing about the Stiperstones plot is the lack of 'spread' of quadrats along DCA axis 1. Two quadrats from the unfavourable plot, are clearly distinct from the rest which are spread along DCA axis 2. These quadrats were very grassy with high frequencies of species such as *Agrostis capillaris* and *Nardus stricta* and were clearly unrepresentative of the plot as a whole. These outliers were therefore excluded from the data and the reduced data set was re-analysed according to normal analytical procedures (Ter Braak 1987). Results of this analysis are shown in Figure 17.

As with the blanket bog DECORANA analyses, quadrats from the more unfavourable plots are located towards the right hand portion of DCA axis 1 on all the graphs. Quadrat scores were significantly different between 'favourable' and 'unfavourable' plots on DCA axis 1 for Ingleborough (Mann-Whitney U = 56.0, $P \ll 0.001$), Kielderhead & Whitelee (Mann-Whitney U = 900.0, $P \ll 0.001$) and approaching significance for Stiperstones (Mann-Whitney U = 303.0, P = 0.069). For Stiperstones, the main difference between favourable and unfavourable scores was along DCA axis 2 (Mann-Whitney U = 265.0, P = 0.016). There was also a significant difference along DCA axis 2 for Ingleborough (Mann-Whitney U = 62.0, P = 0.012) and Kielderhead & Whitelee (Mann-Whitney U = 806.0, $P \ll 0.001$).

Figures 19 to 21 show the DECORANA species plots for Stiperstones, Ingleborough and Kielderhead & Whitelee respectively. Inspection of the Stiperstones plot reveals that several species indicative of grazing pressure (such as *Festuca ovina* and *Deschampsia flexuosa*), plus the invasive *Pteridium aquilinum*, are indeed situated towards the right end of the graph. However, other indicators of grazing pressure, such as *Nardus stricta*, are situated in the centre of axis 1 and towards the bottom end of axis 2 among the more classic species of upland dry dwarf shrub heath. This mixing of species reflects the patchy nature of favourable and unfavourable vegetation on the 'unfavourable' plot at Stiperstones and is the reason why there is no clear separation of quadrats from the two plots along DCA axis 1. Species plots for both Ingleborough and Kielderhead & Whitelee show a clear grouping of mesotrophic and grazing associated species towards the right end of DCA axis 1 (the 'unfavourable' quadrat end), while the species associated with upland NVC types H12-H18 are situated in the left sector of DCA axis 1 (the 'favourable' quadrat end). The unfavourable plots at both these sites were very degraded due to high grazing pressure and were dominated by graminoids such as *Agrostis* spp and *Nardus stricta*. These plots also no longer had *Calluna vulgaris* as a constituent of the plant community although the dwarf shrub *Vaccinium myrtillus* was still present at moderate cover values.

Figures 18 and 22 show the DECORANA quadrat and species scores for all sites pooled. Quadrat scores were significantly different between 'favourable' and 'unfavourable' plots on DCA axis 1 (Mann-Whitney U = 1206.0, $P \ll 0.001$) and on DCA axis 2 (Mann-Whitney U = 2599.0, $P \ll 0.001$). The position of species indicative of degraded dry dwarf shrub heath, particularly graminoids and mesotrophic species, are clearly located towards the unfavourable part of axis 1 (the right end) and axis 2 (top end) in Figure 22. The group of species located at the bottom end of axis 2 and centrally on axis 1 appear to be a mixture of those associated with wetter heaths and may indicate the presence of deeper peat. However, some species of degraded wetter heaths are still present in the group (e.g. *Agrostis canina, Juncus squarrosus*).

Table 15b shows the results of Spearman rank regression (all variables except dung presence) or Mann-Whitney analysis of environmental variables against DECORANA quadrat scores on dry dwarf shrub heath sites. The variable most strongly and consistently correlated with the DCA favourable-unfavourable axis scores is flowering of dwarf shrubs. This grazing-associated attribute is linked with older dwarf shrub growth, particularly in the all sites analysis and also here with grazing of unpalatable species in the other direction (ie towards the unfavourable end of the axis). Contemporary signs of stock presence are also found at this end, although not at Stiperstones. The only inconsistency is the correlation of the attribute grazed growth forms of *Calluna*, which is more prevalent towards the favourable end of DCA axis 1.

3.3.3 Wet heath

As described in Section 3.3.1 above, one plot at Ingleborough occurred on peat greater than 0.5m deep and was therefore deemed to be blanket bog vegetation. This plot was therefore excluded from the within-site analysis. The results of the DECORANA analyses for wet heath plots are shown in Figure 23 for Dunkery & Horner and Figure 24 for Kielderhead & Whitelee. As with the blanket bog and dry dwarf shrub heath DECORANA analyses, quadrats from the more unfavourable plots are located towards the right hand portion of DCA axis 1 on both graphs. Quadrat scores were significantly different between ‘favourable’ and ‘unfavourable’ plots on DCA axis 1 for Dunkery & Horner (Mann-Whitney U = 33.0, $P << 0.001$) and Kielderhead & Whitelee (Mann-Whitney U = 40.0, $P << 0.001$). There was also a significant difference along DCA axis 2 for Dunkery & Horner (Mann-Whitney U = 230.0, $P = 0.001$) and Kielderhead & Whitelee (Mann-Whitney U = 168.0, $P<< 0.001$).

Figures 26 and 27 show the DECORANA species plots for Dunkery & Horner and Kielderhead & Whitelee respectively. The plot for Kielderhead & Whitelee shows a clear grouping of species typical of degraded wet heath, particularly graminoids such as *Holcus lanatus, Juncus effusus* and *Festuca rubra* in the right hand ‘unfavourable’ sector along axis 1. Species more typical of the M15 Trichophorum cespitosum-Erica tetralix wet heath community are clearly grouped in the left hand ‘favourable’ sector. The plot for Dunkery & Horner shows a much more general spread of species typical of the M15 community. The two extremes of DCA axis 1 appear to be related to species adapted to wetter (low scores) and drier (high scores) conditions, although species such as *Potentilla erecta* is a constant species of M15. This may be an effect of past differences in burning regimes, with peat in the ‘unfavourable’ plot possibly having lost its water-retaining ability through a change in structure and nature following uncontrolled burning. There does not appear to be a clear gradation of species due to differential grazing pressure here.

Figures 25 and 28 show the DECORANA quadrat and species scores for all sites pooled. Quadrat scores were significantly different between ‘favourable’ and ‘unfavourable’ plots on DCA axis 1 (Mann-Whitney U = 728.0, $P << 0.001$) and on DCA axis 2 (Mann-Whitney U = 3958.0, $P << 0.001$). The ‘unfavourable‘ plot at Ingleborough is included and appears to be intermediate in community composition along DCA axis 1. The species plot shows a clear grouping of species associated with overgrazed wet heath communities occupying the right hand ‘unfavourable’ sector. The other species appear to be arranged in a gradation from wetter (low scores) to drier (high scores) M15 along DCA axis 2.

Table 15c shows the results of Spearman rank regression (all variables except dung presence) or Mann-Whitney analysis of environmental variables against DECORANA quadrat scores on wet heath sites. As with dry dwarf shrub heath, the attribute flowering dwarf shrubs is the variable most strongly and consistently correlated with the DCA favourable-unfavourable axis scores. This attribute is clearly related also to older growth forms of *Calluna* as shown in the table. Presence of stock dung and peat depth are strongly related to ‘unfavourable’ condition for the all sites analysis. While the stock dung variable is a clear indication of on-going heavy grazing, peat depth is more difficult to explain and may simply be chance differences in plot location. It is doubtful that peat depth is influencing the type of plant community as the species plot clearly shows grazing-suited species clustered at the ‘unfavourable’ end of CDA axis 1. However, peat depth is also strongly correlated with DCA axis 2 on the all sites ordination ($r_s = -0.436$, $P << 0.001$), where there is a change in species’ ecotype as discussed above.

3.3.4 *U. gallii* heath

The results of the DECORANA analyses for *U. gallii* heath plots are shown in Figure 29 for Stiperstones and Figure 30 for Yarner. As with the blanket bog, dry dwarf shrub and wet heath DECORANA analyses, quadrats from the more unfavourable plots are located towards the right hand portion of DCA axis 1 on both graphs. Quadrat scores were significantly different between ‘favourable’ and ‘unfavourable’ plots on DCA axis 1 for Stiperstones (Mann-Whitney U = 22.0, $P < 0.001$) and Yarner (Mann-Whitney U = 79.0, $P << 0.001$). There was also a significant difference along DCA axis 2 for Stiperstones (Mann-Whitney U = 303.0, P = 0.03) and Yarner (Mann-Whitney U = 270.5, P = 0.008).

Figures 32 and 33 show the DECORANA species plots for Stiperstones and Yarner respectively. The species plot for Stiperstones does not show a clear demarcation between species of ‘favourable’ and ‘unfavourable’ *Ulex gallii* heath but there is a definite zone at about score 3 on DCA axis 1 below which these species occur and above which graminoids, grazing-suited and undesirable scrub species occur. The species plot for Yarner, however, shows a distinct group of scrub species at the right hand ‘unfavourable’ end of axis 1. The unfavourable plot here had been hot-burnt about ten years ago and was characterised by a lack of ericoids together with *Pteridium aquilinum* and tree species.

Figures 31 and 34 show the DECORANA quadrat and species scores for all sites pooled. Quadrat scores were not significantly different between ‘favourable’ and ‘unfavourable’ plots on DCA axis 1 but were on DCA axis 2 (Mann-Whitney U = 978.0, $P < 0.001$). It is clear from looking at both quadrat and species plots that there is some similarity between favourable plots in terms of community characteristics, but the unfavourable plots are quite distinct in this respect. A MATCH analysis showed that the two sites have distinct *Ulex gallii* communities: the H4 *Ulex gallii-Agrostis curtisii* NVC community at Yarner and the H8 *Calluna vulgaris-Ulex gallii* NVC community at Stiperstones. Most H4/H8 constants are located towards the middle of axis 1 while the species distinctive of the unfavourable plots are located towards the two ends. The initial differences between the favourable H4/H8 communities at the two sites have been further separated through different causes for unfavourability – fire at Yarner and lack of scrub management at Stiperstones.

Table 15d shows the results of Spearman rank regression (all variables except dung presence) or Mann-Whitney analysis of environmental variables against DECORANA quadrat scores on wet heath sites. There is little consistency among the attributes as to whether they contribute towards explaining the DCA axis scores. Peat depth was not recorded at Yarner so this is a site-specific explanatory variable as is time since burn at Yarner. There is also an inconsistency with grazed dwarf shrub growth forms being related to favourable condition at Yarner, although presence of stock dung is associated with unfavourable condition at Stiperstones. Overall therefore, the measured attributes on the *U. gallii* heath sample plots could not consistently distinguish between favourable and unfavourable vegetation probably due to inherent differences in vegetation community types.

3.4 Relationships between vegetation communities and soil/whole site data

Data on soils at each plot were gathered from bulked samples (see Section 2.2.2.2) and therefore represent individual data points. The soil data, plus data on plot altitude, latitude and longitude, slope aspect and annual rainfall, were regressed against median DCA quadrat scores for whole plots in order to investigate the possibility that between site and between plot variation may be due to external factors other than condition. Latitude and longitude were calculated according to which 100 km Ordnance Survey grid square the site lay in (the most south-western square was scored 1 west, 1 north), plus the first three figures of the standard OS grid-reference in the 100 km square. Thus, Yarner plot C4 was 1786 north, 3792 west and Moorhouse Widdybank plot was 6820 north, 4304 west. Rainfall data applied to whole sites and was therefore duplicated across all plots at each site.

3.4.1 Blanket bog

Both pH (Spearman rank regression coefficient $r_s = -0.878$; $n = 8$, $P < 0.02$), and organic matter ($r_s = 0.964$; $n = 7$, $P = 0.005$) were strongly correlated with DCA axis 1 median scores. Differences in pH would relate well with expected high acidity (low pH levels) in relatively undisturbed peat bog systems while there would also be more intact peat and less inorganic mineral soil constituents here. There were also weaker relationships with DCA axis 1 and Aluminium ($r_s = - 0.847$; $n = 7$, $P < 0.05$) and Manganese ($r_s = - 0.786$; $n = 7$, $P = 0.05$). Usually, Aluminium levels are strongly associated with higher acidity (Proctor 1995). The lack of relationship between low pH and Aluminium suggests that either the element has an external source or that there is some other mechanism such as mixing of the mineral soil with the peat layers resulting in mobilisation of this element in what is already an acid environment. Manganese is usually mobilised under acid conditions under the same processes (Procter 1995).

There was no relationship between axis 1 scores and latitude/longitude, altitude, slope, aspect or rainfall showing that site ‘quality’ was not a function of geographical or physical location.

3.4.2 Dry dwarf shrub heath

There were not enough sites to provide statistical support for the soil analyses and no determinand showed a strong correlation with DCA axis 1 scores. This was also true for the geographical and physical data.

3.4.3 Wet heath

There were not enough sites to provide statistical support for the soil analyses in this habitat but there were indications that Iron content and Exchangeable Carbon were positively and negatively related to DCA axis 1 respectively. These may relate to mobilisation of Iron under disturbed conditions on the unfavourable plots as it is usually bound to dissolved organic matter (Procter 1995) and the amount of bound Carbon in the relatively undisturbed peat on the favourable plots.

3.4.4 *U. gallii* heath

As with the previous two habitat types, there were not enough sites to provide statistical support for the soil analyses but there were indications that organic matter, Magnesium and the Magnesium Index were positively correlated with DCA axis 1 and Aluminium negatively correlated. These may purely be site-related variations due to differences in peat depth and rainfall. There was also an indication that altitude was negatively correlated with DCA axis 1 which is explained by the simple altitudinal differences between the only two sites.

4. Discussion

4.1 Accuracy of attributes

4.1.1 Dwarf shrub cover and diversity

The level of agreement between condition assessment categories and quantitative assessments was generally quite good with these assessments. In the dwarf shrub cover assessments, agreement was attained in seventeen out of the twenty-three plots. Where there was not agreement, assessments were all only a single category out with the percentage point error being less than fifteen percent apart from two of the *U. gallii* plots, where disagreement was large. These plots contained a large amount of mature *U. gallii* but not much *U. europeus*, which would be expected to cause problems in assessing 'allowable' dwarf shrub cover if it was mixed in with the former species. Presumably, as the same level of error was detected at two sites with different observers, there is a difficulty in assessing dwarf shrub cover when it is structurally dominant and this may arise due to the apparent density of foliage when viewed obliquely.

For the dwarf shrub diversity assessment, agreement was good in most habitats apart from blanket bog where agreement was less than forty percent. Neither was there consistency in the direction of disagreement although no plot was more than one condition category out. Where the judgement was towards a more favourable category, the plots contained a combination of sub-dominants which appeared to give an overall higher frequency than there actually was. Where the judgement was towards a less favourable category, the dwarf shrubs tended to be well mixed with the sward, perhaps giving a perception of lower frequency. One other site was well grazed and overall appeared to be in worse ‘condition’ than the quantitative assessment proved.

Generally, although the assessment of dwarf shrubs gave satisfactory results, there would appear to be some inaccuracies which may arise from the relatively rapid condition assessment method. While it is obviously difficult to assess mature dwarf shrub species and cover from above, this needs to be stressed in the guidance as there is clearly some inherent error in the ‘rapid assessment’ method.

4.1.2 Bryophyte/bryophyte and lichen abundance

The level of agreement between condition assessment categories and quantitative assessments was fairly good for bryophyte abundance with only three out of thirteen assessments disagreeing. This attribute applies to both blanket bog and wet heath which are often more open habitats with lower or more patchy dwarf shrub cover. Visual assessment of bryophyte cover among the sward is probably facilitated by this structure.

For bryophyte and lichen cover, all but one of the assessments did not agree although the degree of error was only one category in all cases. Most of the condition assessments awarded more favourable condition than was evident from the quantitative data, although one plot was given lower condition. This would imply that there is not a simple and consistent difference in perception of the terms frequent, occasional and rare as in the guidance or there may be a difference in effectiveness of detecting bryophytes and lichens under a dwarf shrub canopy. This latter possibility is given more credibility by the agreement of assessments in blanket bog and wet heath, where dwarf shrub cover tends to be sparser. In the dry dwarf shrub heath plots, there was a relatively large amount of mature/late mature/degenerate *Calluna* which would make ground cover assessments more difficult.

4.1.3 Graminoid cover

The level of agreement between condition assessment categories and quantitative assessments for this attribute was reasonable, with five (including one marginal), of the thirteen plots being mis-classified. All of these were only one category out. Four of those mis-classified were paired plots at two sites and were consistently mis-classified at each site (Table 5). The condition assessment at Ingleborough was consistent in giving the plots more favourable condition than the quantitative assessment revealed, whereas that at Dunkery and Horner was consistent in giving lower condition. This may reveal a difference in perception of favourable condition at each site by the assessor. Ingleborough has had a long history of severe over-grazing and recent improvements in vegetation ‘condition’ have been marked. Having seen this change, the assessor might have tended towards a more optimistic assessment of graminoid cover. At Dunkery and Horner, both plots were ‘grassy’ in appearance with graminoids common or abundant throughout the plots and this would possibly lead the assessor towards a higher graminoid cover as an oblique view of this type of vegetation would give a denser appearance.

4.1.4 *Calluna* age structure

The level of agreement between condition assessment categories and quantitative assessment for this attribute was extremely good with only one marginal mis-classification (see Table 6). It is interesting to note that this is one of the few attributes which has pictorial guidance.

4.1.5 Grazing impact

4.1.5.1 Flowering dwarf shrubs

The level of agreement between condition assessment categories and quantitative assessment for this attribute appeared to be good despite the difficulty of comparison. This is a conspicuous feature of dwarf shrub health during the summer months and would appear to be an easy attribute to measure.

4.1.5.2 Grazed growth forms

Agreement was fairly good but with some mis-classification. There may have been some difficulty in interpreting this measure, particularly where there had been some heather beetle damage to the *Calluna*. There may be a need for more detailed guidance notes here.

4.1.5.3 Grazing of unpalatable species

Agreement was again reasonably good with this attribute but evidence of grazing of unpalatable species was extremely rare even in plots where grazing levels were obviously high. This points to either this being an attribute that is very difficult to detect and measure in the field or that it is of rare occurrence in the upland situation, probably as stock are relatively free to move and find more palatable species. In this study, this attribute did not contribute much to the assessment of grazing pressure.

4.1.5.4 Uprooted dwarf shrub seedlings in recent burns

As with the above attribute, this probably occurs very rarely in the uplands and was not detected at all in this study.

4.1.5.5 Large herbivore dung

There appeared to be a high degree of agreement between the condition assessment categories and quantitative assessment for this attribute at all sites except one. At this site, Yarner, roe deer were the only large herbivore on the plots and the clumped nature of their dunging clearly resulted in dung being missed from within the quadrats. Otherwise, the conspicuous nature of stock dung appears to make it a good measure of current grazing pressure, not of long-term grazing history.

4.1.5.6 Trampled bare ground; and

4.1.5.7 Trampling damage to *Sphagnum* hummocks

Neither of these attributes were recorded at anything but the lowest level of importance in the condition assessments and were missed where they were detected in the quantitative monitoring. They are clearly not a feature of the habitat at the levels of stock grazing on the plots in this study and may only be relevant very locally under extreme high grazing pressure in the uplands generally.

4.1.5.8 Width of heavy grazing zone

As with the above attributes, the condition assessment and measured assessment were both at the lowest levels and were probably not relevant under the grazing regimes on the study plots.

4.1.6 Summary

There would appear to be a number of areas where attributes appear to be difficult to measure accurately or where there might be inherent difficulties in using a particular attribute. Some attributes, such as those in the grazing impact assessment, may be of rare occurrence and might provide no added value on top of the other easily measured attributes. Generally, attributes which are either easily measured or which have 'tighter' guidance, tended to have better levels of agreement between the condition assessment and the quantitative measure. If all current attributes in the guidance are deemed to remain important, it is suggested that further guidance, and/or training is used to ensure consistency and reduction of errors in recording. Additionally, some attributes may be adding little to the overall assessment and resources may be better used recording 'surrogate' or 'primary' attributes more accurately.

4.2 Botanical composition

4.2.1 C-S-R strategies

The small number of significant differences between favourable and unfavourable plots across habitats for the C-S-R radii makes any solid conclusions difficult. However, two sets of plots showed a consistently higher score for the R-radius on the unfavourable plots. These were on the blanket bog and wet heath habitats which show a good deal of similarity in botanical composition and functional ecology (Rodwell 1991). Ruderal species might be expected to be more prevalent among disturbed communities due to their ability to quickly colonize gaps but also due to their inability to compete with other species (Grime *et al* 1988). This clearly points to some disturbance factor acting on these plots, perhaps due to higher grazing pressure.

On the dry dwarf shrub heath, one favourable plot showed a higher C-radius and lower S-radius score than its paired unfavourable plot. Although a subtle effect, this was due to the presence of high stress-tolerators and low competitors, that are adapted to higher grazing levels, on the unfavourable plot. Again, grazing appears to be the driving force for communities containing species of different C-S-R strategies among some plots.

4.2.2 Suited species scores

There was a clear tendency for unfavourable plots to score highest for grazing suited species, although only one habitat, blanket bog, showed a statistically significant difference (section 3.2.2.1). Mean grazing suited species scores for most blanket bog plots (negative), showed that this habitat is particularly unsuitable in terms of species' tolerance to anything but light grazing pressure.

There was also a tendency for favourable wet heath plots to score more highly on wet suited species although this was not significant. As discussed in section 3.2.2.3, this could be due to a degradation of the characteristic suite of species of wet heath communities due to drainage and/or other features of management associated with unfavourable condition.

4.2.3 Vegetation community composition

The multivariate analysis of botanical data proved extremely successful in separating favourable and unfavourable plots using community data. Both pairs of plots and all plots combined within habitat types showed good separation along the main DCA axis which accounted for most variation in the data. The only exception was in the *U. gallii* heaths, where community types (and therefore composition), were distinctly different between the two sites in the study. Here, the second DCA axis proved efficient at separating the favourable and unfavourable plots.

Clearly, these results need to be used with caution as, even with the efforts made to select paired plots within sites which represented similar (potential) vegetation, inherent differences in soils and previous history, particularly burning, would show typical differences in site (quadrat) scores between the plots. However, species' ordinations well highlighted the compositional differences between favourable and unfavourable plots, with many reflecting the suited species and C-S-R analyses previously done.

Independent environmental variables showed that favourable plots tended to be associated with healthy mature *Calluna* and flowering dwarf shrubs in general while unfavourable plots tended to be associated with young *Calluna*, *Calluna* showing signs of grazing or browsing plus signs of contemporary stock activity. This combination of attributes explained nearly all of the differences associated with favourability along the most important DCA axis and rather neatly summarize the most important problems facing the upland habitats on the sites in this study – those associated with overgrazing. Work on moorland ESAs by ADAS has tended to concentrate on the direct effects of grazing on *Calluna* stems, giving rise to a Grazing Index and Biomass Utilisation index (Critchley *et al* 2002). Such indices have therefore been used as an index of moorland quality and monitoring of these under different grazing prescriptions has been accepted as a suitable index of overall grazing pressure.

One intriguing result of the regression analyses was the differences shown between favourable and unfavourable plots due to peat depth. It is impossible to establish cause and effect here, whether on blanket bogs, for example, lower peat depth (perhaps due to over-burning), has led to conditions which attract stock to more palatable plant species or whether continued high stock levels have caused peat erosion or some other mechanism which has reduced the depth of the peat.

4.2.4 Relationships between vegetation communities and soil/whole site data

Results of this analysis showed some worrying trends where the potentially toxic element Aluminium appears to be mobilising, although levels may not yet be serious. However, the mechanisms behind this are not known apart from an association with more acidic conditions, possibly arising from external sources in ombrogenous water, or possibly where peat soil is becoming more acid due to continuous burning cycles (A. Crowle, pers. comm.). Recent work has also suggested that where stock levels are higher, increased biological activity in the peat may lead to higher levels of acidity (S. Ross, Penny Anderson Associates, pers. comm.). Some, or a combination of these factors may be at work at the sites in this study and would warrant further investigation.

4.3 Further work

This study has shown that there are strong correlations between grazing pressure and botanical/vegetation community composition in upland dwarf shrub habitats. The study sites were selected from a range of known dwarf shrub communities and with a variety of management regimes. However, a large proportion (approximately 35 per cent of upland heathland and blanket bog) of the area of upland dwarf shrub communities in England are still managed as grouse moor and these are probably under-represented in the present study. Managing uplands for grouse is known to have a profound influence on biodiversity in general (English Nature 2001) and rotational burning remains a controversial management method. It is suggested, therefore, that further research into the effects of this type of management on condition is carried out, particularly in some of the key uplands on Dartmoor and the east Pennines.

5. Acknowledgements

I would like to thank Doug McCutcheon who carried out much of the survey work on the northern sites; local team and site management staff from English Nature: Peter Corkhill and John Osborne at Ingleborough NNR, Tom Wall, Caroline Daguet and David Hatfield at Stiperstones NNR, Phil Page, Dave Mercer and Albert Knott at Yarner Wood NNR, Flemming Ulf-Hansen, Julia Rand, Ian Slater. Bill Burlton and and Martin Davison from the Forest Authority; Steve Lowe from the Northumberland Wildlife Trust; John Adamson from the Centre for Ecology and Hydrology at Merlewood. Nigel Critchley and John Fowbert from ADAS Redesdale. Thanks are also due to Louise Amos and Marc Turner of English Nature for inputting the field data.

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Table 1 Dwarf shrub cover measure and condition score

Blanket bog

Site/Plot	Mean dwarf shrub cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
MH/UT: Widdybank Fell	50.9	0	Y	
MH/UT: Valley Bog	30.7	0	N (one out)	+2
MH/UT: TSS	74.5	0	Y	
MH/UT: Plot 206	64.0	0	Y	
KH/WL: Sandy's Gears Fav	72.2	0	Y	
KH/WL: Sandy's Gears UF	71.4	0	Y	
ING: Scar Close Moss	22.6	0	N (one out)	+10
ING: Fenwick Lot	3.0	2	Y	

Dry dwarf shrub heath

Site/Plot	Mean dwarf shrub cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
STIP: Fav Plot	87.0	0	Y	
STIP: UF Plot	71.6	1	Y	
ING: South House Moor Trig	23.1	1	N (one out)	+2
ING: Park Fell	4.1	6	Y	
KH/WL: Compt 84	97.6	0	Y	
KH/WL: Compt 2	4.3	6	Y	

Wet heath

Site/Plot	Mean dwarf shrub cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
ING: South House Moor	12.1	1	N (one out)	+14
DU/HR: Exford Common West	50.4	0	Y/N (marginal)	(<+1)
DU/HR: Exford Common East	14.6	2	Y	
KH/WL: Compt 105	55.0	0	Y	
KH/WL: Compt 1	8.0	2	Y	

U. gallii heath

Site/Plot	Mean dwarf shrub cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
STIP: Mytton Dingle	85.5	0	Y	
STIP: Perkins Beach	36.8	0	N(one out)	+38
YAR: Compt C4	47.1	0	N(one out)	+28
YAR: Compt A2/A4	10.4	2	Y	

Summary Statistics for Table 1

Site/Plot	Correct category (%)	One category out (%)	Marginal (%)
Blanket bog	6 (75%)	2 (25%)	
Dry dwarf shrub heath	5 (83.3%)	1 (16.7%)	
Wet heath	3 (60%)	1 (20%)	1 (20%)
U. gallii heath	2 (50%)	2 (50%)	
Total	16 (69.6%)	6 (26.1%)	1 (4.3%)

NB - The scoring system for condition assessment is:

Blanket bog

0 points	1 point	2 points
Cover >33% except in wetter areas	<33% except in wetter areas	<5%

Dry dwarf shrub and *U. gallii* heaths

0 points	1 point	2 points	6 points
Cover >75%	26-75%	5-25%	<5%

Wet heath

0 points	1 point	2 points	4 points
Cover 51-75%	>75% or 26-50%	5-25%	<5%

Table 2 Dwarf shrub diversity measure and condition score

Blanket bog

Site/Plot	Dwarf shrub diversity (No spp widespread & frequent)	Condition assessment score	Correct category?	Direction of error of assessment
MH/UT: Widdybank Fell	2	0	Y	
MH/UT: Valley Bog	1	0	N(one out)	+
MH/UT: TSS	1	0	N(one out)	+
MH/UT: Plot 206	2	0	Y	
KH/WL: Sandy's Gears Fav	2	1	N(one out)	-
KH/WL: Sandy's Gears UF	2	1	N(one out)	-
ING: Scar Close Moss	4	1	N(one out)	-
ING: Fenwick Lot	1	1	Y	

Dry dwarf shrub heath

Site/Plot	Dwarf shrub diversity (No spp widespread & frequent)	Condition assessment score	Correct category?	Direction of error of assessment
STIP: Fav Plot	3	0	Y	
STIP: UF Plot	3	0	Y	
ING: South House Moor Trig	1	0	N(one out)	+
ING: Park Fell	1	1	Y	
KH/WL: Compt 84	2	0	Y	
KH/WL: Compt 2	1	1	Y	

Wet heath

Site/Plot	Dwarf shrub diversity (No spp widespread & frequent)	Condition assessment score	Correct category?	Direction of error of assessment
ING: South House Moor	2	0	Y	
DU/HR: Exford Common West	3	0	Y	
DU/HR: Exford Common East	3	1	N(one out)	-
KH/WL: Compt 105	3	0	Y	
KH/WL: Compt 1	1	1	Y	

U. gallii heath

Site/Plot	Dwarf shrub diversity (No spp widespread & frequent)	Condition assessment score	Correct category?	Direction of error of assessment
STIP: Mytton Dingle	3	0	Y	
STIP: Perkins Beach	2	0	Y	
YAR: Compt C4	2	0	Y	
YAR: Compt A2/A4	1	1	Y	

Summary Statistics for Table 2

Site/Plot	Correct category (%)	One category out (%)
Blanket bog	3 (37.5)	5 (62.5)
Dry dwarf shrub heath	5 (83.3)	1 (16.7)
Wet heath	4 (80.0)	1 (20.0)
U. gallii heath	4 (100.0)	0 (0.0)
Total	16 (69.6)	7 (30.4)

NB - The scoring system for condition assessment is:

All habitats

0 points	1 point
2 or more spp widespread & widespread & frequent	no more than 1 sp widespread & frequent

Table 3 Bryophyte cover/frequency measure and condition score

Blanket bog

Site/Plot	Mean bryophyte cover (%)	Bryophyte frequency (%)	Condition assessment score	Correct category (from cover)?	Direction of error of assessment
MH/UT: Widdybank Fell	49.9	100	0	Y	
MH/UT: Valley Bog	52.1	100	0	Y	
MH/UT: TSS	36.4	96.7	0	Y	
MH/UT: Plot 206	67.1	100	0	Y	
KH/WL: Sandy's Gears Fav	60.6	100	0	Y	
KH/WL: Sandy's Gears UF	23.9	100	1	Y	
ING: Scar Close Moss	52.8	96.7	0	Y	
ING: Fenwick Lot	26.1	96.7	4	N (one out)	-

Wet heath

Site/Plot	Mean bryophyte cover (%)	Bryophyte frequency (%)	Condit-ion assess-ment score	Correct category (from cover?	Direction of error of assessment
ING: South House Moor	13.9	73.3	0	Y	
DU/HR: Exford Common West	36.5	96.7	0	Y	
DU/HR: Exford Common East	10.0	76.7	2	N (one out)	+
KH/WL: Compt 105	42.9	100	0	Y	
KH/WL: Compt 1	17.3	100	0 to 2*	Y/N	(+)

* Observer recorded a range.

NB - The scoring system for condition assessment is:

Blanket bog

0 points	1 point	2 points	4 points
Abundant, including frequent and widespread Sphagnum spp	Frequent to abundant but Sphagnum spp occastion-rare	Occasional, Sphagnum spp more or	Rare

Wet heath

0 points	2 points	4 points
Frequent patches	Occasional patches	Rare

Table 4 Bryophyte/Lichen cover/frequency measure and condition score

Dry dwarf shrub heath

Site/Plot	Mean bryophyte/ lichen cover (%)	Bryophyte/ lichen frequency (%)	Condition assessment score	Correct category (from cover)?	Direction of error of assessment
STIP: Fav Plot	29.3	100	0	N (one out)	+ (marginal)
STIP: UF Plot	27.8	90	0	N (one out)	+
ING: South House Moor Trig	23.9	100	0	N (one out)	+
ING: Park Fell	7.4	83.3	1	N (one out)	+
KH/WL: Compt 84	47.3	100	0	Y	
KH/WL: Compt 2	19.6	100	2	N (one out)	-

NB - The scoring system for condition assessment is:

0 points	2 points	4 points
Frequent patches	Occasional	Rare

Table 5 Graminoid cover measure and condition score

Blanket bog

Site/Plot	Mean graminoid cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
MH/UT: Widdybank Fell	21.2	0	Y	
MH/UT: Valley Bog	33.5	0	Y	
MH/UT: TSS	14.2	0	Y	
MH/UT: Plot 206	14.9	0	Y	
KH/WL: Sandy's Gears Fav	17.6	0	Y	
KH/WL: Sandy's Gears UF	23.8	1	N (one out)	+26
ING: Scar Close Moss	58.7	0	N (one out)	-9
ING: Fenwick Lot	59.8	0	N (one out)	-10

Wet heath

Site/Plot	Mean graminoid cover (%)	Condition assessment score	Correct category?	Percentage point error of assessment
ING: South House Moor	57.5	1	Y	
DU/HR: Exford Common West	32.8	1	N (one out)	+17
DU/HR: Exford Common East	73.5	2	N (one out-marginal)	+1
KH/WL: Compt 105	57.7	1	Y	
KH/WL: Compt 1	81.0	2	Y	

NB - The scoring system for condition assessment is:

0 points	2 points	4 points
Cover <50%	cover 50-75%	cover >75%

Table 6 *Calluna* age structure measure and condition score

Dry dwarf shrub heath

Site/Plot	% Calluna late mature/ degenerate age class	Condition assessment score	Correct category?	Percentage point error of assessment
STIP: Fav Plot	28.5	0	Y	
STIP: UF Plot	60.1	0	Y	
ING: South House Moor Trig	6.9	1	Y	
ING: Park Fell	0	1	Y	
KH/WL: Compt 84	75.3	0	Y	
KH/WL: Compt 2	0	1	Y	

Wet heath

Site/Plot	% Calluna late mature/ degenerate age class	Condition assessment score	Correct category?	Percentage point error of assessment
ING: South House Moor	0	1	Y	
DU/HR: Exford Common West	54.1	0	Y	
DU/HR: Exford Common East	32.8	1	Y (marginal)	
KH/WL: Compt 105	50.7	0	Y	
KH/WL: Compt 1	0	1	Y	

U. gallii heath

Site/Plot	% Calluna late mature/ degenerate age class	Condition assessment score	Correct category?	Percentage point error of assessment
STIP: Mytton Dingle	52.4	0	Y	
STIP: Perkins Beach	0	1	Y	
YAR: Compt C4	100	0	Y	
YAR: Compt A2/A4	9.1	1	Y	

NB - The scoring system for condition assessment is:

Dry dwarf shrub/Ulex gallii heath

0 points	1 points
>25% late mature/degenerate or excluded from burning	<25% late mature/degenerate or excluded from burning

Wet heath

0 points	1 points
>33% late mature/degenerate or excluded from burning	<33% late mature/degenerate or excluded from burning

Table 7 Dwarf shrub flowering measure and condition score

Blanket bog

Site/Plot	Mean proportion of flowering shoots (%)	Condition assessment category
MH/UT: Widdybank Fell	9.3	N/A
MH/UT: Valley Bog	8.2	N/A
MH/UT: TSS	12.6	N/A
MH/UT: Plot 206	1.4	N/A
KH/WL: Sandy's Gears Fav	68.0	N/A
KH/WL: Sandy's Gears UF	66.5	N/A
ING: Scar Close Moss	47.6	N/A
ING: Fenwick Lot	8.3	N/A

Dry dwarf shrub heath

Site/Plot	Mean proportion of flowering shoots (%)	Condition assessment category
STIP: Fav Plot	76.6	Abundant & conspicuous
STIP: UF Plot	78.4	Abundant & conspicuous
ING: South House Moor Trig	2.7	Obvious but patchy
ING: Park Fell	0	Sparse
KH/WL: Compt 84	68.2	Obvious but patchy
KH/WL: Compt 2	0	Sparse (absent)

Wet heath

Site/Plot	Mean proportion of flowering shoots (%)	Condition assessment category
ING: South House Moor	22.7	Sparse
DU/HR: Exford Common West	51.2	Abundant & conspicuous/obvious but patchy
DU/HR: Exford Common East	44.4	Obvious but patchy
KH/WL: Compt 105	33.1	Obvious but patchy
KH/WL: Compt 1	0	N/A (*Calluna* absent)

U. gallii heath

Site/Plot	Mean proportion of flowering shoots (%)	Condition assessment category
STIP: Mytton Dingle	100.0	Abundant & conspicuous
STIP: Perkins Beach	100.0	Abundant & conspicuous
YAR: Compt C4	97.6	Abundant & conspicuous
YAR: Compt A2/A4	98.6	Abundant & conspicuous

Table 8 Grazed growth forms of *Calluna* measure and condition score

Blanket bog

Site/Plot	Mean frequency of grazed growth forms (%)	Condition assessment category
MH/UT: Widdybank Fell	0	Hard to find
MH/UT: Valley Bog	0	Hard to find
MH/UT: TSS	0	Hard to find
MH/UT: Plot 206	0	Hard to find
KH/WL: Sandy's Gears Fav	0	Localised
KH/WL: Sandy's Gears UF	0	Widespread
ING: Scar Close Moss	0	Hard to find
ING: Fenwick Lot	0	N/A (*Calluna* absent)

Dry dwarf shrub heath

Site/Plot	Mean frequency of grazed growth forms (%)	Condition assessment category
STIP: Fav Plot	0	Hard to find
STIP: UF Plot	0	Hard to find
ING: South House Moor Trig	2.7	Hard to find
ING: Park Fell	0	N/A (*Calluna* absent)
KH/WL: Compt 84	68.2	Hard to find
KH/WL: Compt 2	0	N/A (*Calluna* absent)

Wet heath

Site/Plot	Mean frequency of grazed growth forms (%)	Condition assessment category
ING: South House Moor	0	Hard to find (none)
DU/HR: Exford Common West	41.5	Widespread
DU/HR: Exford Common East	31.6	Localised/widespread
KH/WL: Compt 105	20.0	Hard to find
KH/WL: Compt 1	0	N/A (*Calluna* absent)

U. gallii heath

Site/Plot	Mean frequency of grazed growth forms (%)	Condition assessment category
STIP: Mytton Dingle	0	Hard to find
STIP: Perkins Beach	0	Hard to find
YAR: Compt C4	3.1	Hard to find
YAR: Compt A2/A4	0	Hard to find

Table 9 Grazing of unpalatable species measure and condition score

Blanket bog

Site/Plot	Mean frequency of grazed unpalatable species (%)	Condition assessment category
MH/UT: Widdybank Fell	0	Hard to find
MH/UT: Valley Bog	0	Hard to find
MH/UT: TSS	0	Hard to find
MH/UT: Plot 206	0	Hard to find
KH/WL: Sandy's Gears Fav	0	Hard to find
KH/WL: Sandy's Gears UF	0	Some
ING: Scar Close Moss	0	Hard to find
ING: Fenwick Lot	0.1	Some

Dry dwarf shrub heath

Site/Plot	Mean frequency of grazed unpalatable species (%)	Condition assessment category
STIP: Fav Plot	0	Hard to find
STIP: UF Plot	10.5	Some
ING: South House Moor Trig	0	Hard to find
ING: Park Fell	0	Hard to find
KH/WL: Compt 84	0	Hard to find (none)
KH/WL: Compt 2	0	Some

Wet heath

Site/Plot	Mean frequency of grazed unpalatable species (%)	Condition assessment category
ING: South House Moor	0	Hard to find (none)
DU/HR: Exford Common West	0.2	Hard to find
DU/HR: Exford Common East	0	Hard to find
KH/WL: Compt 105	0	Hard to find
KH/WL: Compt 1	0	N/A

U. gallii heath

Site/Plot	Mean frequency of grazed unpalatable species (%)	Condition assessment category
STIP: Mytton Dingle	0	Hard to find
STIP: Perkins Beach	0	Some
YAR: Compt C4	0	Hard to find
YAR: Compt A2/A4	0	Hard to find

Table 10 Uprooted dwarf shrub seedlings measure and condition score

Dry dwarf shrub heath

Site/Plot	Mean proportion of dwarf shrub seedlings uprooted (%)	Condition assessment category
STIP: Fav Plot	0	Hard to find
STIP: UF Plot	0	Hard to find
ING: South House Moor Trig	0	Hard to find
ING: Park Fell	0	Hard to find
KH/WL: Compt 84	0	N/A
KH/WL: Compt 2	0	N/A

Wet heath

Site/Plot	Mean proportion of dwarf shrub seedlings uprooted (%)	Condition assessment category
ING: South House Moor	0	Hard to find
DU/HR: Exford Common West	0	Hard to find
DU/HR: Exford Common East	0	Hard to find
KH/WL: Compt 105	0	Hard to find
KH/WL: Compt 1	0	N/A

U. gallii heath

Site/Plot	Mean proportion of dwarf shrub seedlings uprooted (%)	Condition assessment category
STIP: Mytton Dingle	0	Hard to find
STIP: Perkins Beach	0	N/A
YAR: Compt C4	0	Hard to find
YAR: Compt A2/A4	0	Hard to find

Table 11 Large herbivore dung measure and condition score

Blanket bog

Site/Plot	Mean frequency of herbivore dung (%)	Condition assessment category
MH/UT: Widdybank Fell	0	N/A
MH/UT: Valley Bog	0	N/A
MH/UT: TSS	0	N/A
MH/UT: Plot 206	0	N/A
KH/WL: Sandy's Gears Fav	0	N/A
KH/WL: Sandy's Gears UF	33.3	N/A
ING: Scar Close Moss	0	N/A
ING: Fenwick Lot	46.7	N/A

Dry dwarf shrub heath

Site/Plot	Mean frequency of herbivore dung (%)	Condition assessment category
STIP: Fav Plot	10.0	Easy to find but not conspicuous
STIP: UF Plot	13.3	Easy to find but not conspicuous
ING: South House Moor Trig	3.3	Rare and difficult to find
ING: Park Fell	50.0	Easy to find but not conspicuous
KH/WL: Compt 84	26.7	Easy to find but not conspicuous
KH/WL: Compt 2	53.3	Very conspicuous

Wet heath

Site/Plot	Mean frequency of herbivore dung (%)	Condition assessment category
ING: South House Moor	0	Rare and difficult to find
DU/HR: Exford Common West	3.3	Rare and difficult to find
DU/HR: Exford Common East	10.0	Easy to find but not conspicuous
KH/WL: Compt 105	10.0	Easy to find but not conspicuous
KH/WL: Compt 1	46.7	Very conspicuous

U. gallii heath

Site/Plot	Mean frequency of herbivore dung (%)	Condition assessment category
STIP: Mytton Dingle	0	Rare and difficult to find
STIP: Perkins Beach	13.3	Rare and difficult to find
YAR: Compt C4	0	Easy to find but not conspicuous
YAR: Compt A2/A4	0	Easy to find but not conspicuous

Table 12 Trampled bare ground measure and condition score

Blanket bog

Site/Plot	Mean proportion of trampled bare ground, paths & enhanced hagging(%)	Condition assessment category
MH/UT: Widdybank Fell	0	Hard to find
MH/UT: Valley Bog	0	Hard to find
MH/UT: TSS	0	Hard to find
MH/UT: Plot 206	0	Hard to find
KH/WL: Sandy's Gears Fav	0	Hard to find
KH/WL: Sandy's Gears UF	0	Hard to find
ING: Scar Close Moss	0	Hard to find
ING: Fenwick Lot	0	Hard to find

Dry dwarf shrub heath

Site/Plot	Mean proportion of trampled bare ground (%)	Condition assessment category
STIP: Fav Plot	0.3	None, other than sporadic sheep scars or rabbit scrapes in recent burns
STIP: UF Plot	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
ING: South House Moor Trig	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
ING: Park Fell	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
KH/WL: Compt 84	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
KH/WL: Compt 2	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns

Wet heath

Site/Plot	Mean proportion of trampled bare ground (%)	Condition assessment category
ING: South House Moor	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
DU/HR: Exford Common West	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
DU/HR: Exford Common East	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
KH/WL: Compt 105	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
KH/WL: Compt 1	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns

U. gallii heath

Site/Plot	Mean proportion of trampled bare ground (%)	Condition assessment category
STIP: Mytton Dingle	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
STIP: Perkins Beach	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
YAR: Compt C4	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns
YAR: Compt A2/A4	0	None, other than sporadic sheep scars or rabbit scrapes in recent burns

Table 13 Trampling damage to *Sphagnum* hummocks measure and condition score

Blanket bog

Site/Plot	Mean proportion of Sphagnum hummocks trampled (%)	Condition assessment category
MH/UT: Widdybank Fell	0	Hard to find
MH/UT: Valley Bog	0	Hard to find
MH/UT: TSS	0	Hard to find
MH/UT: Plot 206	0.5	Hard to find
KH/WL: Sandy's Gears Fav	0	Hard to find
KH/WL: Sandy's Gears UF	0	Hard to find
ING: Scar Close Moss	0	Hard to find
ING: Fenwick Lot	0	Hard to find

Table 14 Width of heavy grazing zone measure and condition score

Dry dwarf shrub heath

Site/Plot	Width of heavy grazing zone (m)	Condition assessment category
STIP: Fav Plot	0	<1m or absent
STIP: UF Plot	0	<1m or absent
ING: South House Moor Trig	0	<1m or absent
ING: Park Fell	0	N/A
KH/WL: Compt 84	0	N/A
KH/WL: Compt 2	0	N/A

Wet heath

Site/Plot	Width of heavy grazing zone (m)	Condition assessment category
ING: South House Moor	0	<1m or absent
DU/HR: Exford Common West	0	<1m or absent
DU/HR: Exford Common East	0	<1m or absent
KH/WL: Compt 105	0	N/A
KH/WL: Compt 1	0	N/A

U. *gallii* heath

Site/Plot	Width of heavy grazing zone (m)	Condition assessment category
STIP: Mytton Dingle	0	<1m or absent
STIP: Perkins Beach	0	<1m or absent
YAR: Compt C4	0	<1m or absent
YAR: Compt A2/A4	0	<1m or absent

Table 15 Significant independent variables between plots in DECORANA analyses (along major axis of separation)

a) Blanket Bog

Site	Peat depth	*Cv*[1] pioneer	*Cv* building	*Cv* early mature	*Cv* late mature	*Cv* degenerate	Flowering dwarf shrubs	*Cv* gzd growth forms[2]	Gzng other[3] species	Bare ground[4]	Damage to *Sphagnum* hummocks	Presence of stock dung	Time since burn
Ingleborough	---					-	---					+++	
Kielderhead & Whitelee	--		++		---							+	
Moorhouse & Upper Teesdale	?		++		---	-							
All sites	-		++			--	+++					++[a]	

Notes for table: 1- *Cv* = *Calluna vulgaris*; 2- Grazed growth forms include ‘topiary’, ‘drumstick’ and ‘carpet’ growth forms; 3- Signs of grazing of *Empetrum nigrum*, *Vaccinium vitis-idaea* or *Nardus stricta* where present; Presence of trampled bare ground, stock paths and enhanced hagging.

\+ Positive relationship with axis score.
\- Negative relationship with axis score.
? – No data.
a - Stock dung in all sites analysis more prevalent at more **favourable** sites.

Significance of Spearman rank regression coefficient or Mann-Whitney U statistic: + $P < 0.05$; ++ $P < 0.01$; +++ $P < 0.001$.

b) Dry Dwarf Shrub Heath (With Outliers)

Site	Peat depth	*Cv*[1] pioneer	*Cv* building	*Cv* early mature	*Cv* late mature	*Cv* degenerate	Flowering dwarf shrubs	*Cv* gzd growth forms[2]	Gzng other[3] species	Uproot-ed dwarf shrubs	Bare ground[4]	Presence of stock dung	Time since burn
Stiperstones		++		---		-	---		+				
Ingleborough							---					++	
Kielderhead & Whitelee							---					++	
All sites		+++	+++	-	--	---	---	-	+			+++	

Notes for table: 1- *Cv* = *Calluna vulgaris*; 2- Grazed growth forms include 'topiary', 'drumstick' and 'carpet' growth forms; 3- Signs of grazing of *Empetrum nigrum*, *Vaccinium vitis-idaea* or *Nardus stricta* where present; 4- Presence of trampled bare ground or stock paths.

c) Wet Dwarf Shrub Heath

Site	Peat depth	*Cv*[1] pioneer	*Cv* build-ing	*Cv* early mature	*Cv* late mature	*Cv* degenerate	Flowering dwarf shrubs	*Cv* gzd growth forms[2]	Gzng other[3] species	Uprooted dwarf shrubs	Bare ground[4]	Presence of stock dung	Time since burn
Dunkery & Horner		+++	-	- - -	---		---						
Kielderhead & Whitelee	++	+			-		---						
All sites [a]	+++			-	---	-	---	--	-			+++	

Notes for table: 1- *Cv* = *Calluna vulgaris*; 2- Grazed growth forms include 'topiary', 'drumstick' and 'carpet' growth forms; 3- Signs of grazing of *Erica tetralix, Empetrum nigrum*, *Vaccinium vitis-idaea* or *Nardus stricta* where present; 4- Presence of trampled bare ground or stock paths.

a – All sites includes one plot on Ingleborough.

d) *Ulex gallii* Dry Dwarf Shrub Heath

Site	**Peat depth**	***Cv*[1] pioneer**	***Cv* building**	***Cv* early mature**	***Cv* late mature**	***Cv* degenerate**	**Flowering dwarf shrubs**	***Cv* gzd growth forms[2]**	**Gzng other[3] species**	**Uprooted dwarf shrubs**	**Bare ground[4]**	**Presence of stock dung**	**Time since burn**
Stiperstones	+++		++		---							++	
Yarner	?		+	+++	---	--		--					+++
All sites [a]	+++												
All sites [b]	--	-	--	+			---					++	

Notes for table: 1- *Cv* = *Calluna vulgaris*; 2- Grazed growth forms include 'topiary', 'drumstick' and 'carpet' growth forms; 3- Signs of grazing of *Empetrum nigrum*, *Vaccinium vitis-idaea* or *Nardus stricta* where present; 4- Presence of trampled bare ground or stock paths.

? – No data.
a – Decorana axis 2: this was the only major axis showing a significant difference between favourable and unfavourable plots.
b – Decorana axis 1 (non-significant favourable v unfavourable): floristic differences between sites and lack of data for peat depth has probably resulted in an unrealistic assumption that both sets of favourable and unfavourable plots have similar properties.

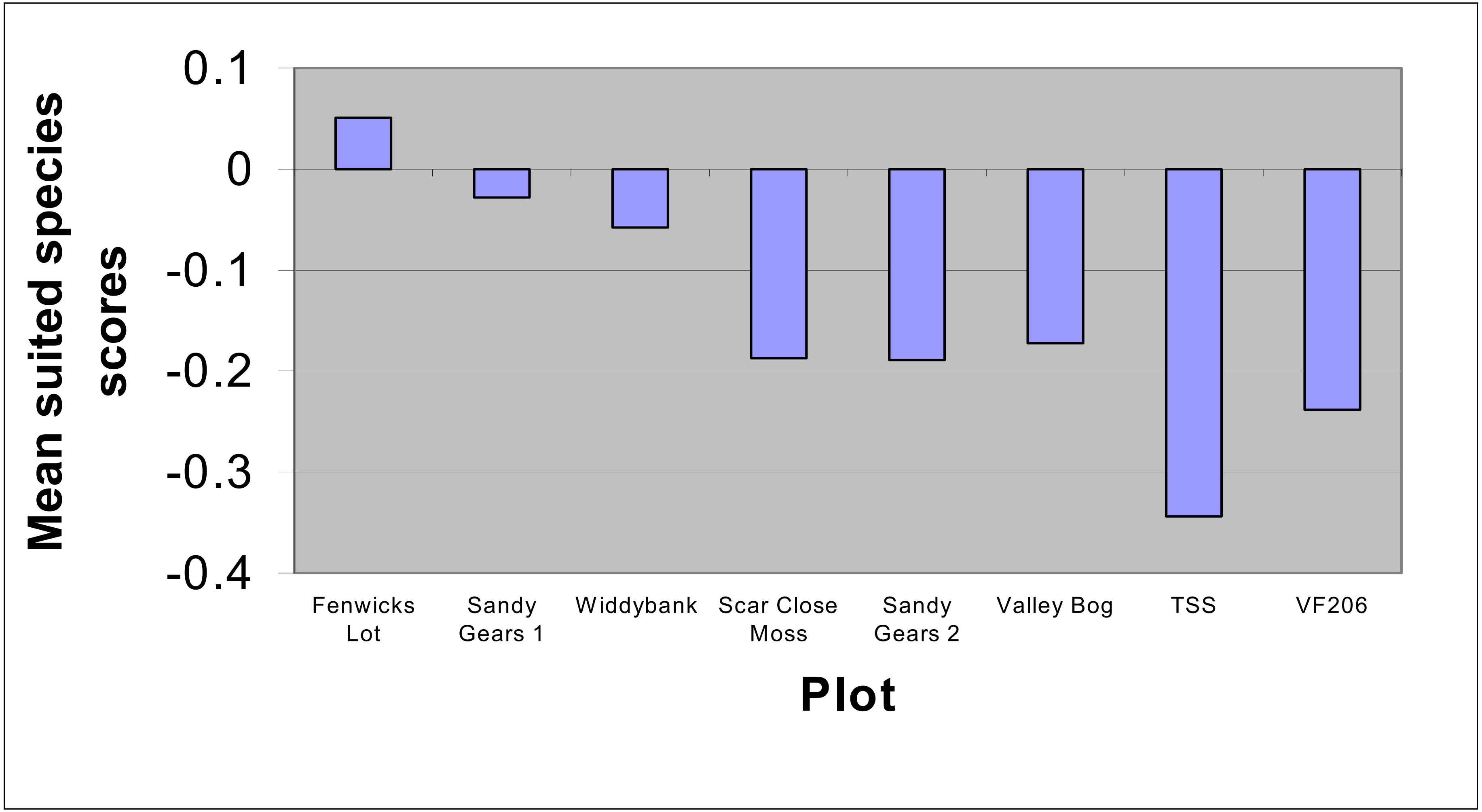

Figure 1. Blanket bog: grazing suited species scores

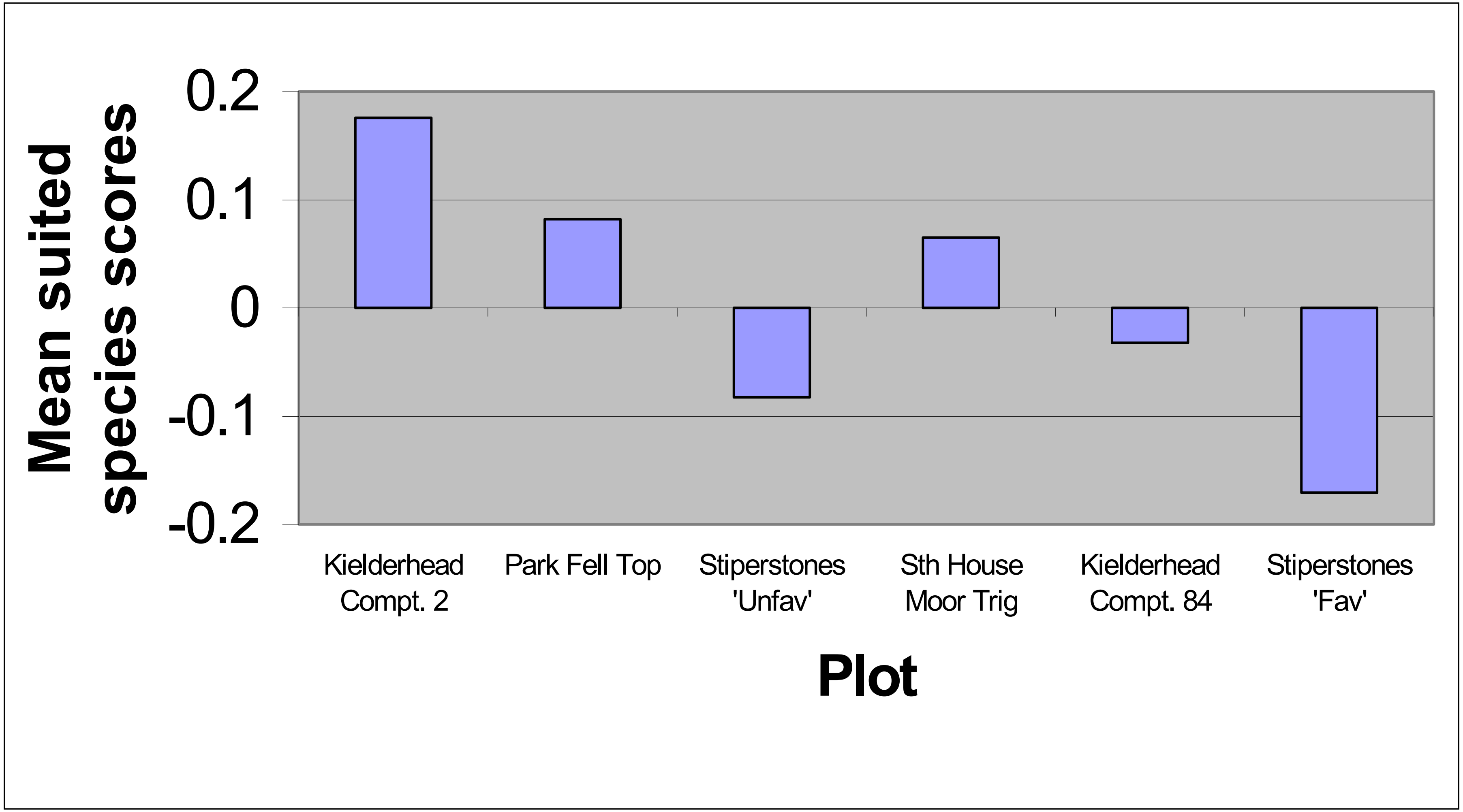

Figure 2. Dry dwarf shrub heath: grazing suited species scores

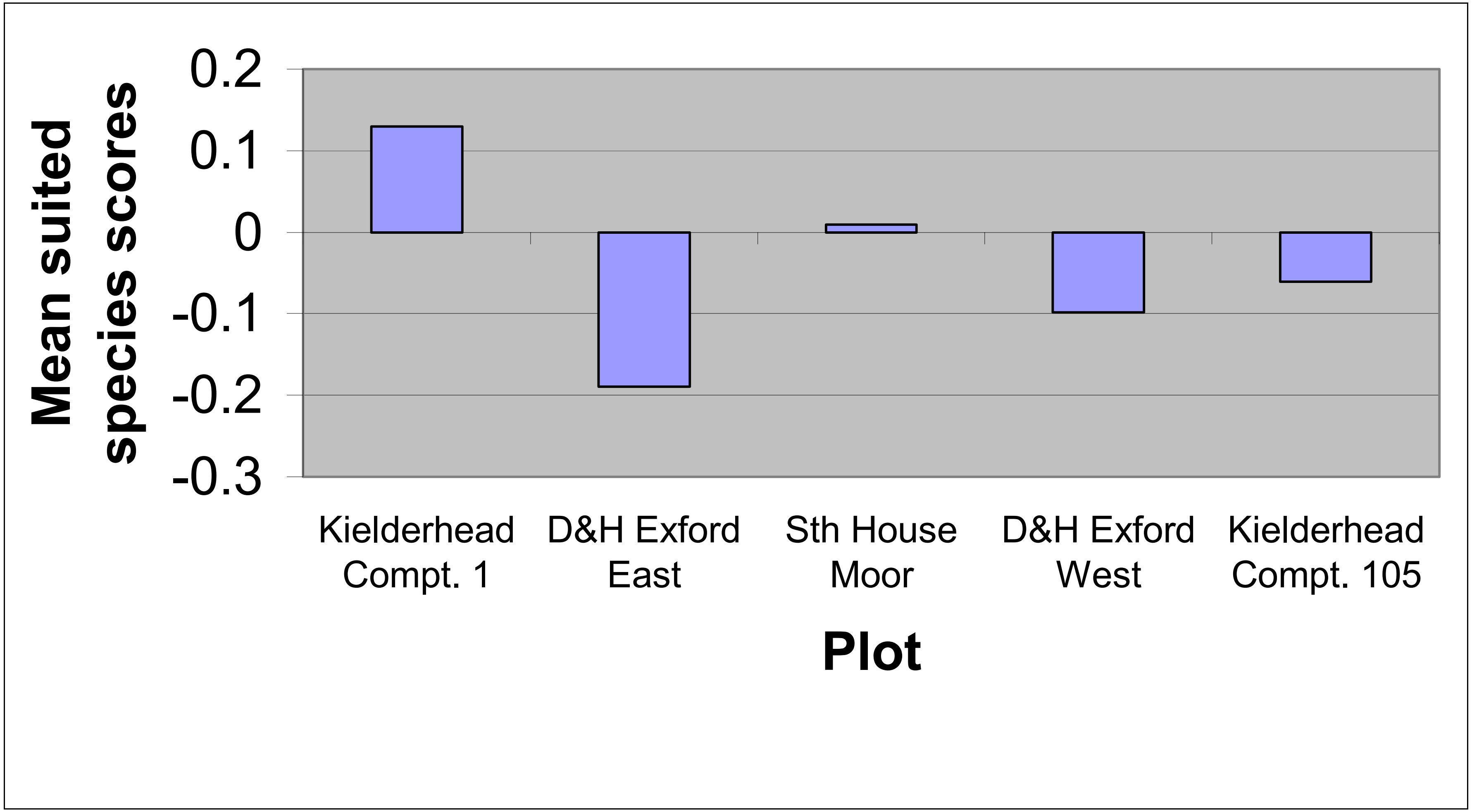

Figure 3. Wet heath: grazing suited species scores

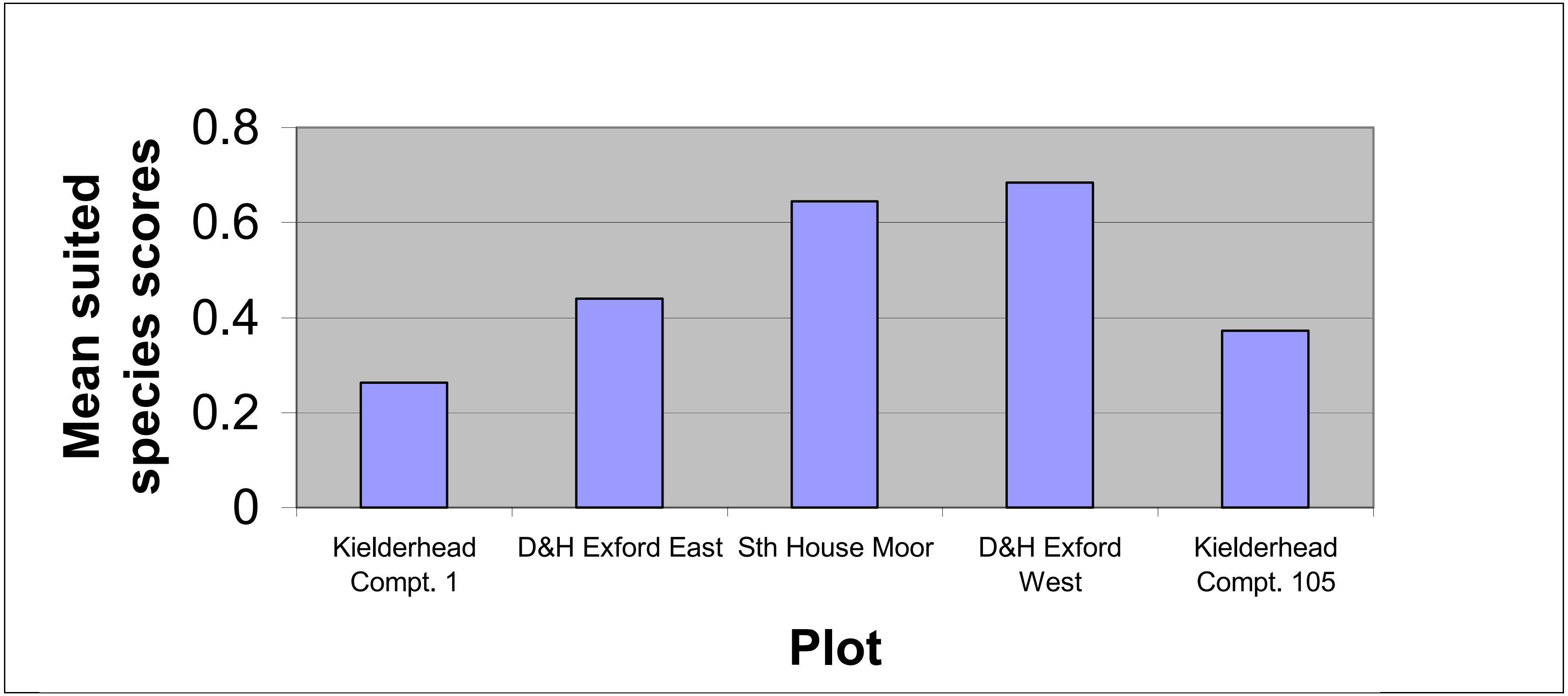

Figure 4. Wet heath: wet suited species scores

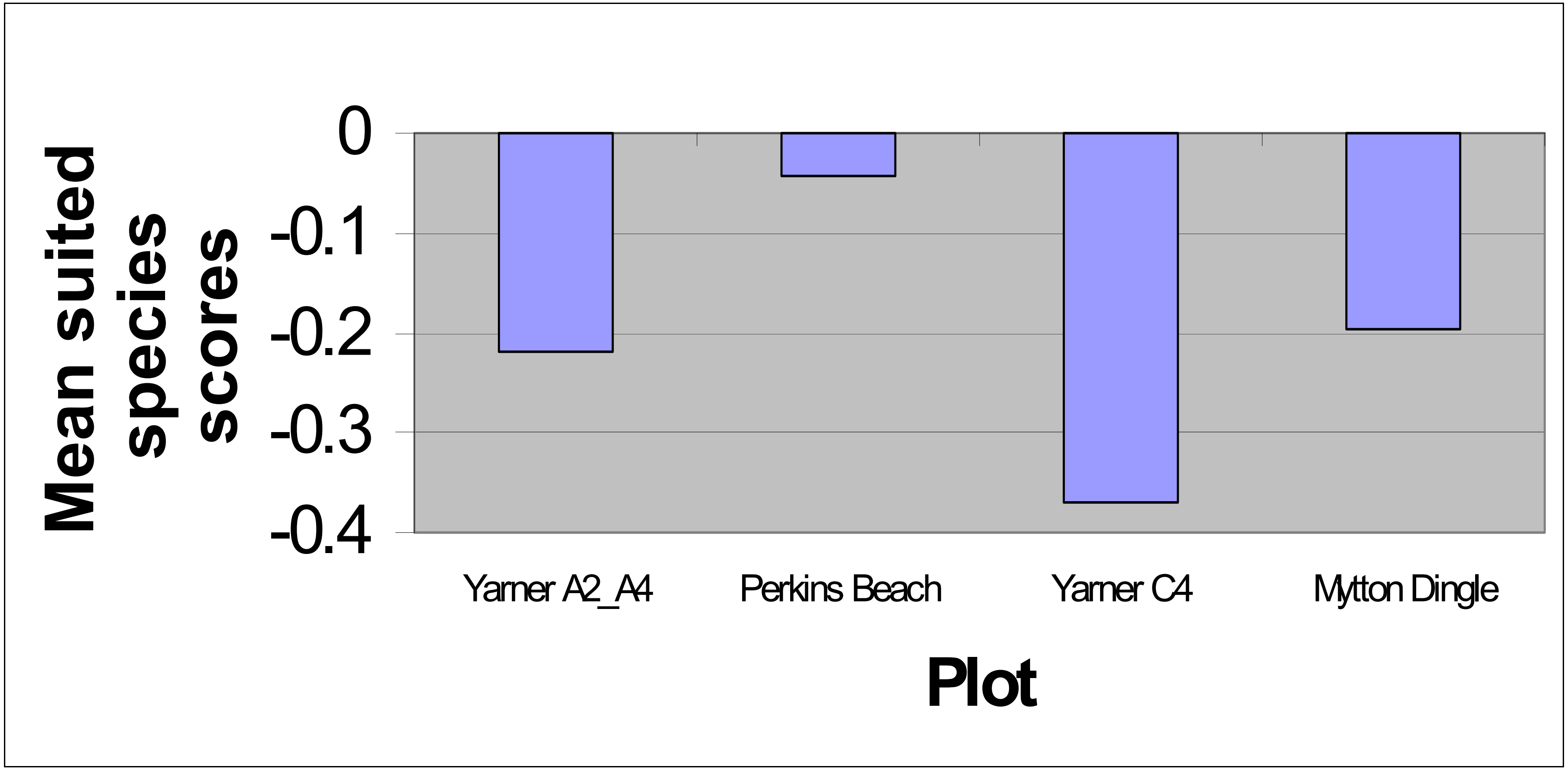

Figure 5. ***U. gallii*** **heath: grazing suited species scores**

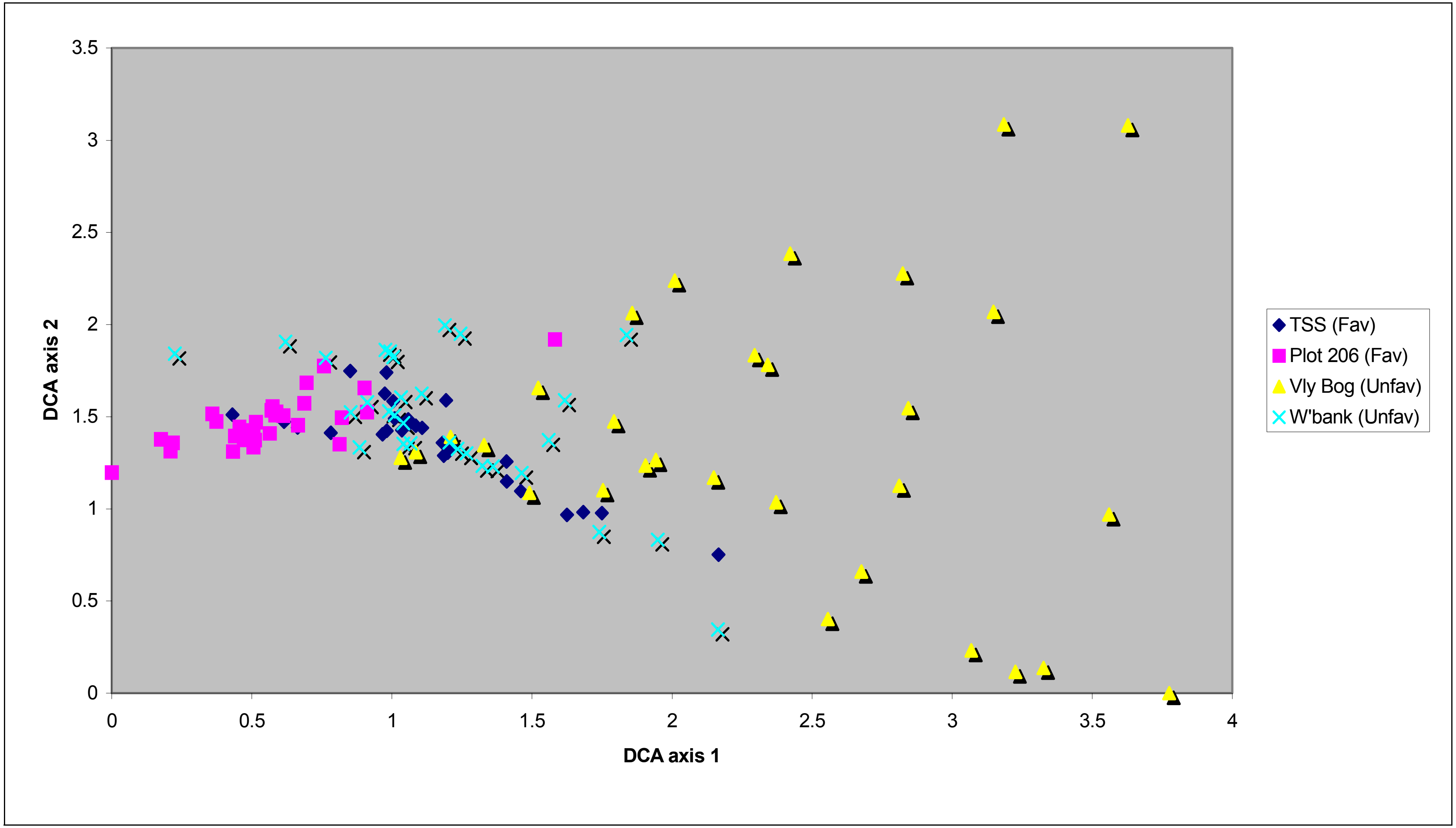

Figure 6. Blanket bog: Moorhouse and Upper Teesdale plots

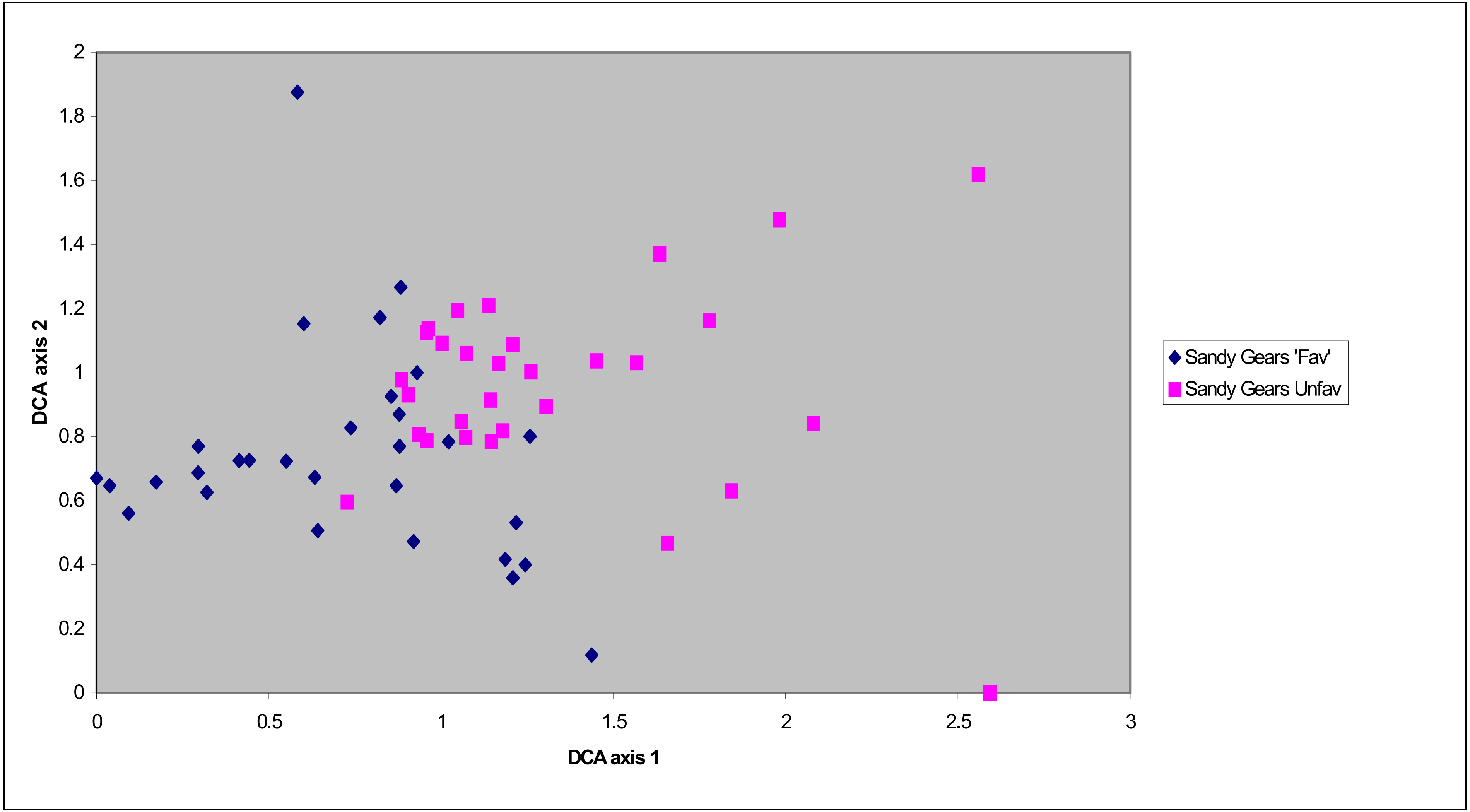

Figure 7. Blanket bog: Kielderhead and Whitelee plots

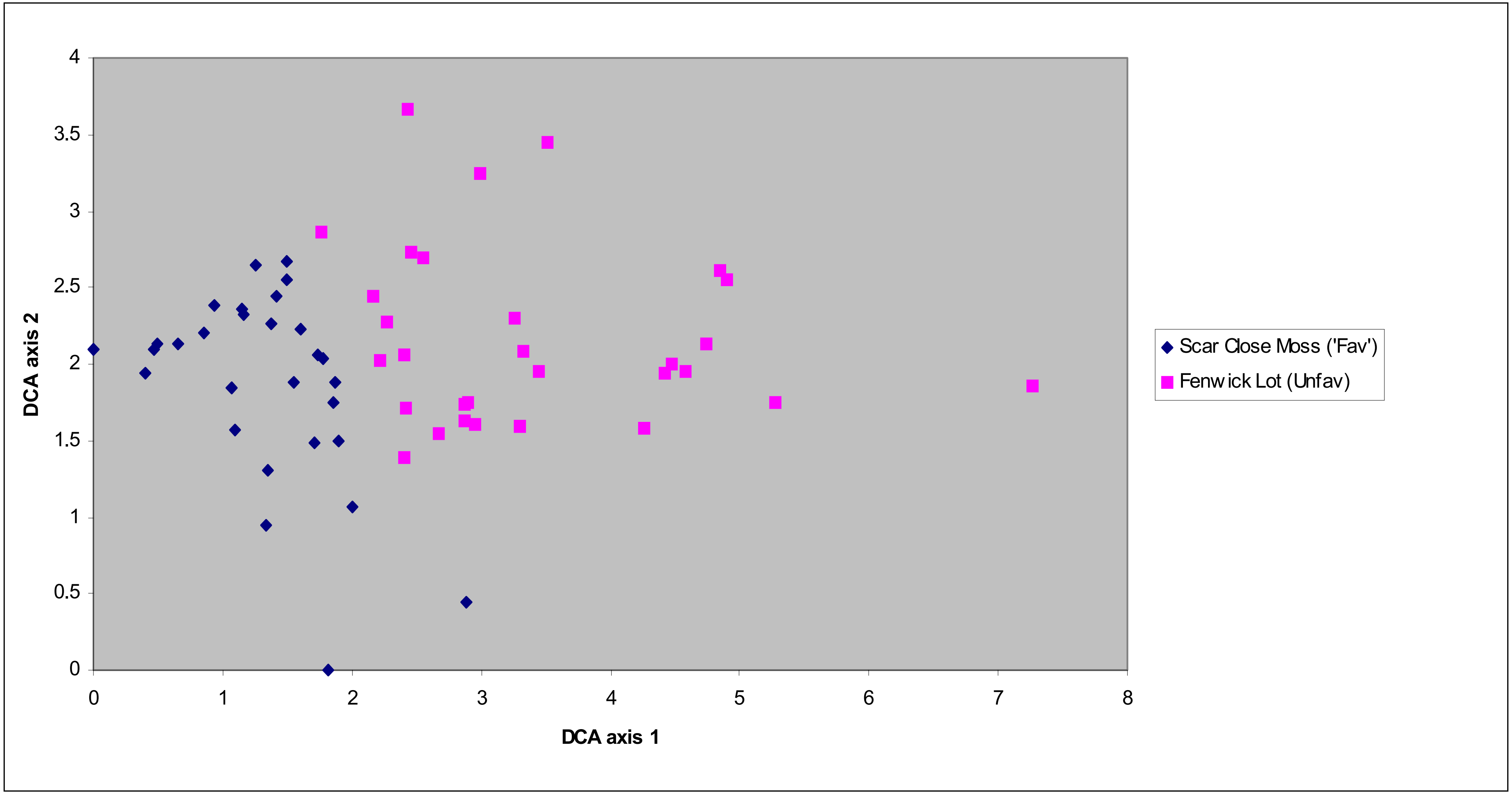

Figure 8. Blanket bog: Ingleborough plots

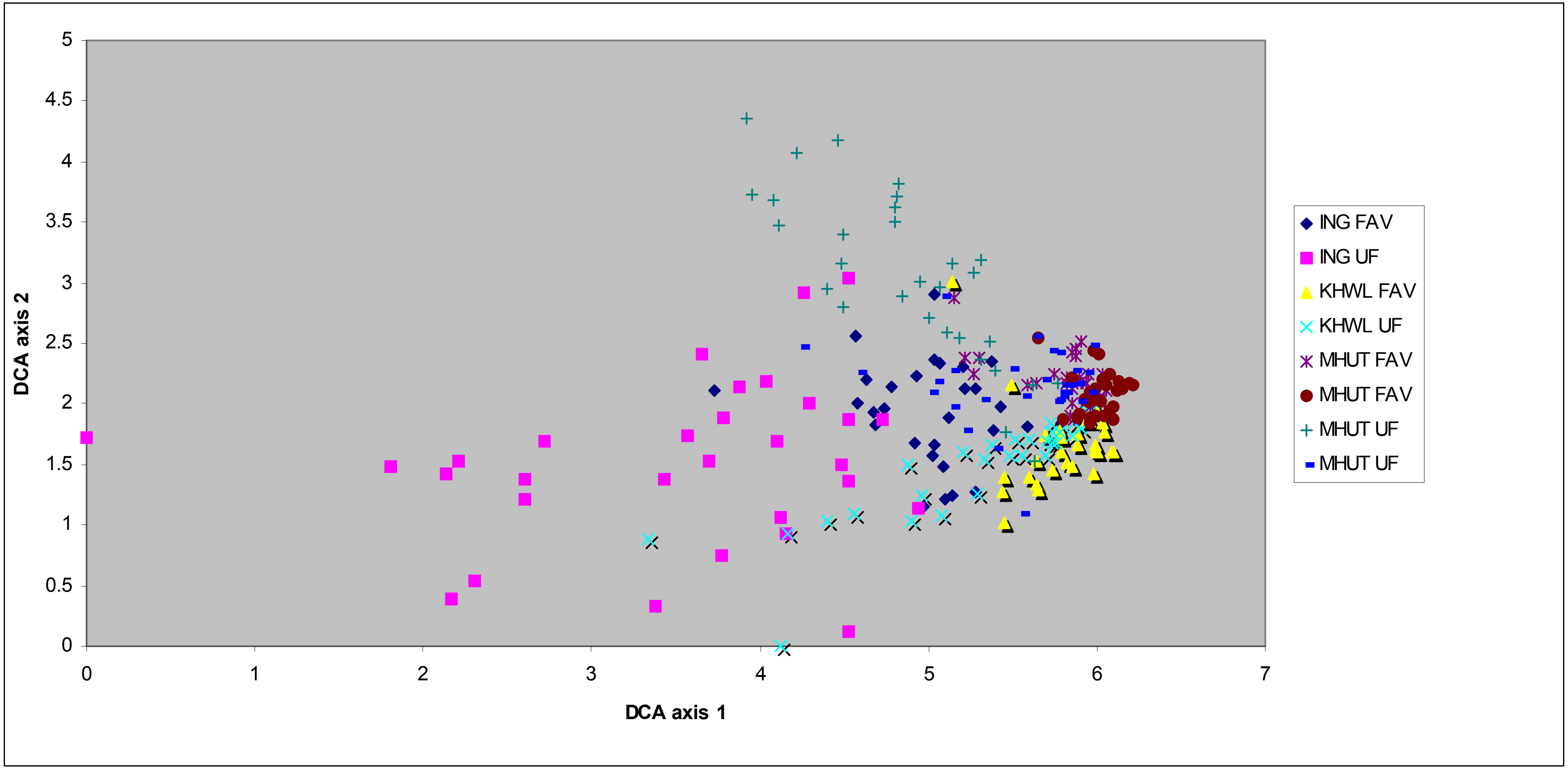

Figure 9. Blanket bog: all sites DCA plot

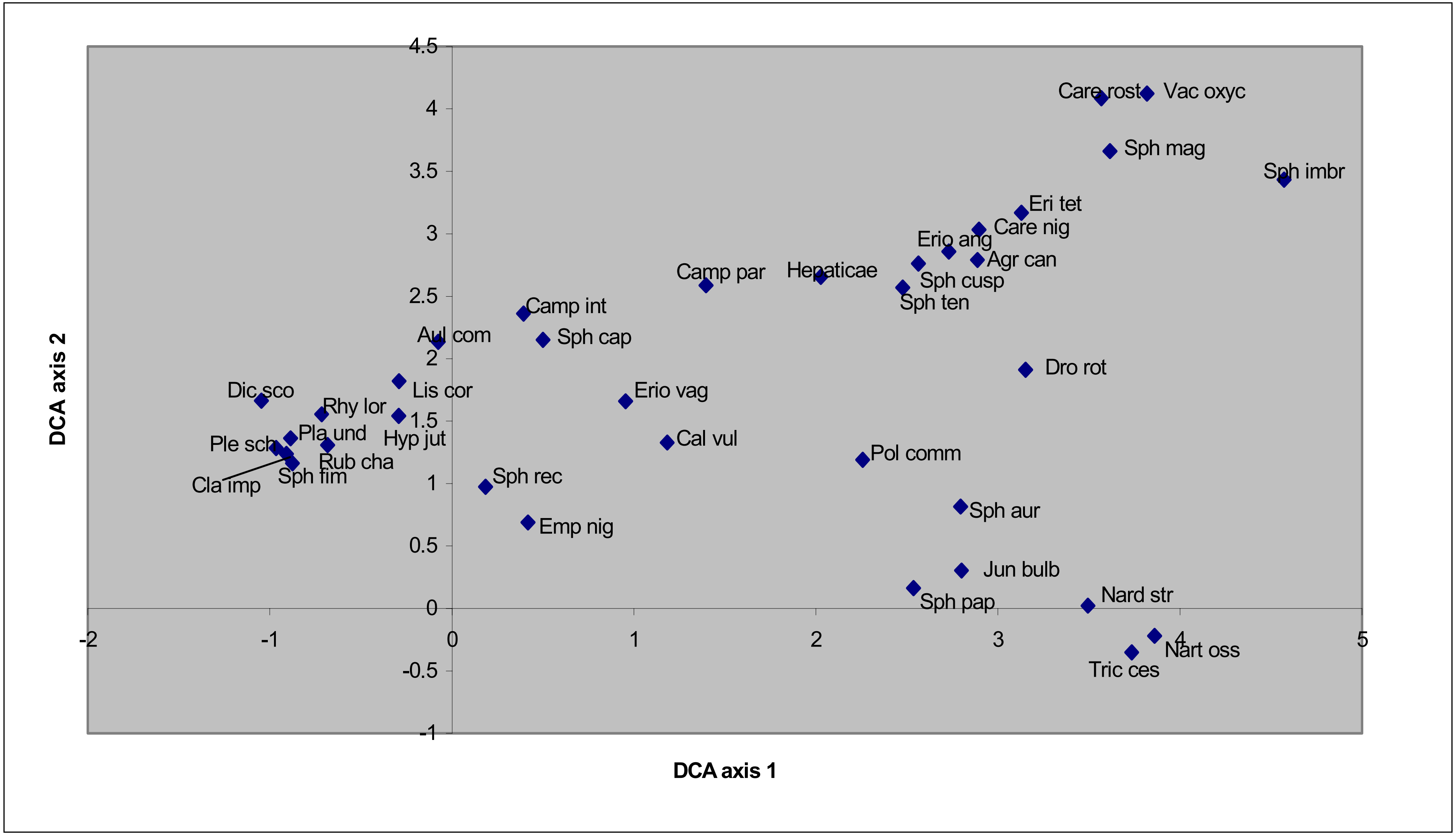

Figure 10. Blanket bog: Moorhouse and Upper Teesdale species plot

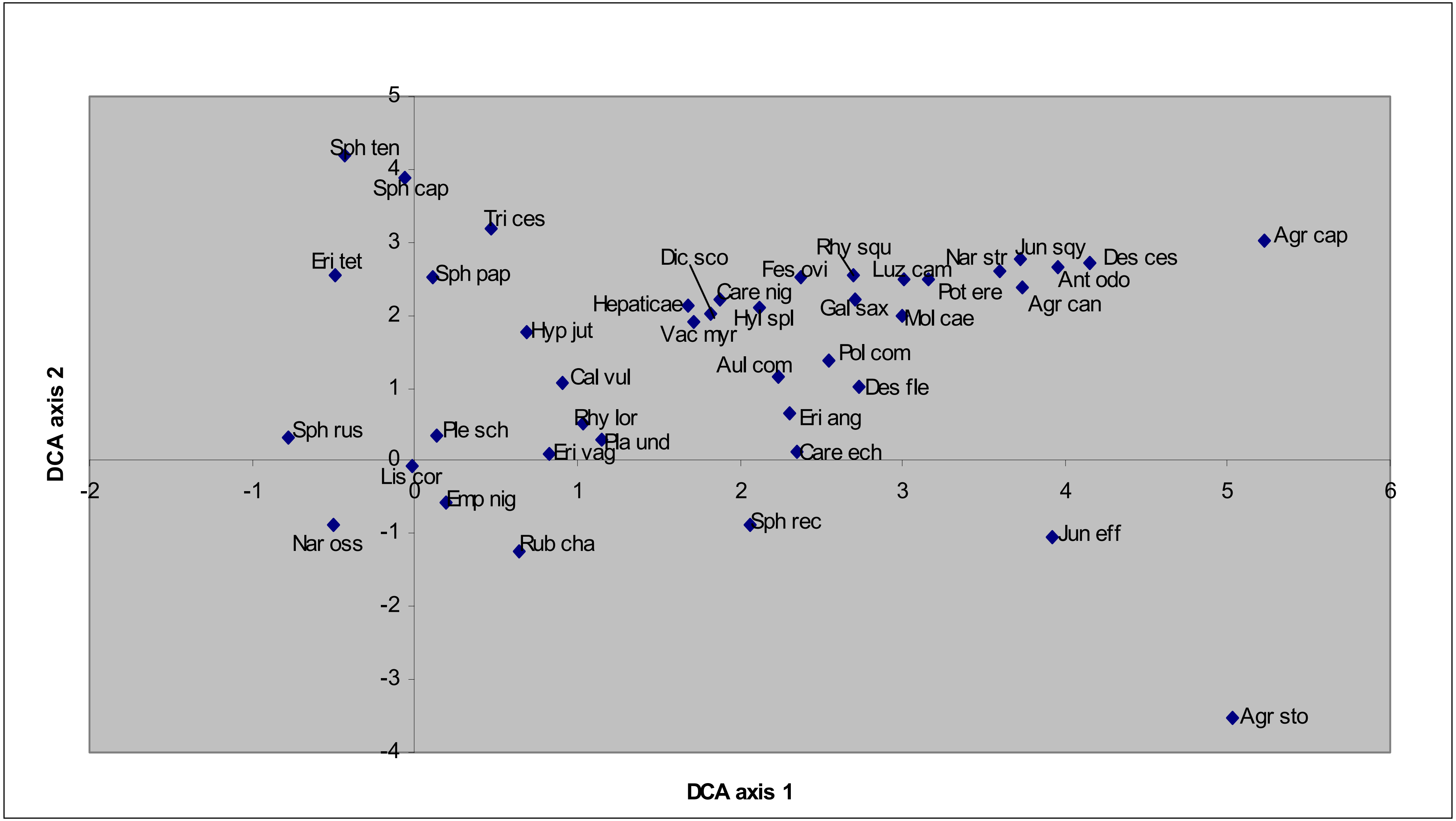

Figure 11. Blanket bog: Kielderhead and Whitelee species plot

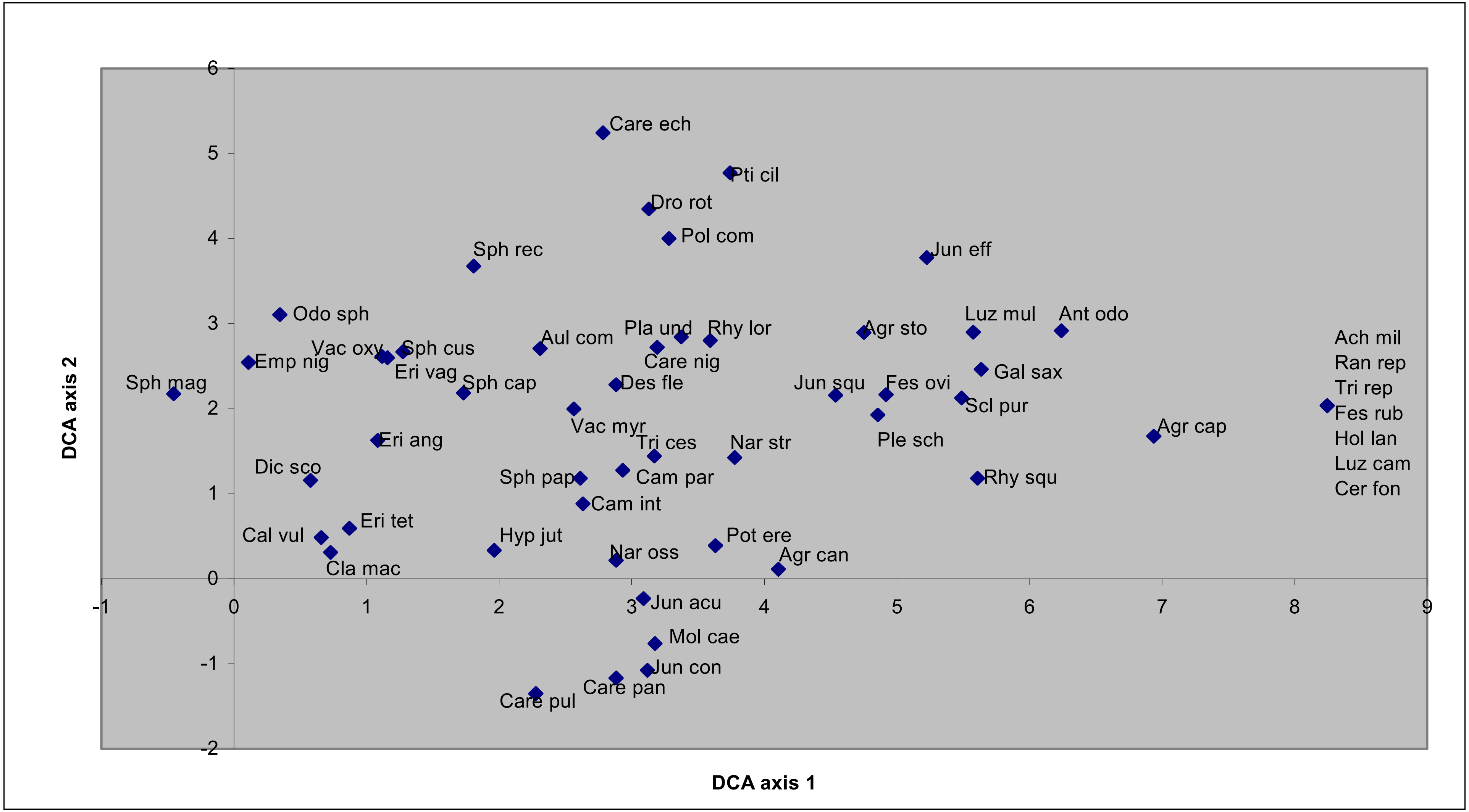

Figure 12. Blanket bog: Ingleborough species plot

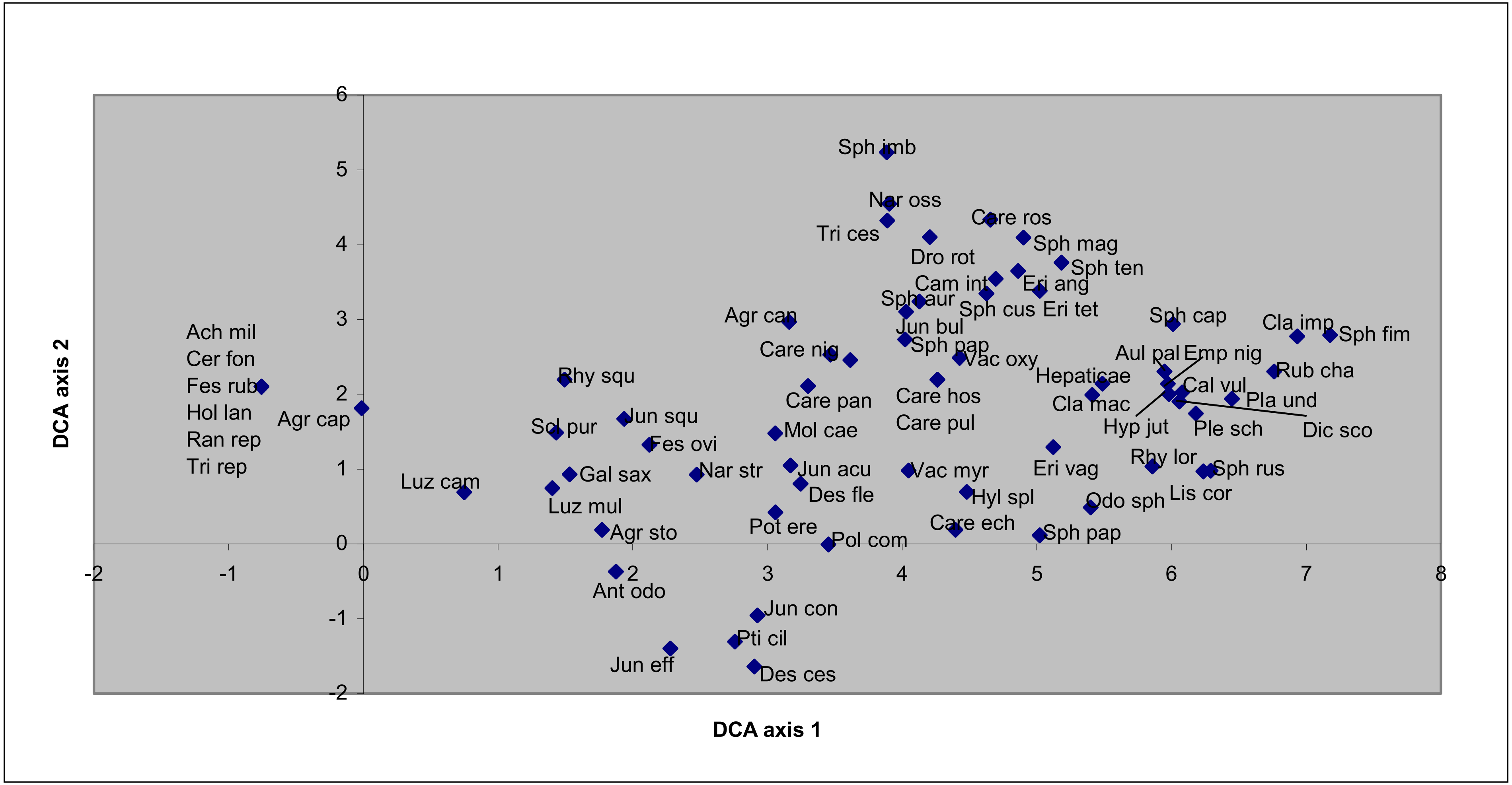

Figure 13. Blanket bog: all sites species plot

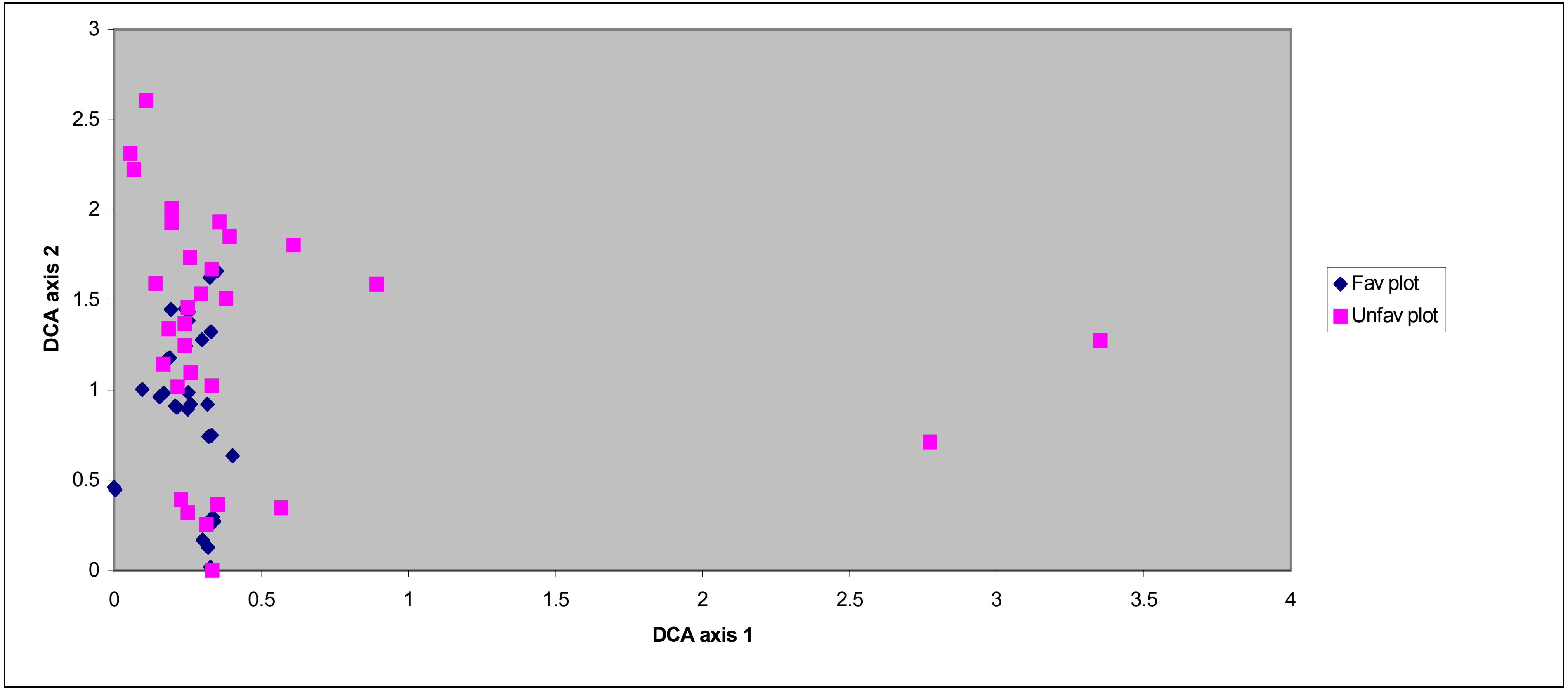

Figure 14. Dry dwarf shrub heath: Stiperstones plots

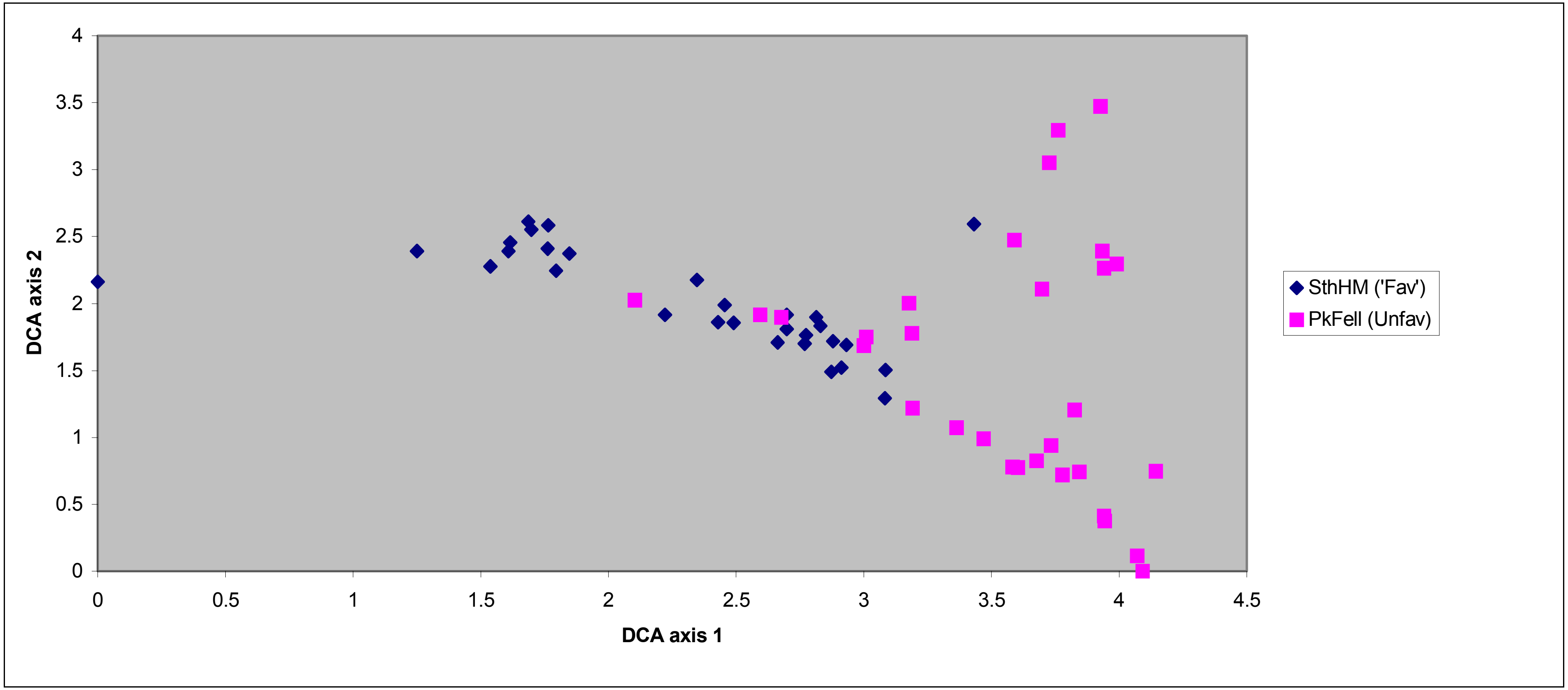

Figure 15. Dry dwarf shrub heath: Ingleborough plots

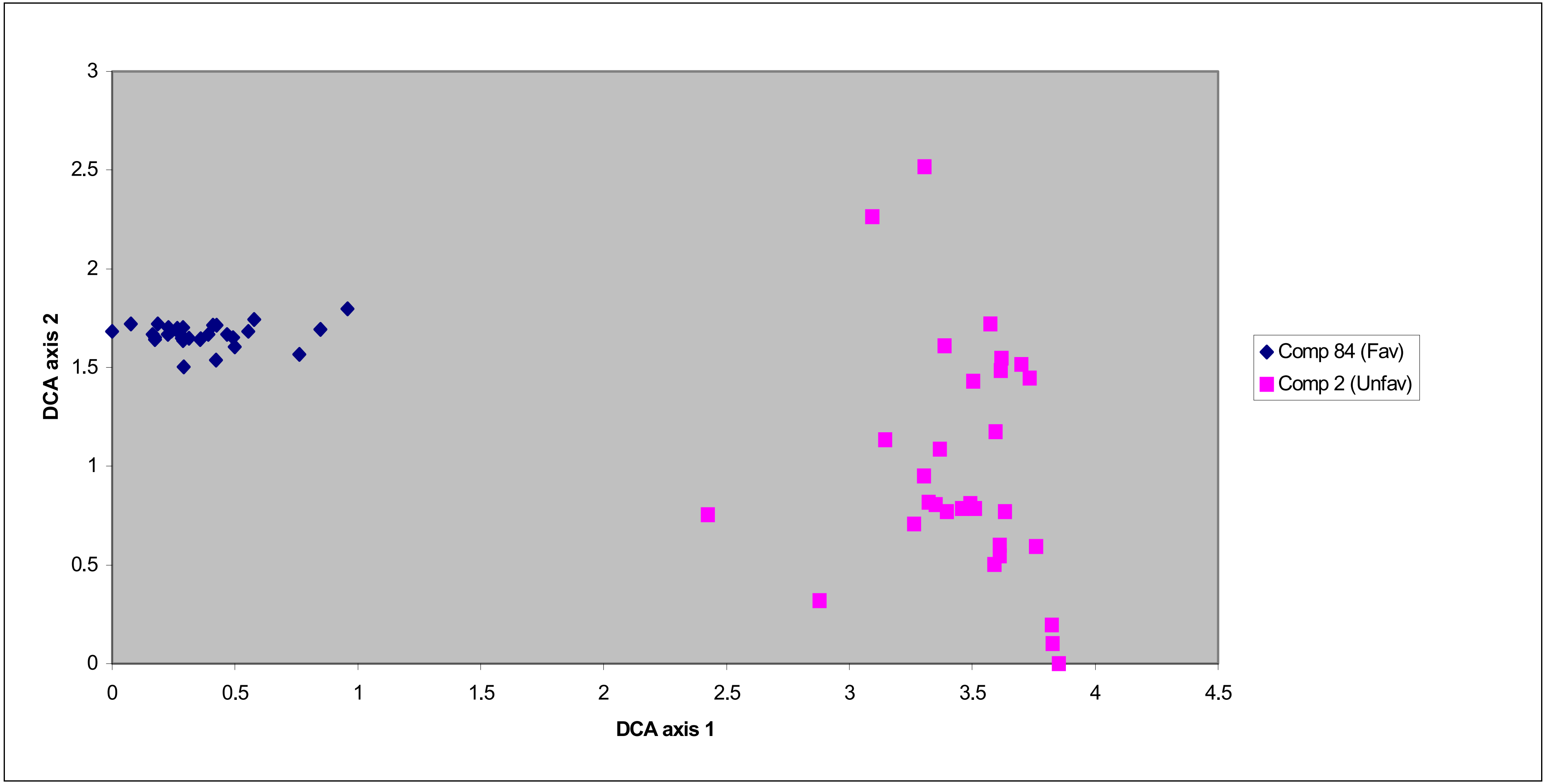

Figure 16. Dry dwarf shrub heath: Kielderhead and Whitelee plots

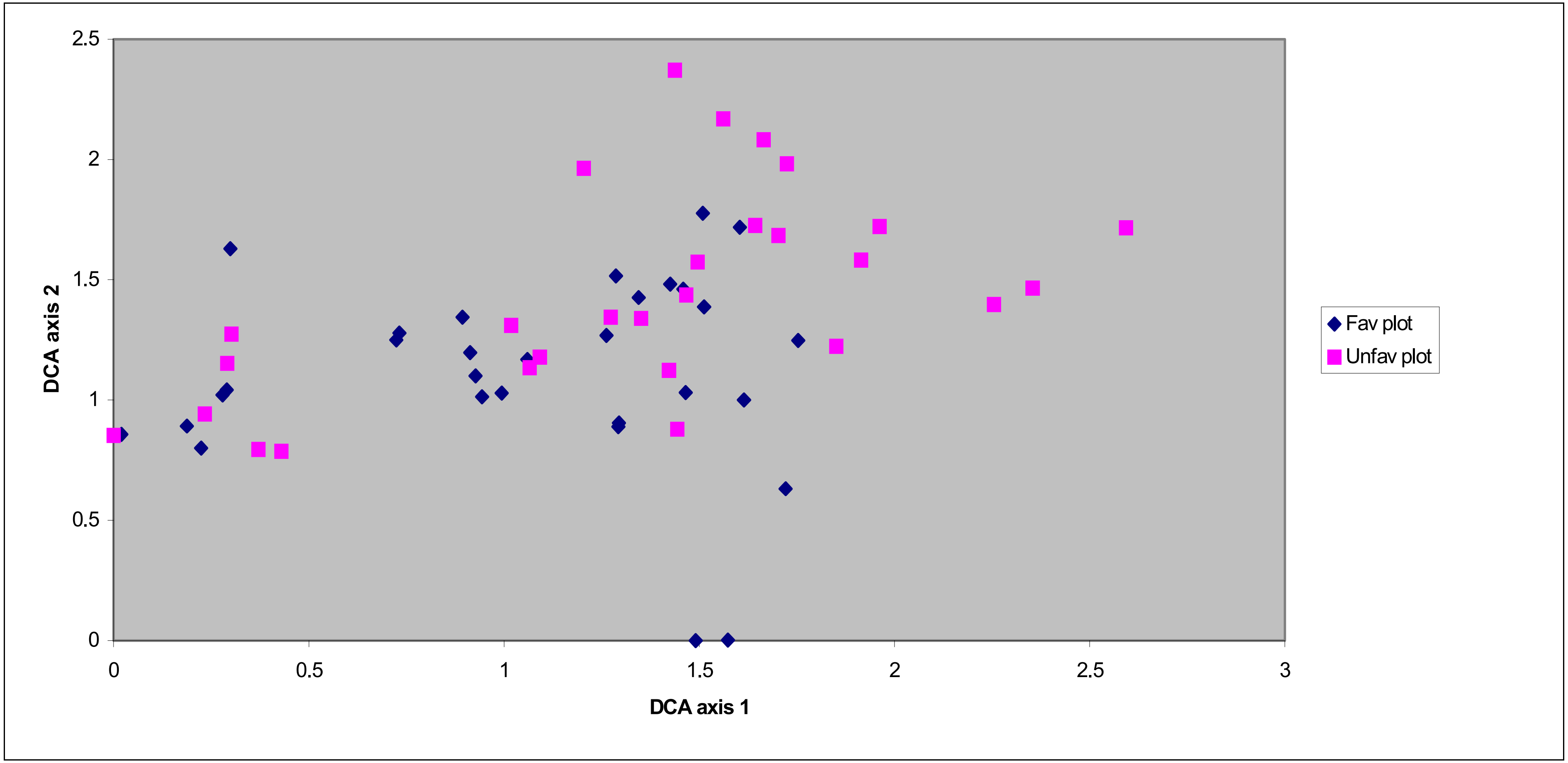

Figure 17. Dry dwarf shrub heath: Stiperstones plots (minus outliers)

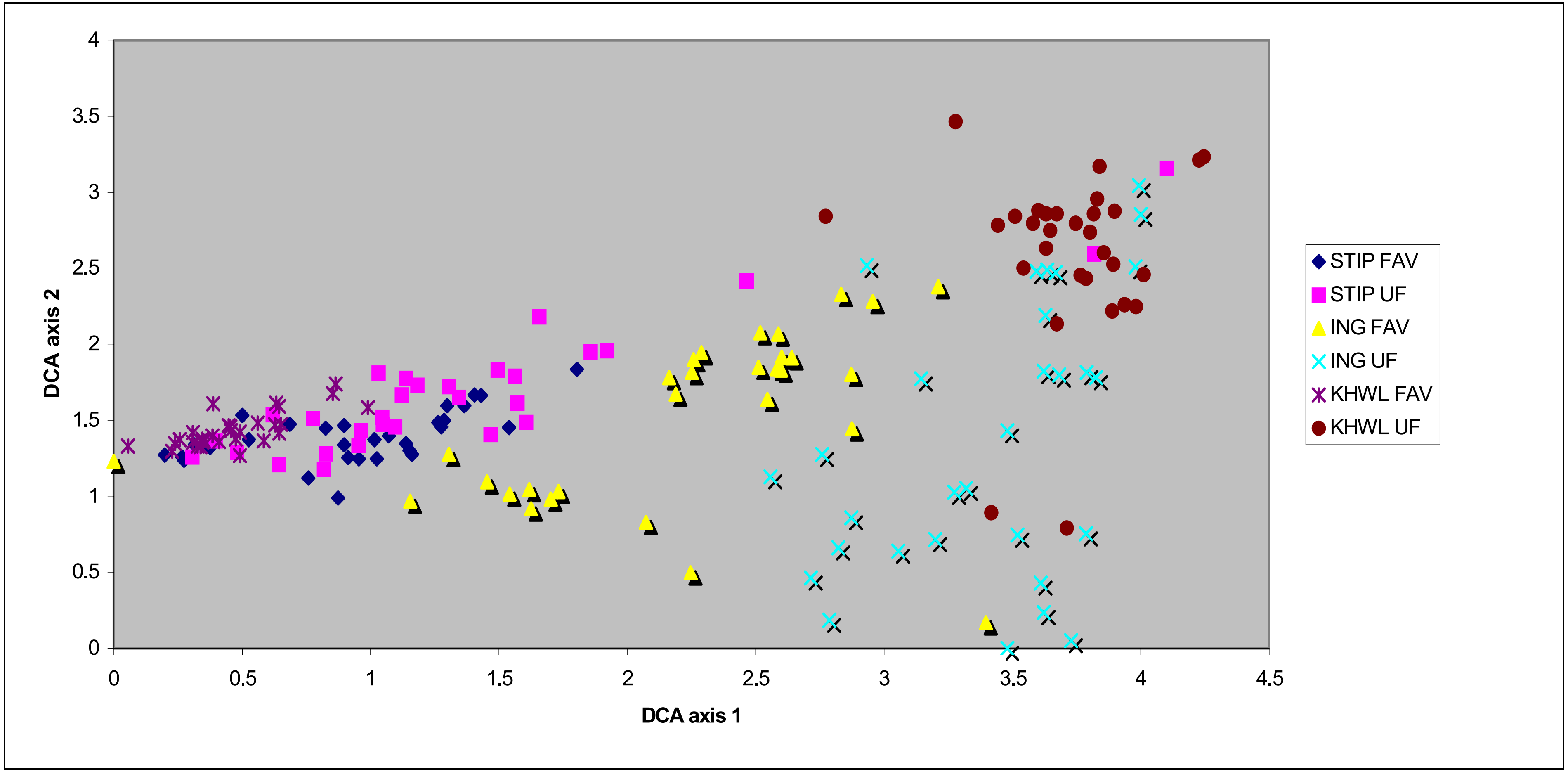

Figure 18. Dry dwarf shrub heath: all sites DCA plot

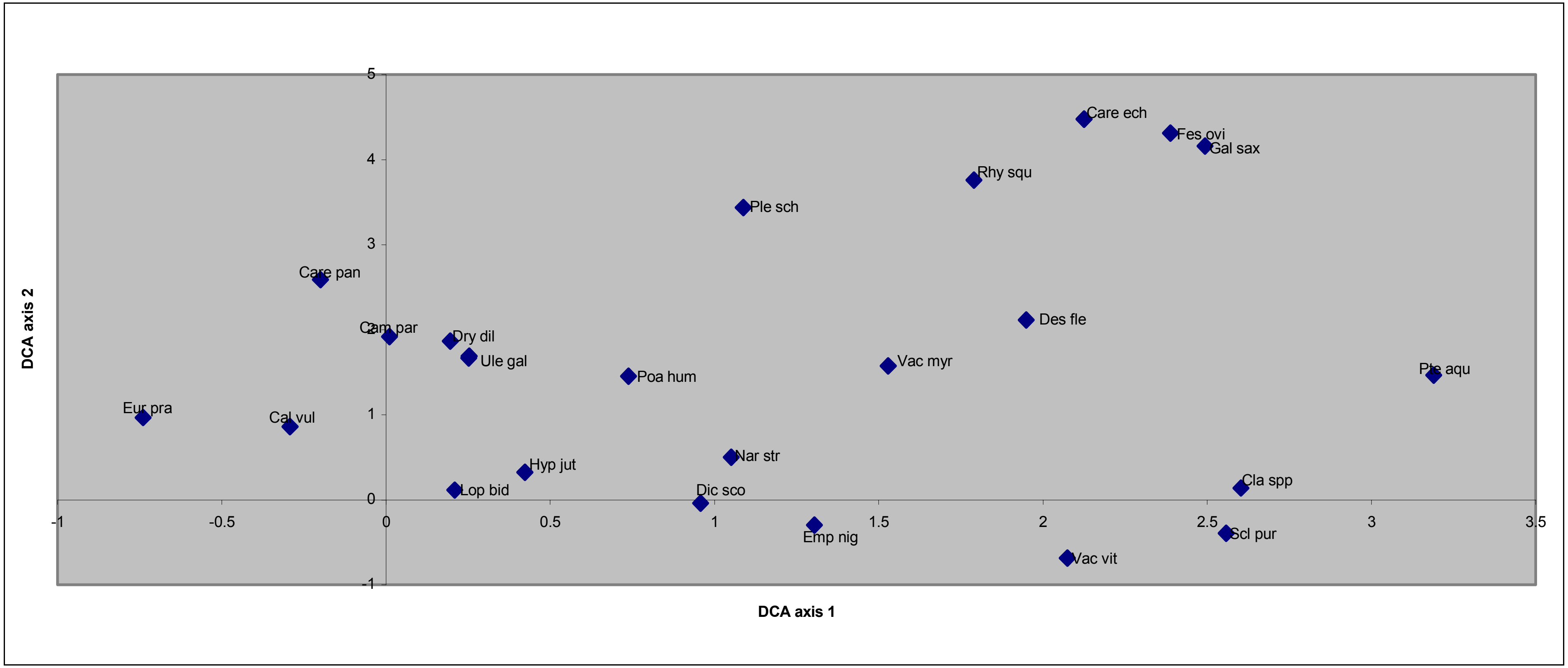

Figure 19. Dry dwarf shrub heath: Stiperstones species plot

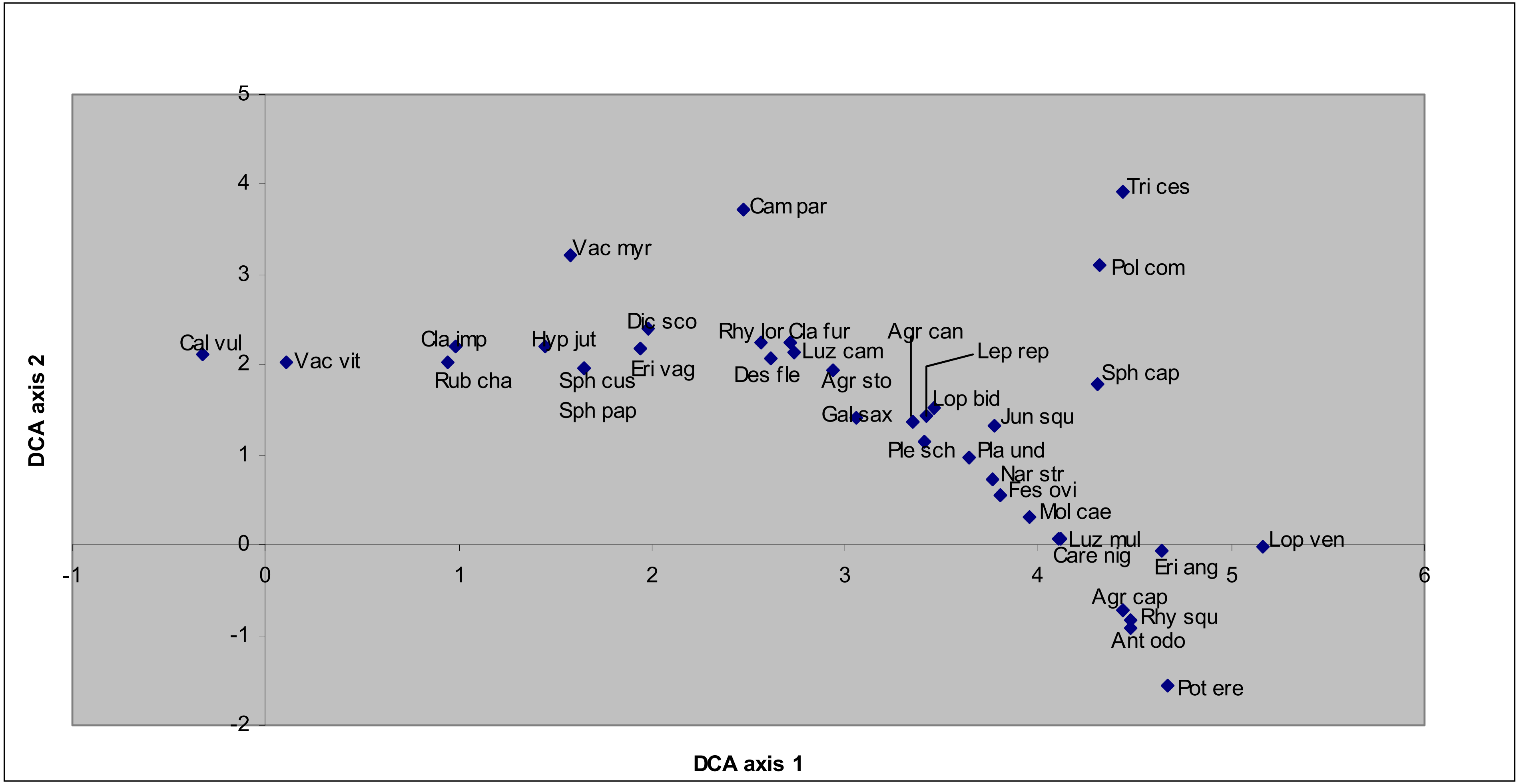

Figure 20. Dry dwarf shrub heath: Ingleborough species plot

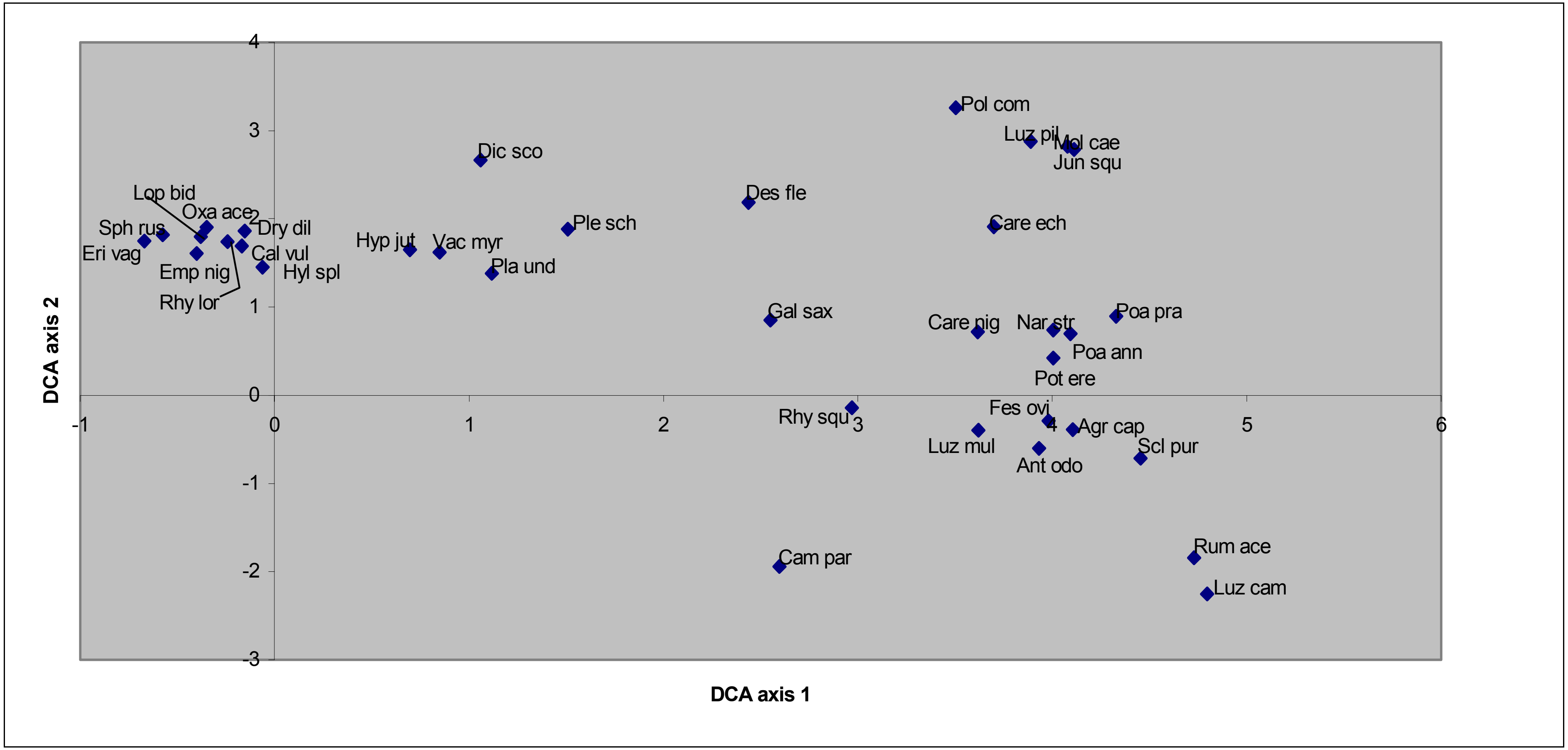

Figure 21. Dry dwarf shrub heath: Kielderhead and Whitelee species plot

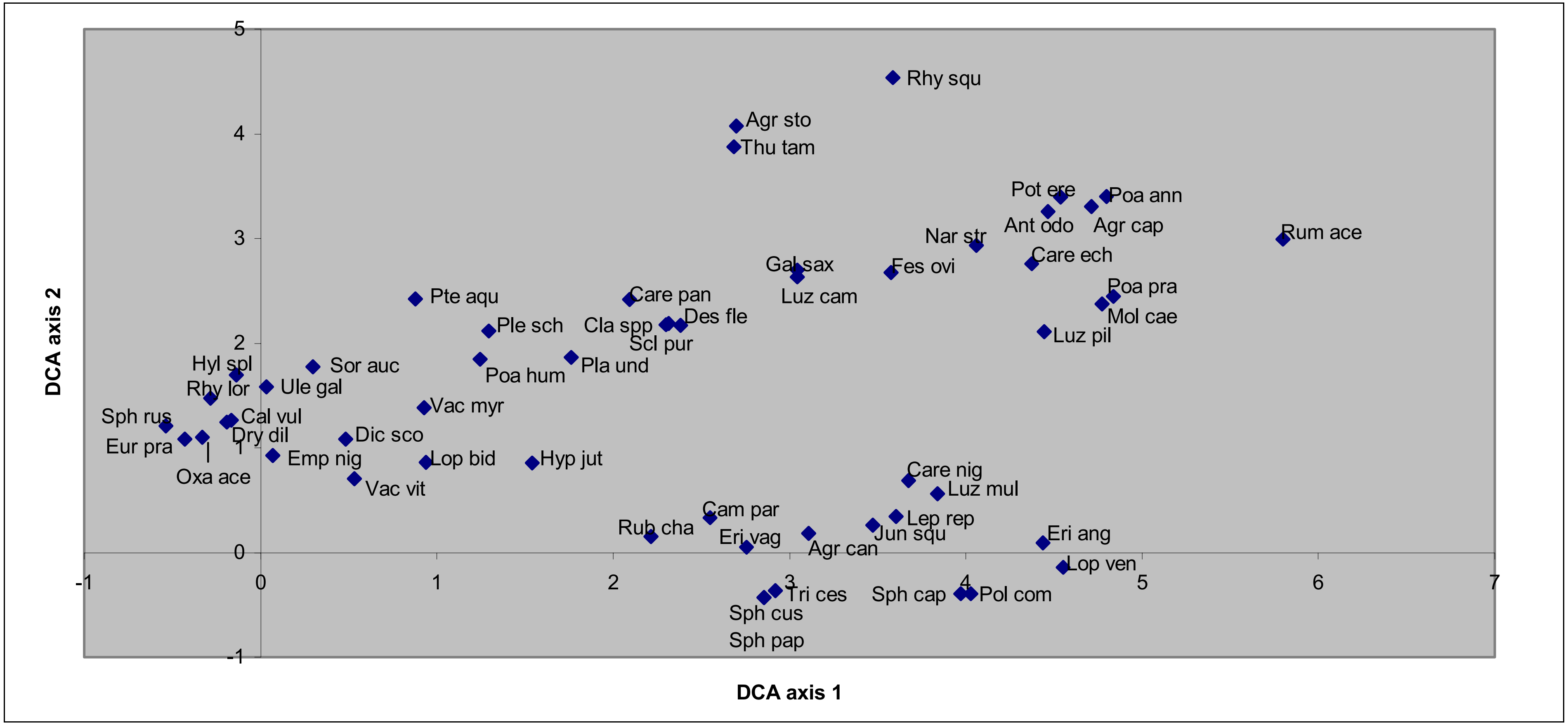

Figure 22. Dry dwarf shrub heath: all sites species plot

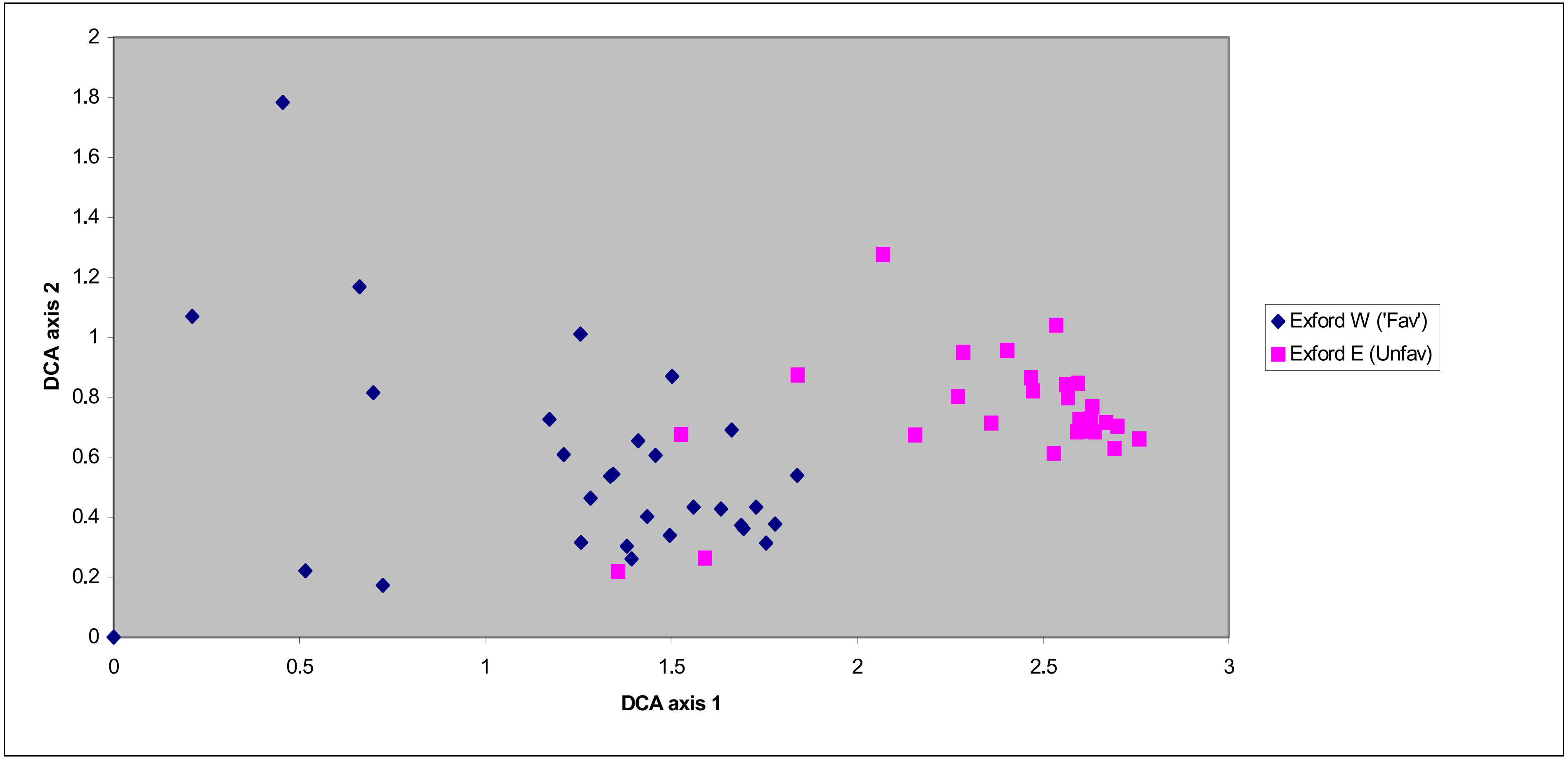

Figure 23. Wet heath: Dunkery & Horner (Exford) plots

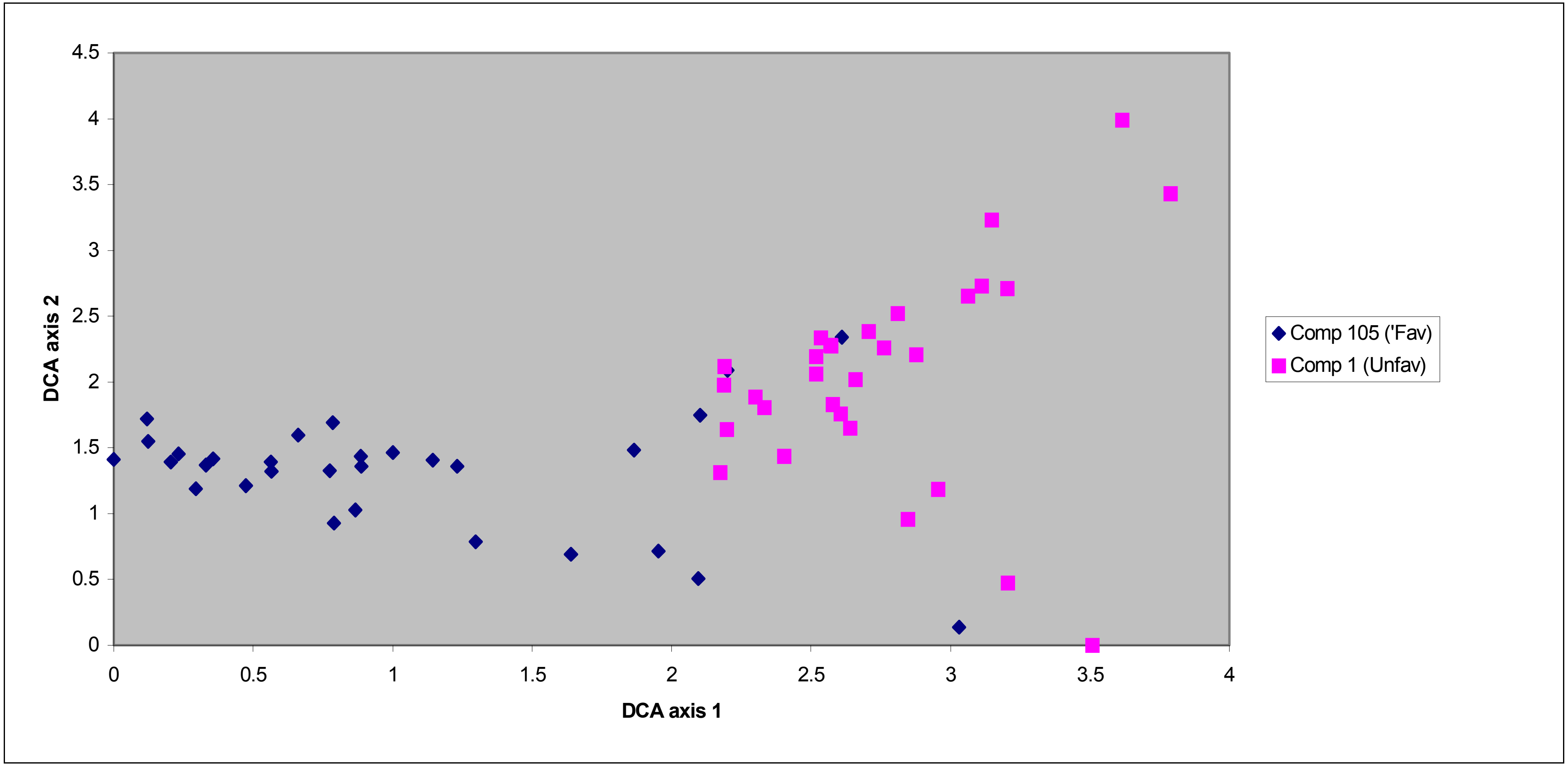

Figure 24. Wet heath: Kielderhead and Whitelee plots

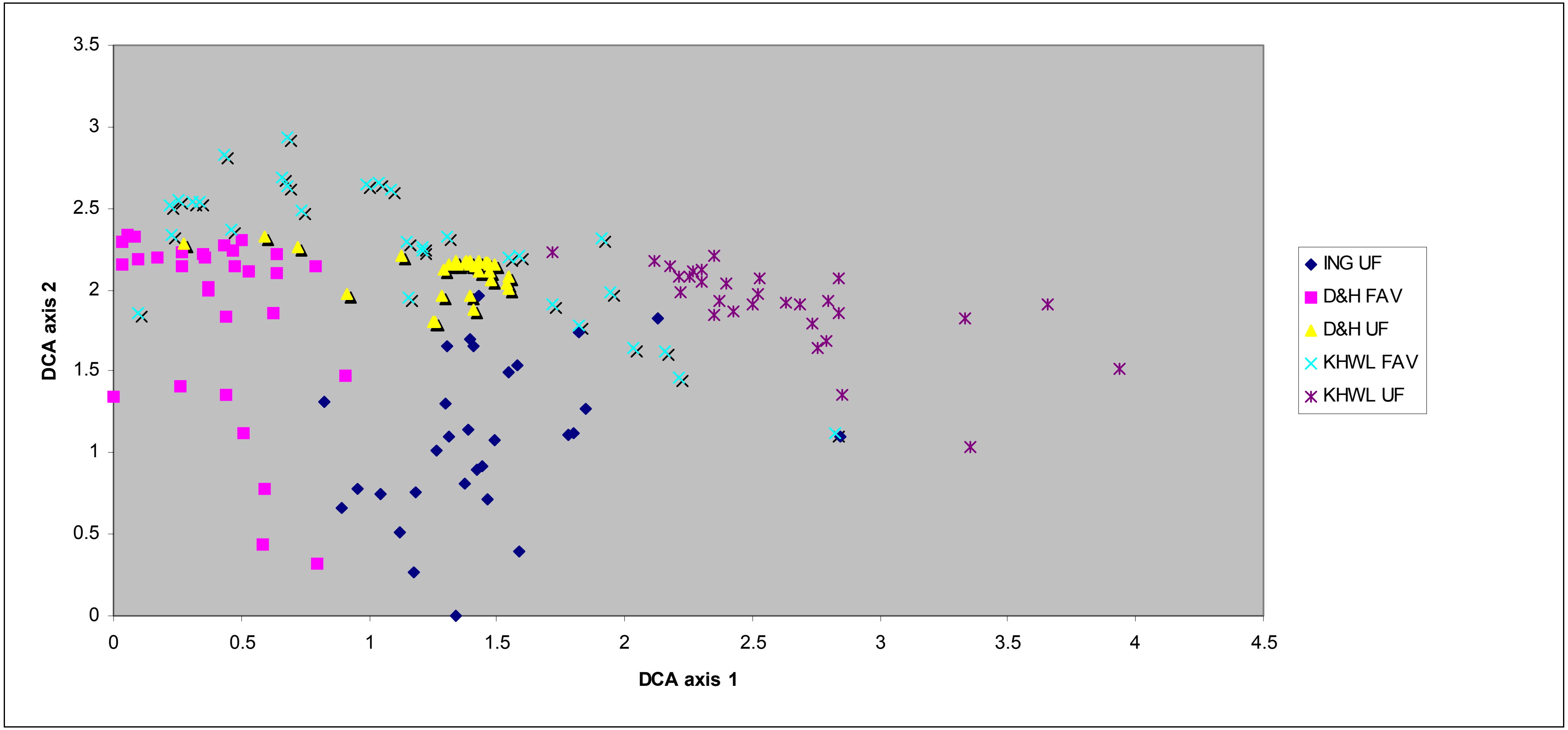

Figure 25. Wet heath: all sites (excluding Ing. High Lot) DCA plot

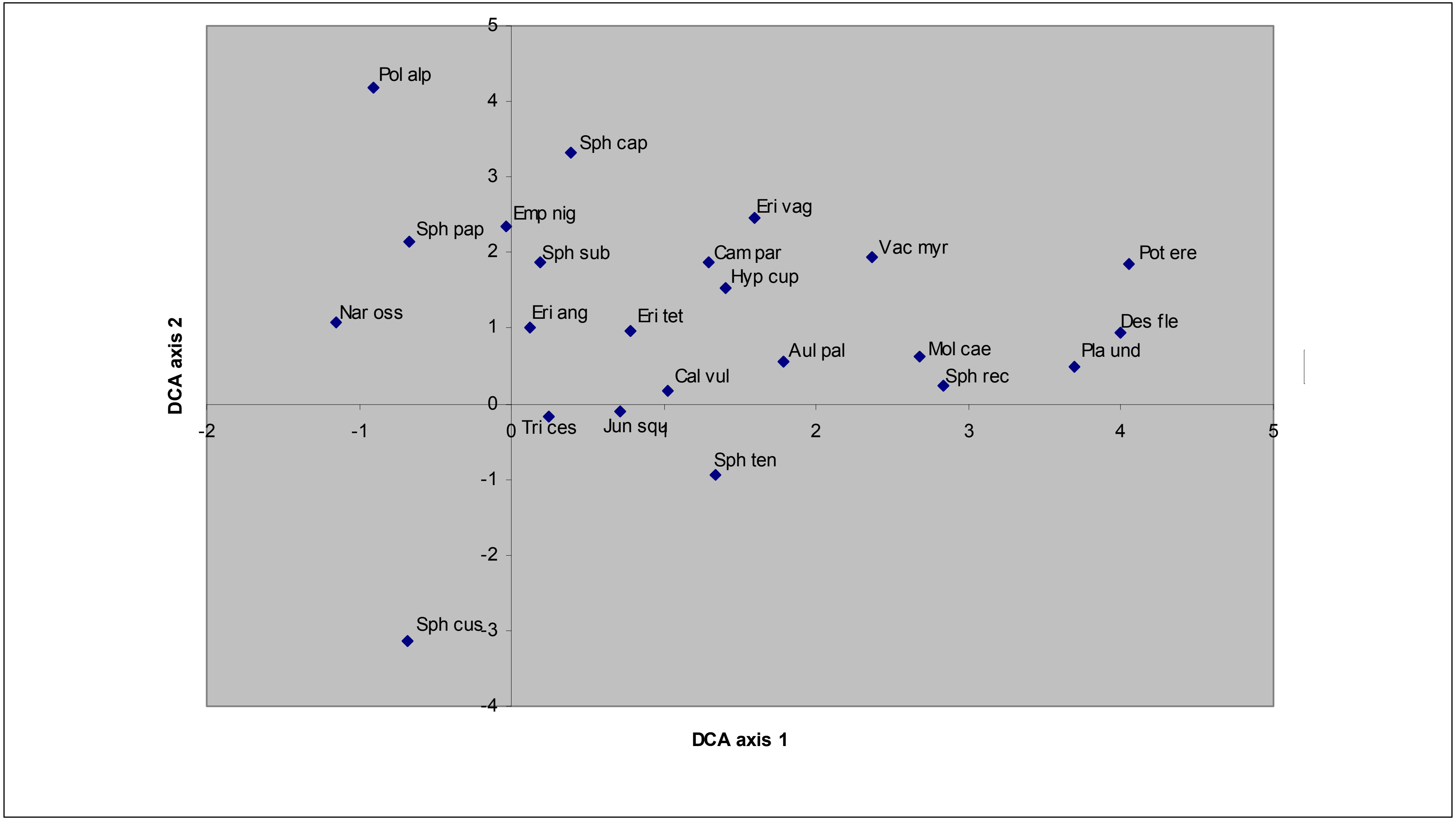

Figure 26. Wet heath: Dunkery & Horner species plot

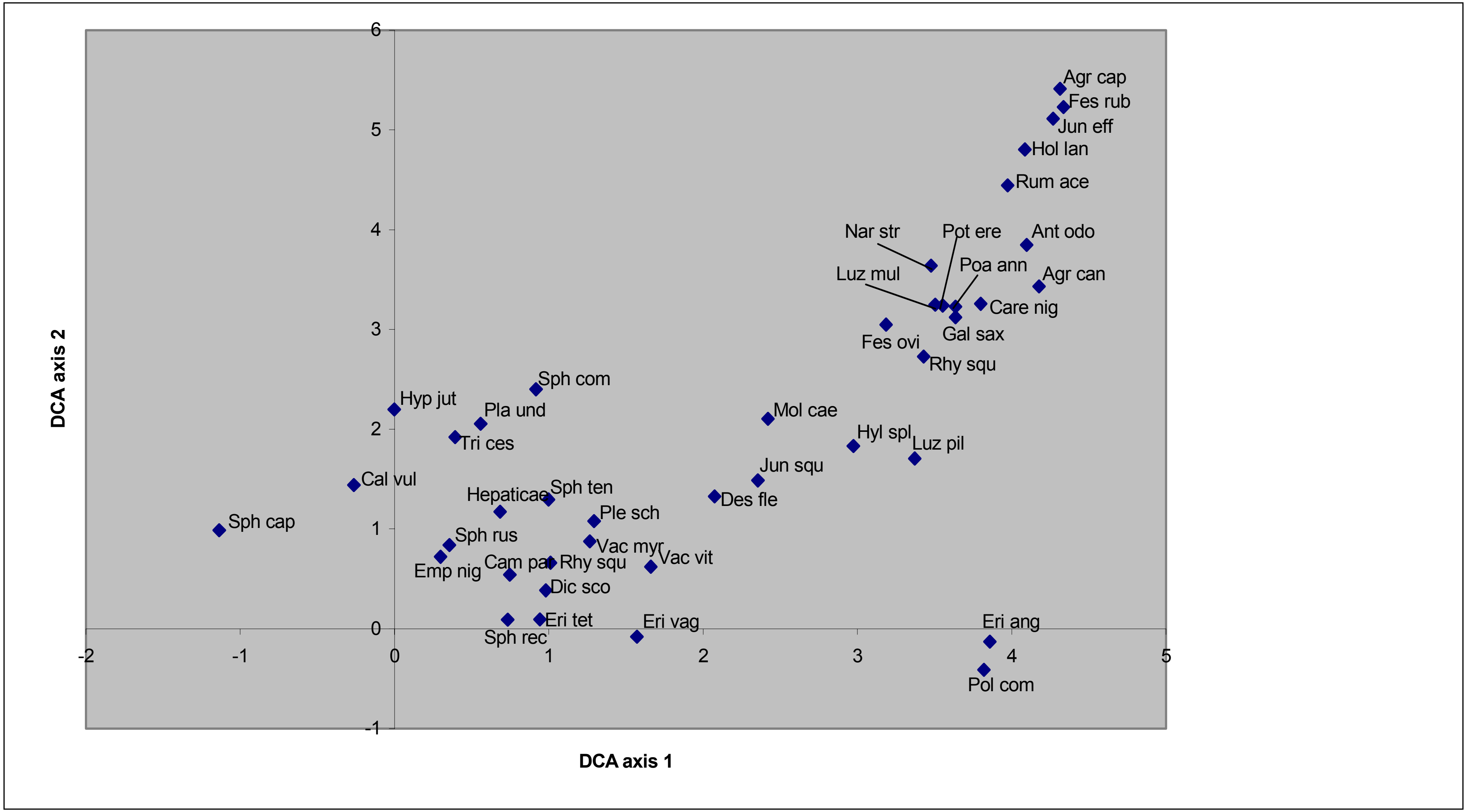

Figure 27. Wet heath: Kielderhead and Whitelee species plot

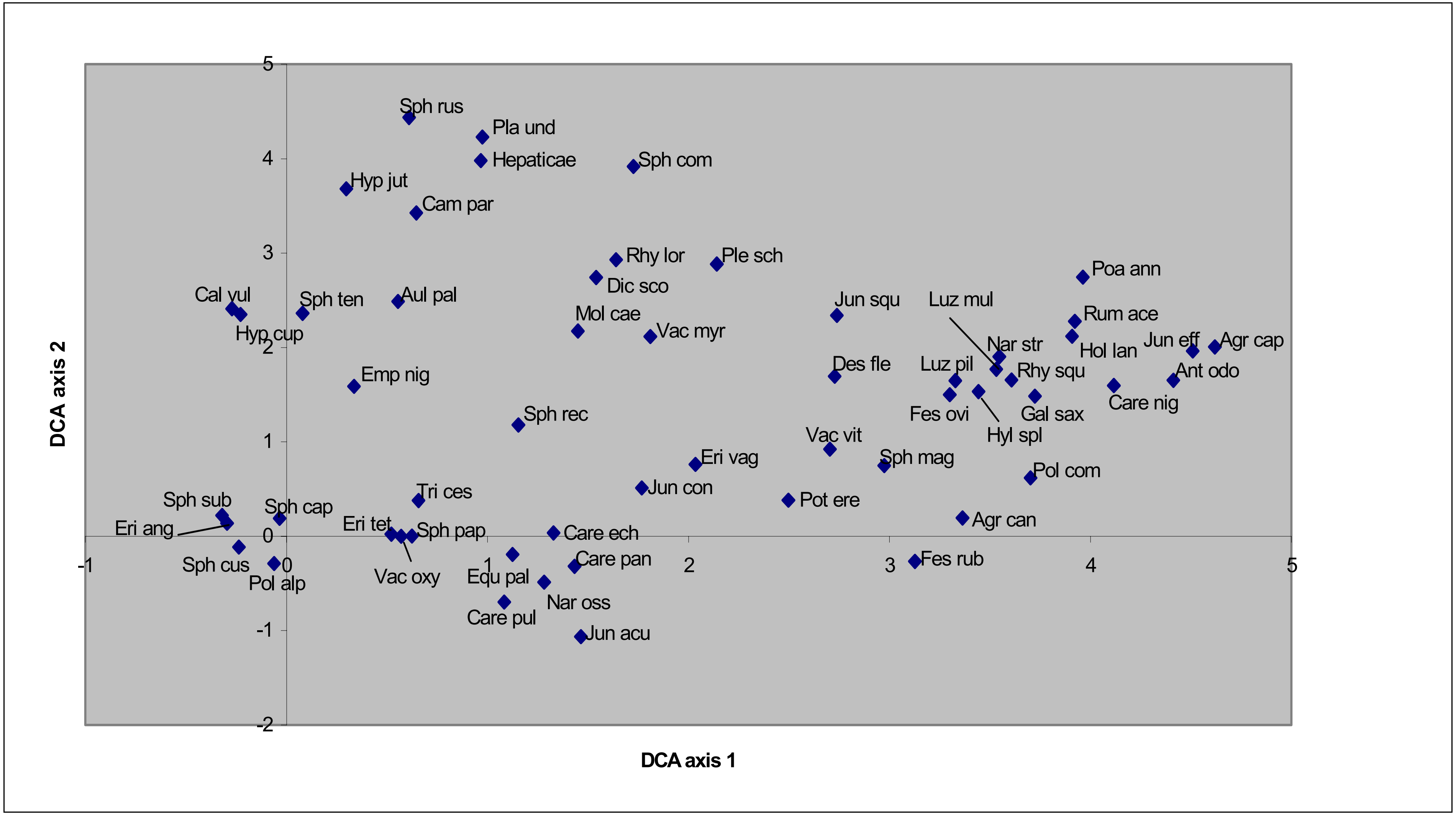

Figure 28. Wet heath: all sites species plot

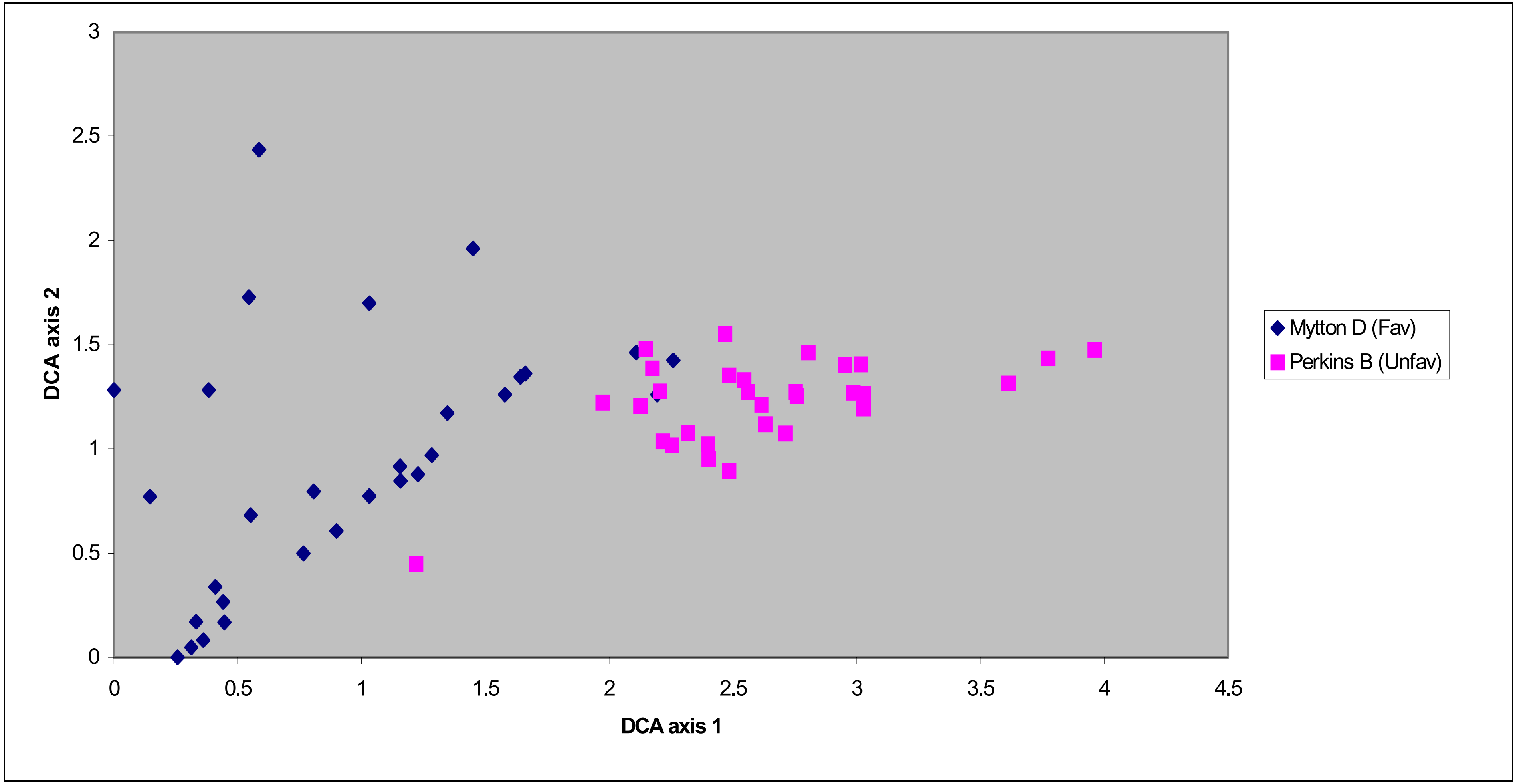

Figure 29. ***Ulex galli*** **heath: Stiperstones plots**

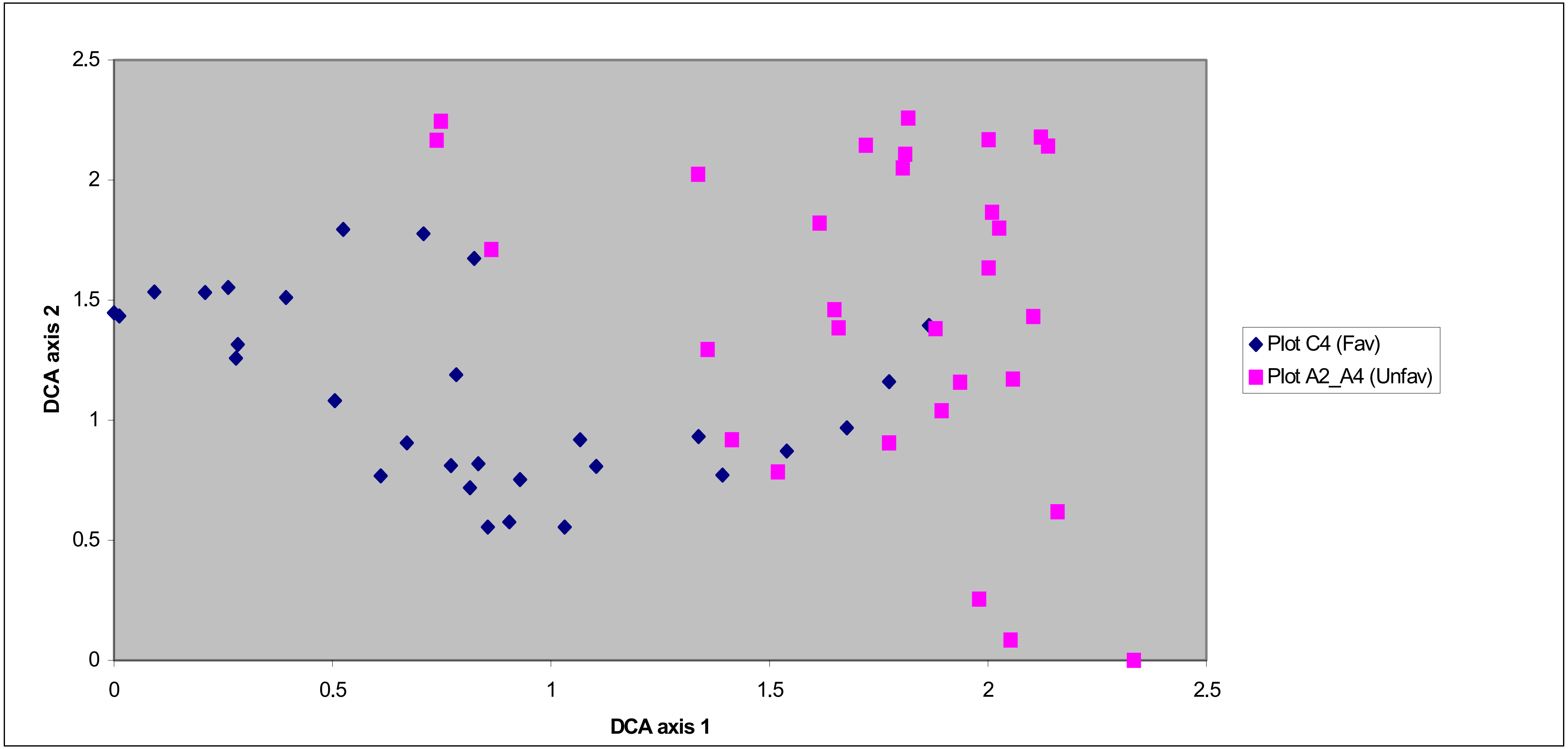

Figure 30. ***Ulex gallii*** **heath: Yarner plots**

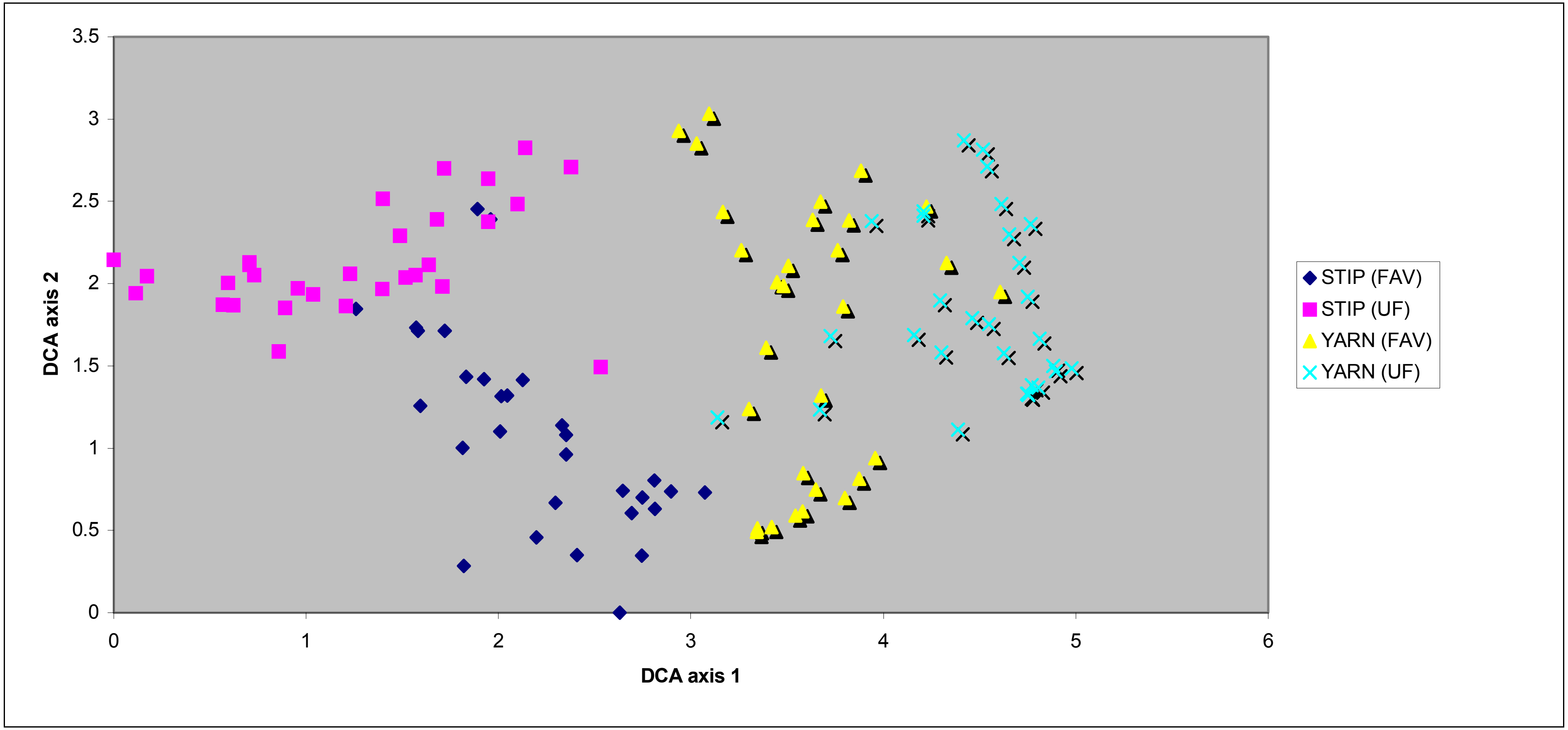

Figure 31. ***Ulex gallii*** **heath: all sites DCA plot**

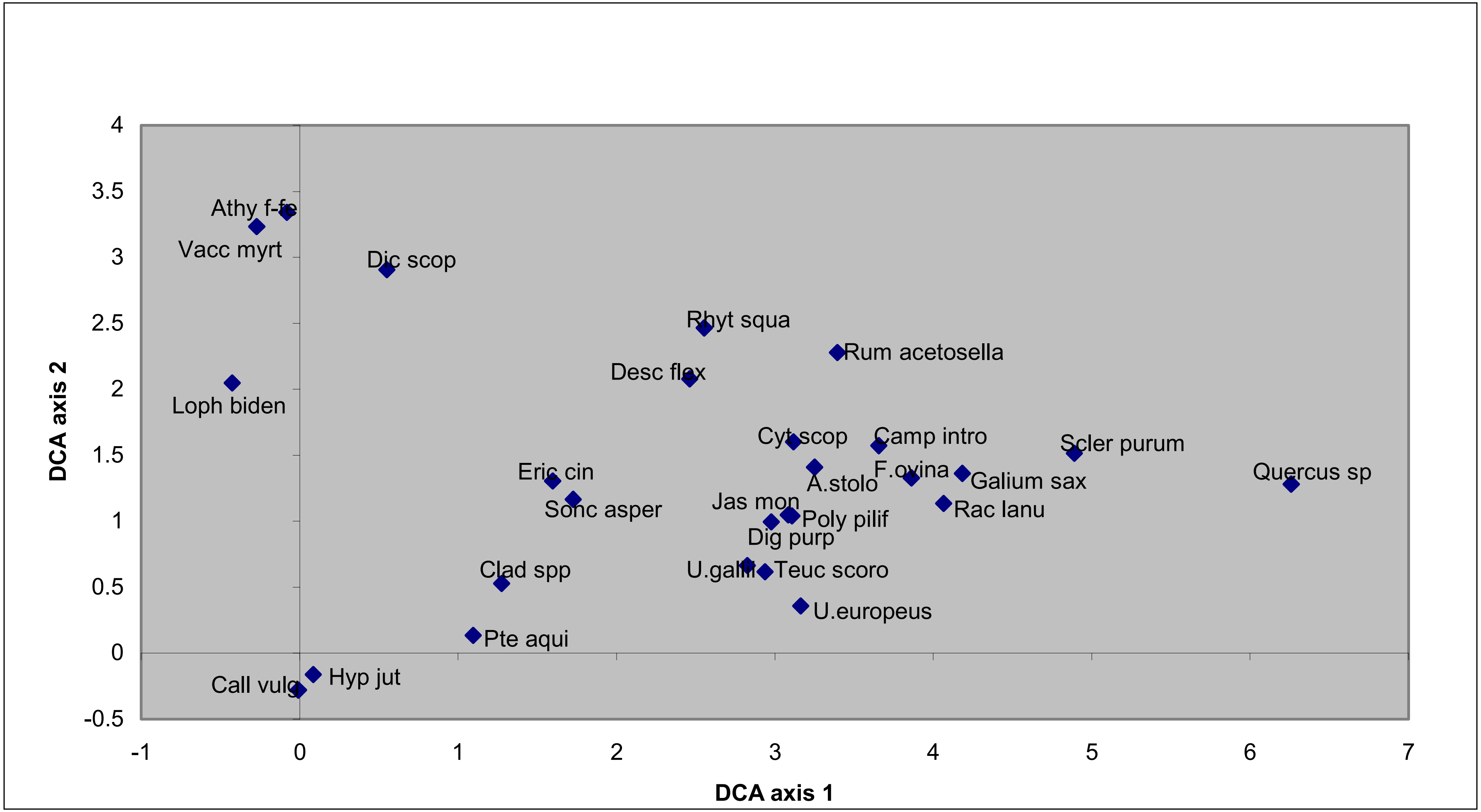

Figure 32. Ulex gallii heath: Stiperstones species plot

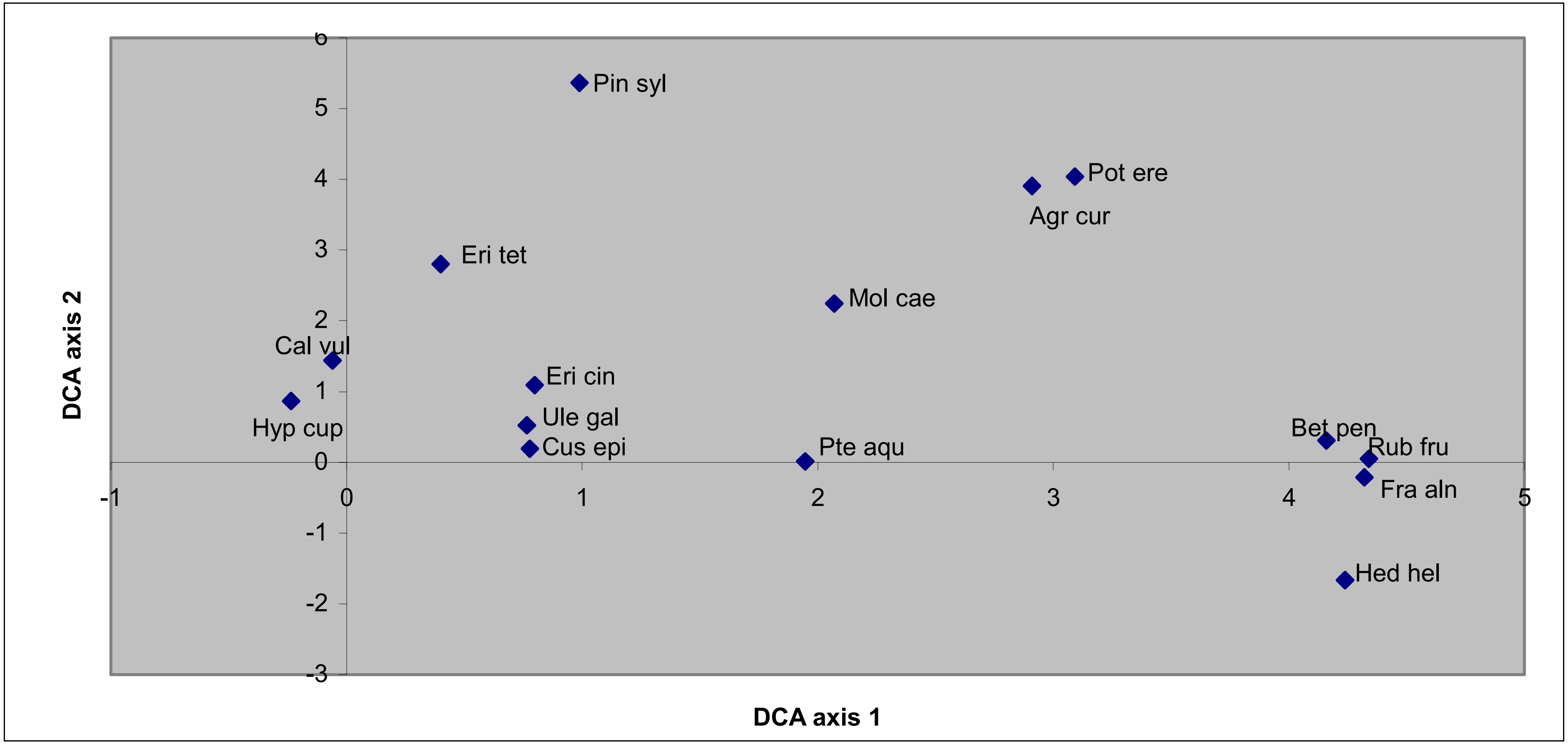

Figure 33. ***Ulex gallii*** **heath: Yarner species plot**

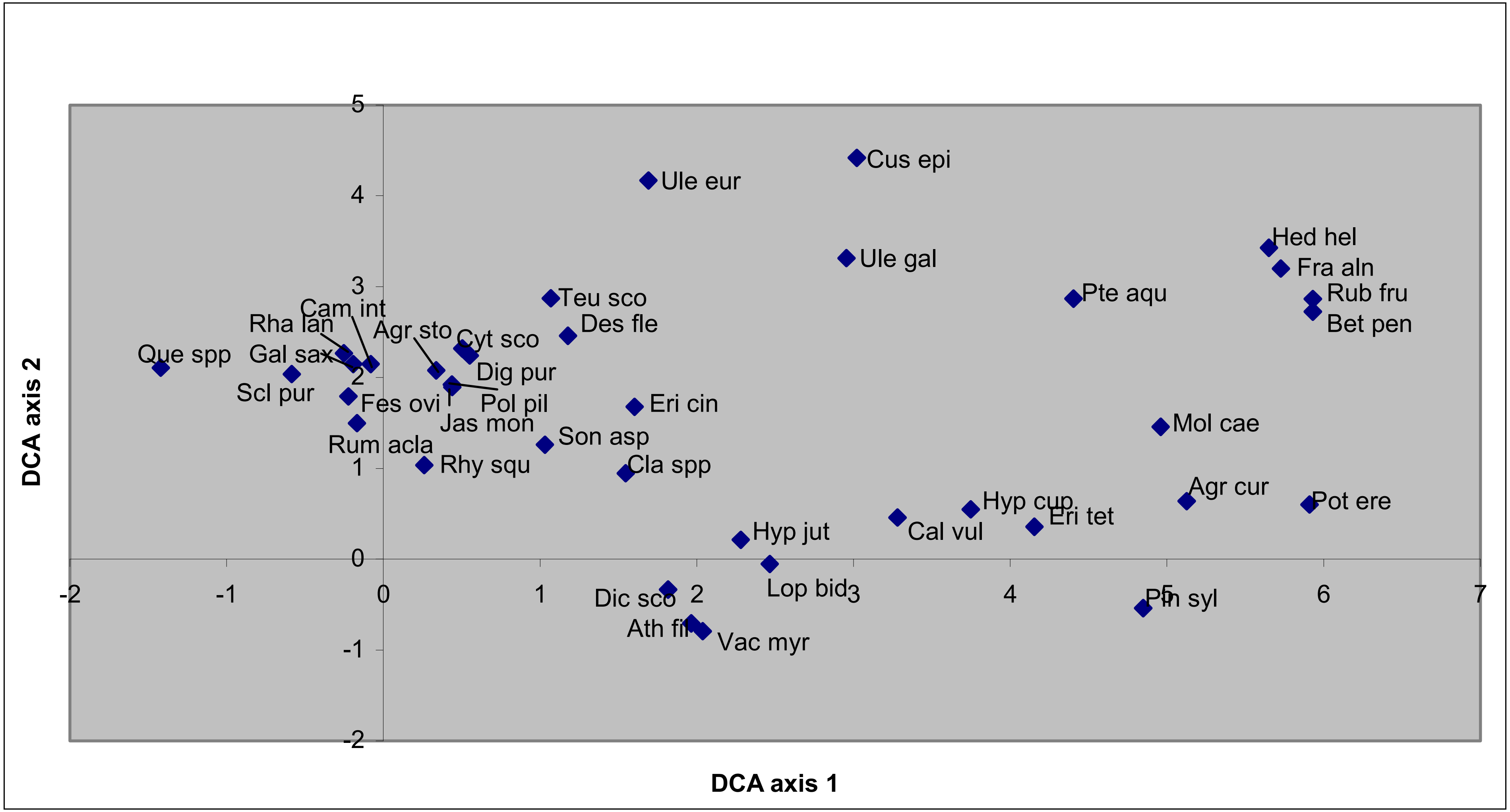

Figure 34. ***Ulex gallii*** **heath: all sites species plot**

Appendix 1a. Tranche 1 Validation Network Sites and NVC communities

Upland sites

Site	H4-8	H12-18	M15	M17-19	U2-20
Yarner Wood NNR, Devon	✓				
Stiperstones NNR, Shropshire	✓	✓			
Ingleborough NNR, N. Yorkshire		✓	✓	✓	
Kielderhead NNR & Whitelee SSSI, Northumberland		✓	✓	✓	
Moorhouse & Upper Teesedale NNR, Cumbria & North'land				✓	✓
Dunkery & Horner NNR, Somerset	✓	✓	✓	✓	

Appendix 1b. Maps

Yarner Wood NNR

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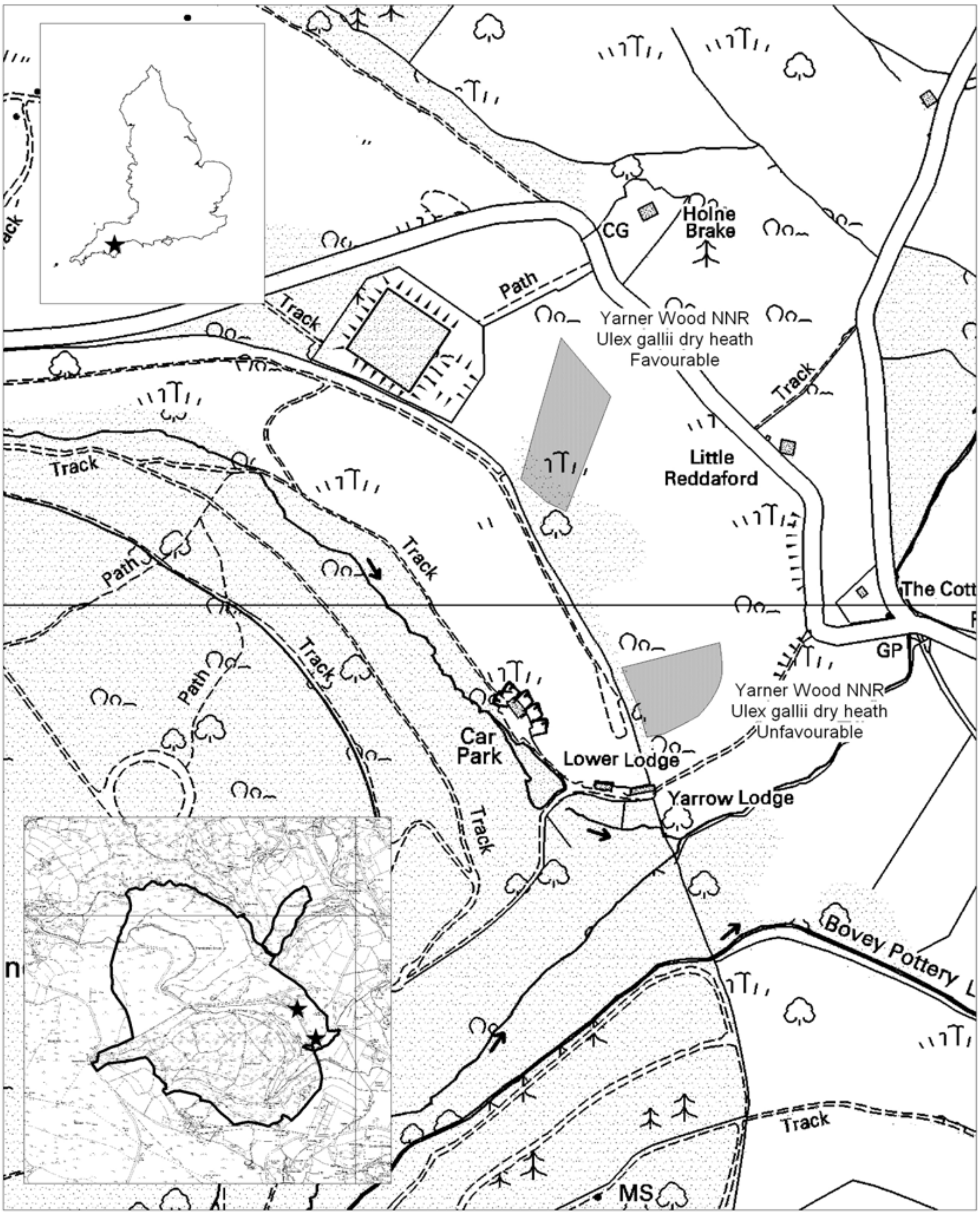
Validation network plots: Ulex gallii dry heath



Scale 1:5000 Map 1 of 1

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Yarner Wood NNR, Devon

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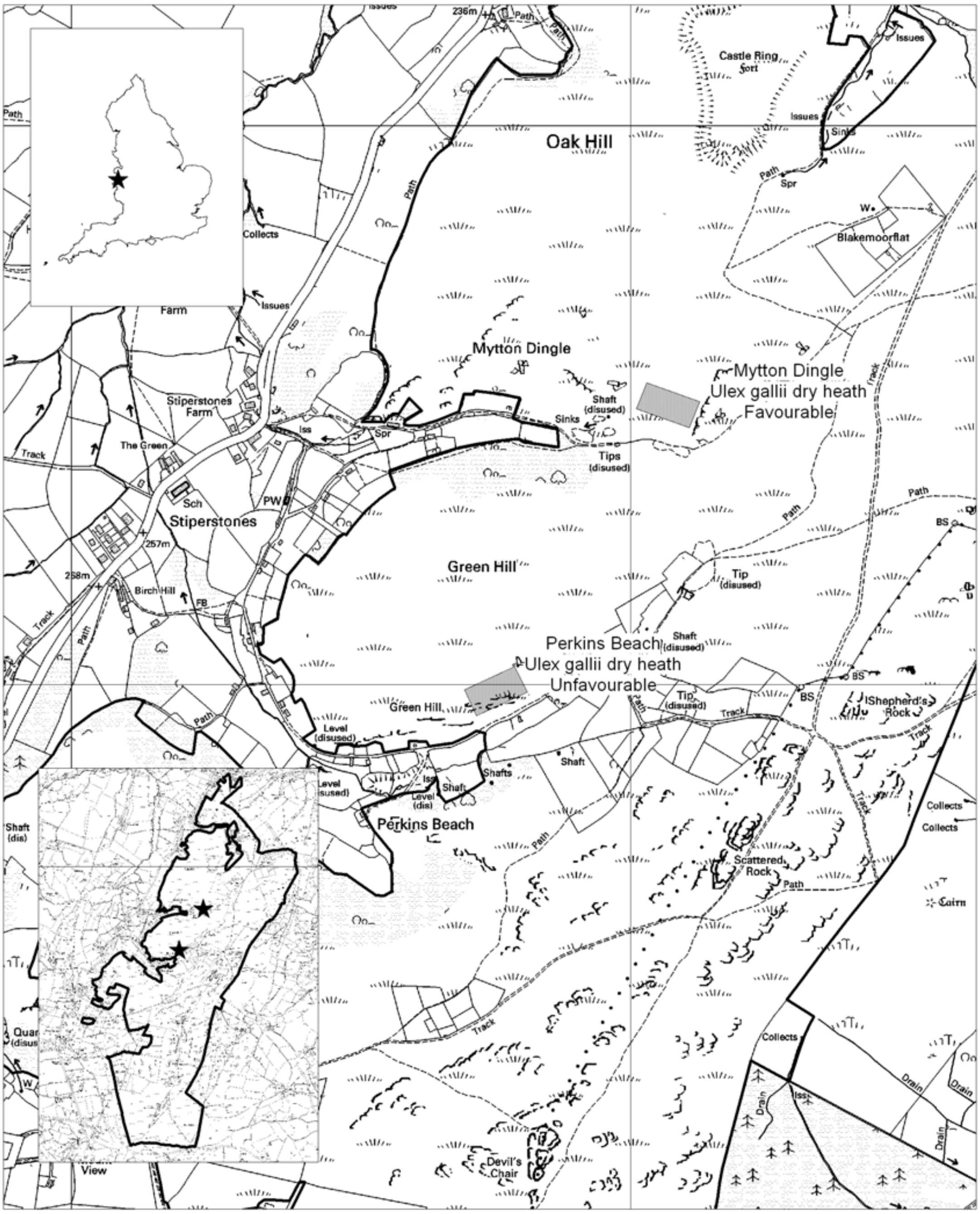
Stiperstones NNR

Validation network plots: Ulex gallii dry heath



Scale 1:10000 Map 1 of 2

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Stiperstones NNR, Shropshire (1)

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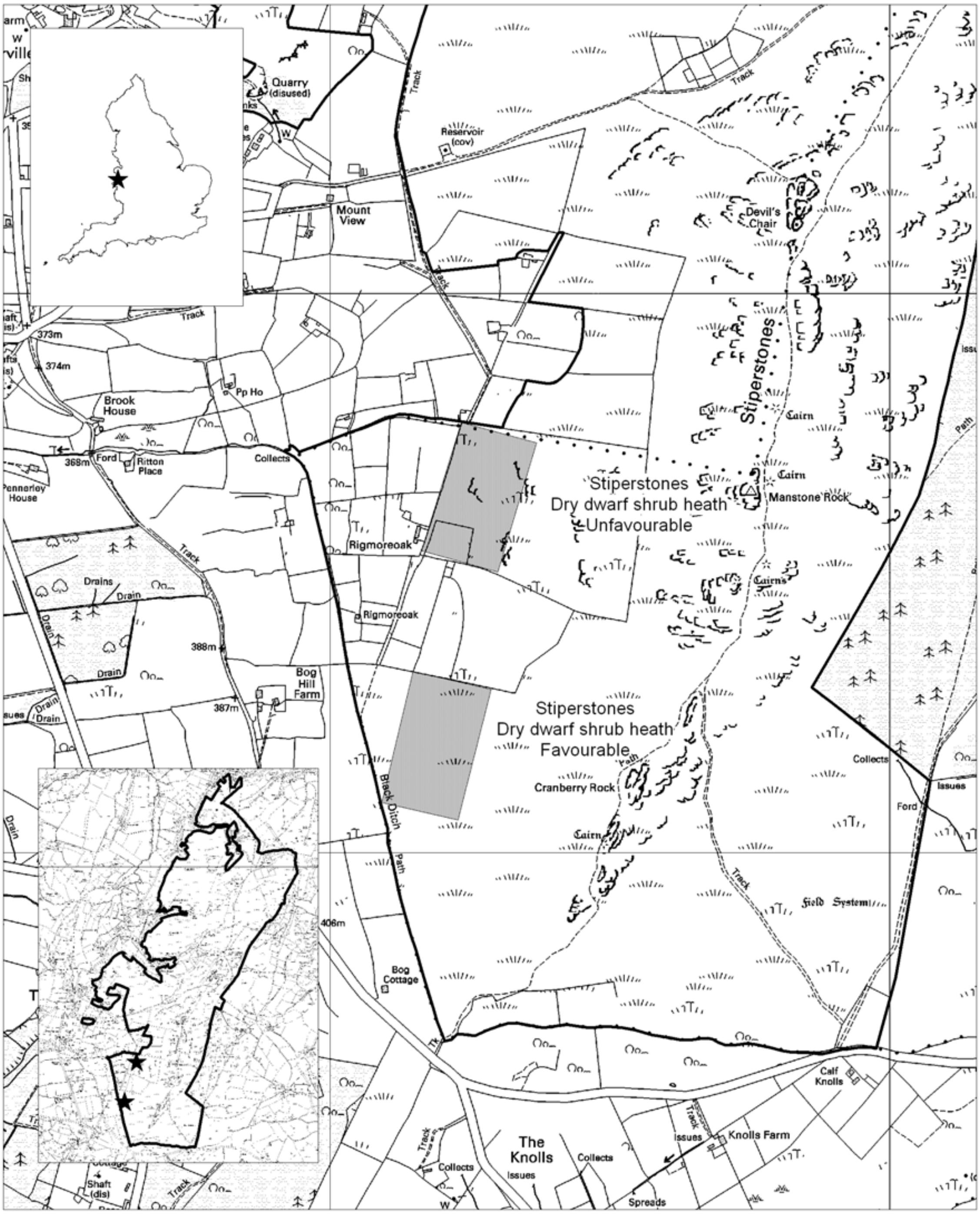
Stiperstones NNR

Validation network plots: dry dwarf shrub heath



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Stiperstones NNR, Shropshire (2)

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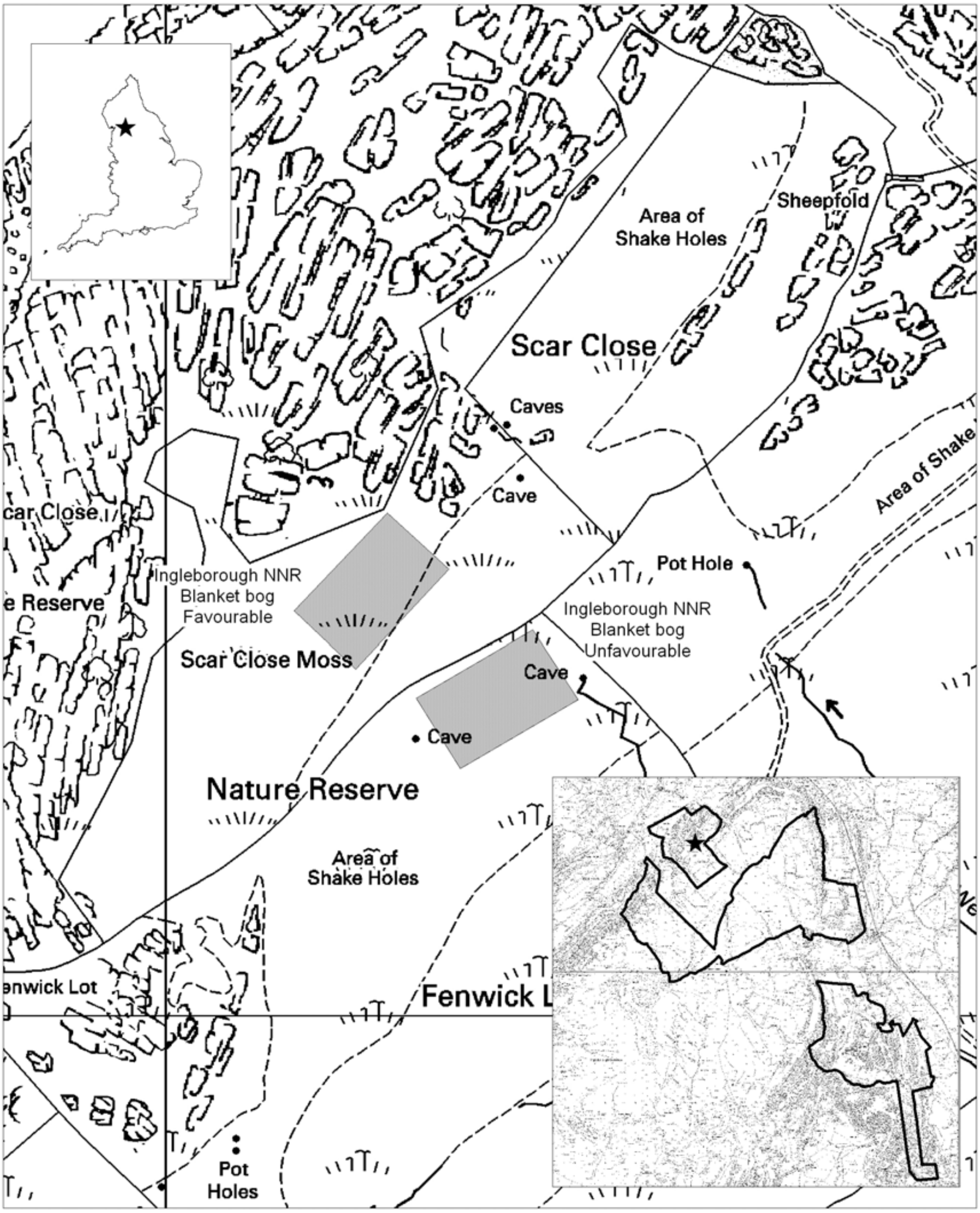
Ingleborough NNR

Validation network plots: blanket bog



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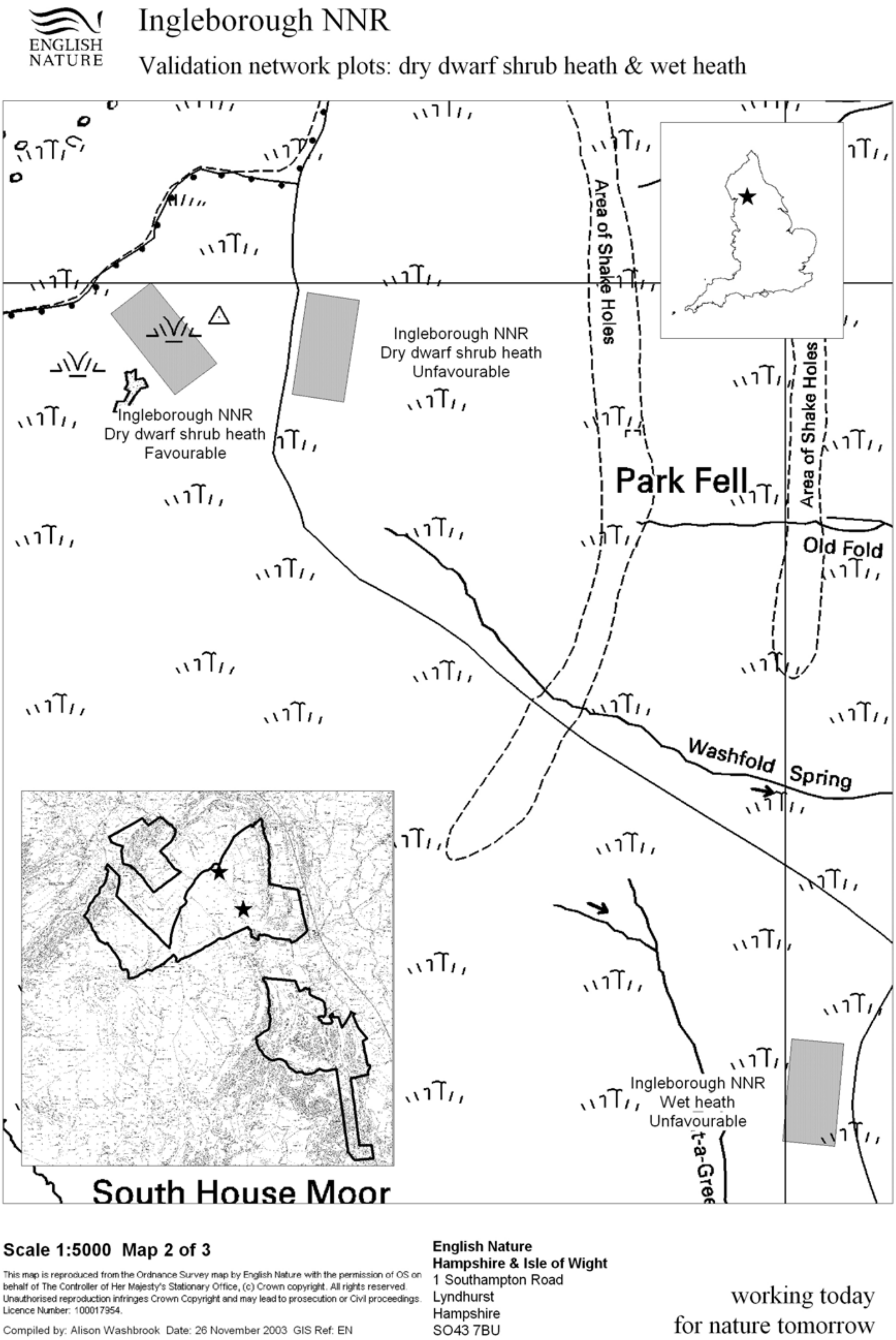
Ingleborough NNR, N. Yorkshire (1)

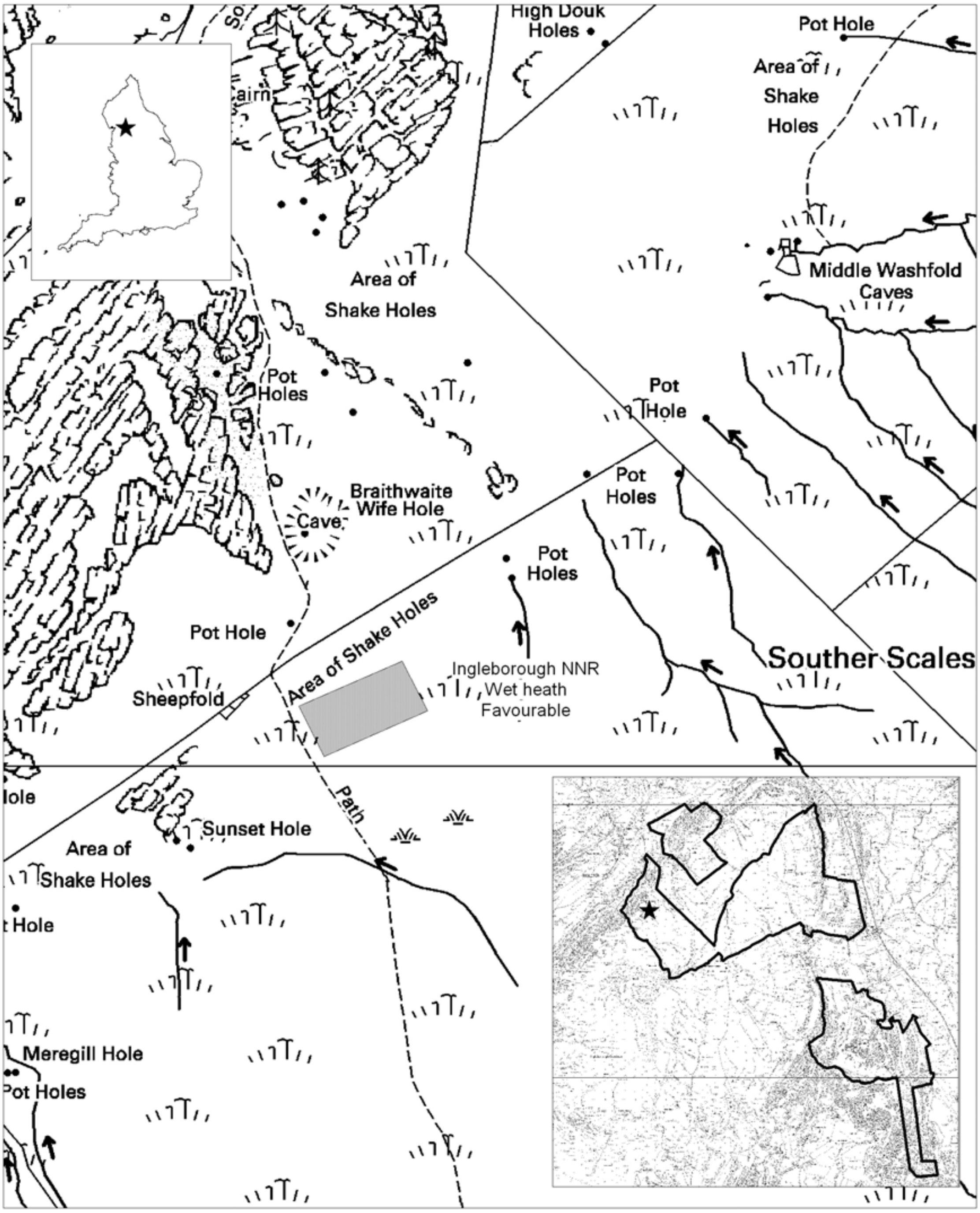


Ingleborough NNR, N. Yorkshire (2)

ENGLISH NATURE

Ingleborough NNR

Validation network plots: wet heath



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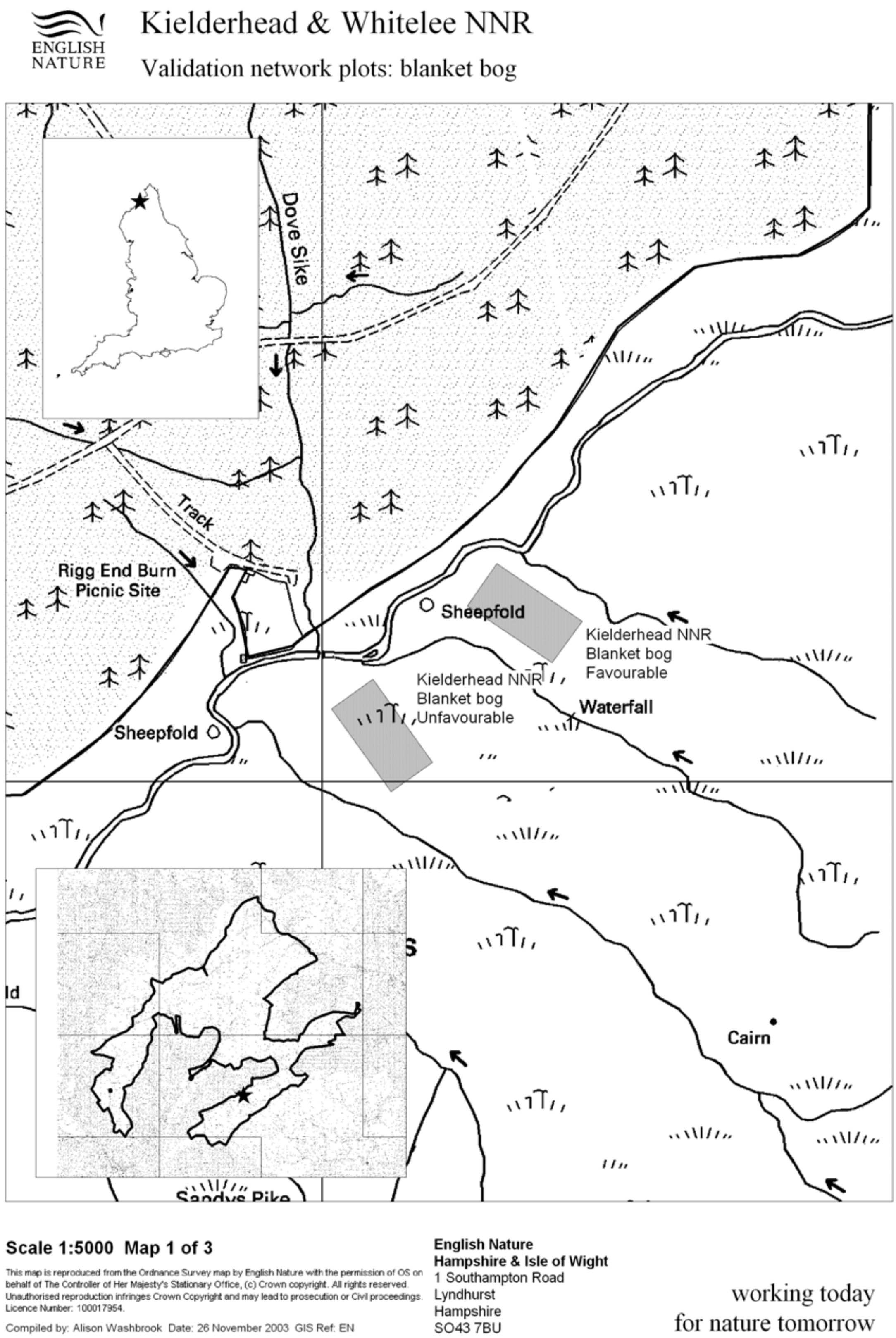
Ingleborough NNR, N. Yorkshire (3)



Kielderhead NNR & Whitelee SSSI, Northumberland (1)

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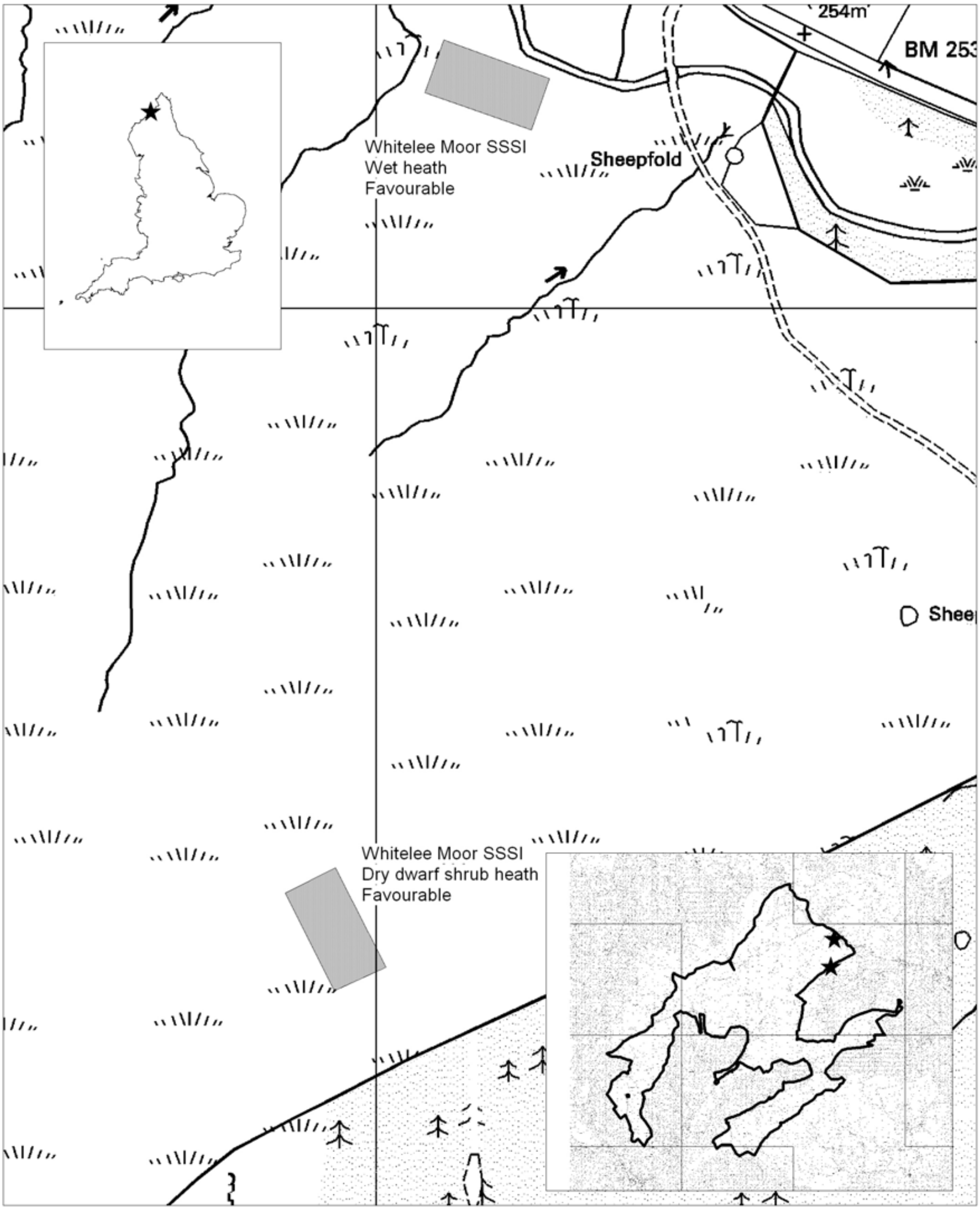
Kielderhead & Whitelee NNR

Validation network plots: dry dwarf shrub heath & wet heath



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Kielderhead NNR & Whitelee SSSI, Northumberland (2)

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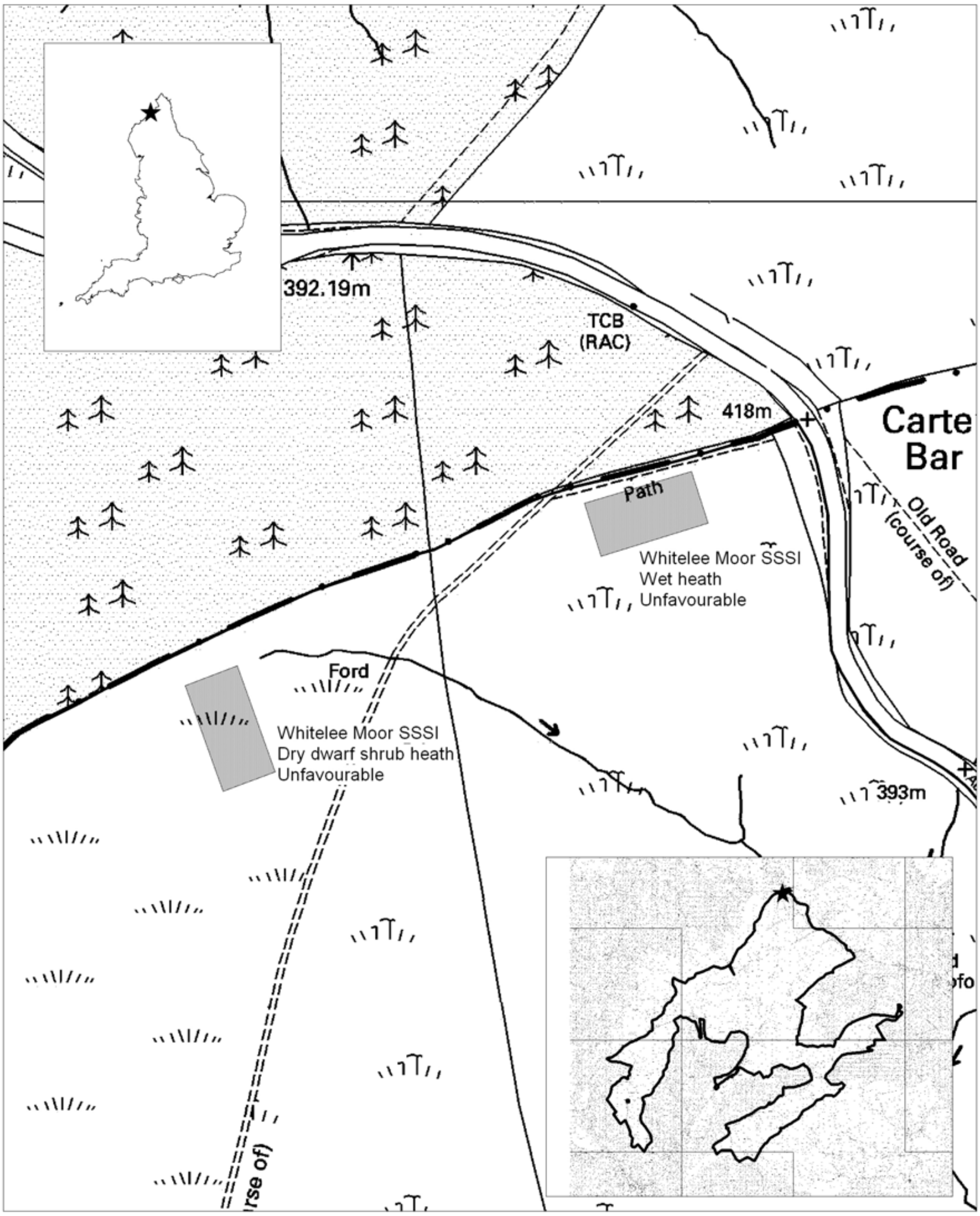
Kielderhead & Whitelee NNR

Validation network plots: dry dwarf shrub heath & wet heath



Scale 1:5000 Map 3 of 3

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Kielderhead NNR & Whitelee SSSI, Northumberland (3)

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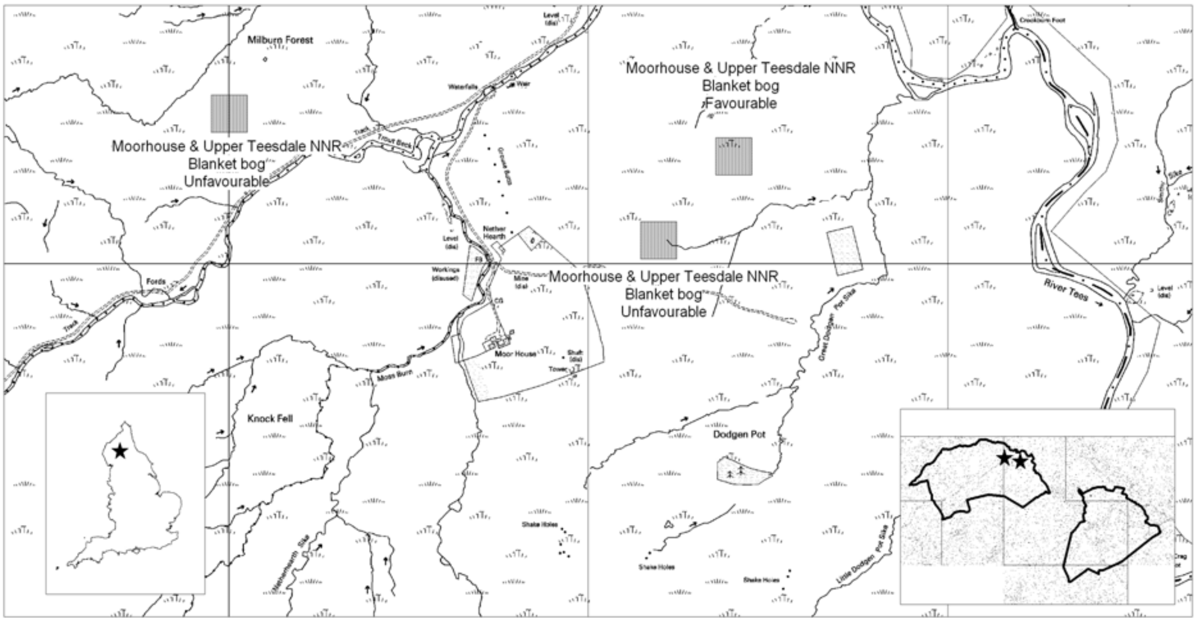
Moorhouse & Upper Teesdale NNR

Validation network plots: blanket bog



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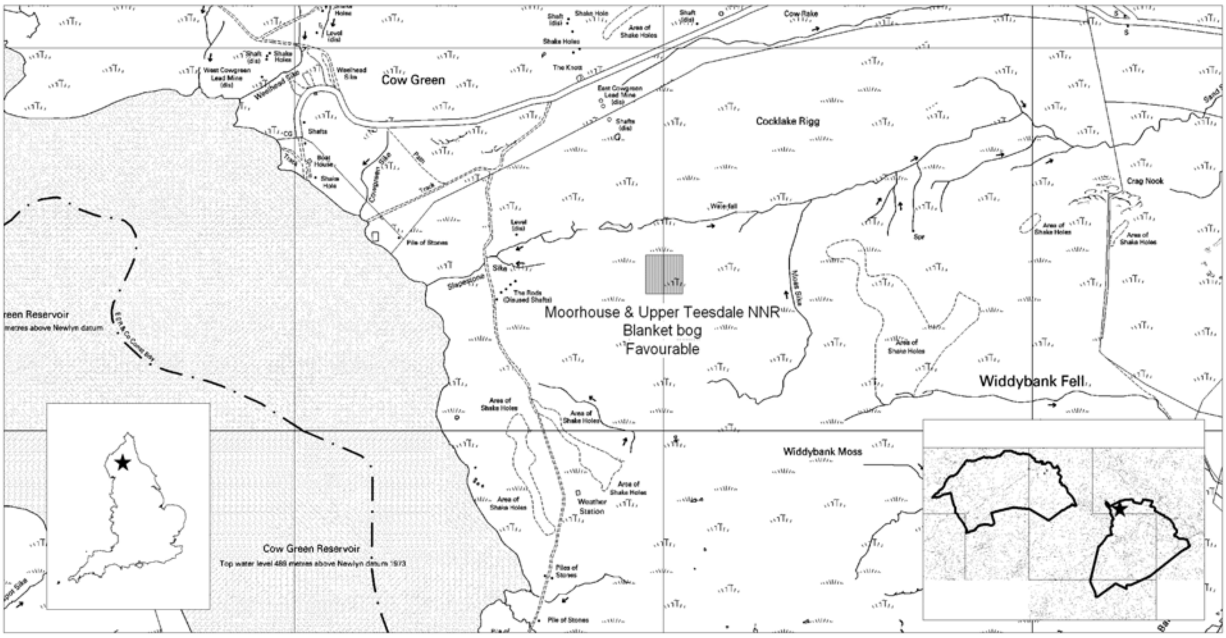
Moorhouse & Upper Teesdale NNR, Cumbria & Northumberland (1)

Moorhouse & Upper Teesdale NNR

Validation network plots: blanket bog



Scale 1:10000 Map 2 of 2

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Moorhouse & Upper Teesdale NNR, Cumbria & Northumberland (2)

Dunkery & Horner SSSI

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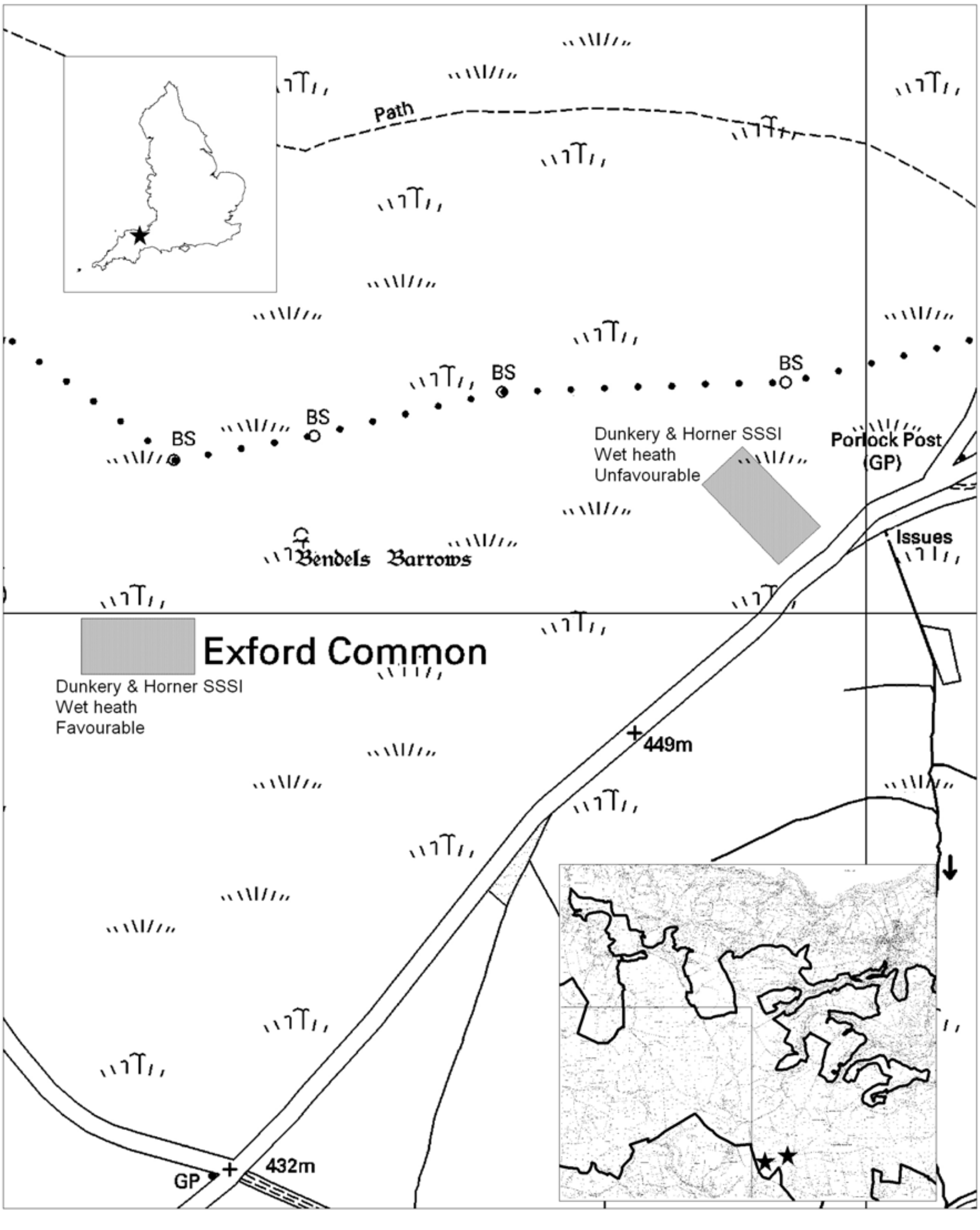
Validation network plots: wet heath



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Dunkery & Horner NNR, Somerset

Appendix 2. ENSIS condition of target units on Tranche 1 Validation Network Sites and their management

Upland sites

Site	UD	UN	UR	FR	FM	Management
Yarner Wood NNR, Devon †			✓	✓	✓	Burning/cutting, sheep & cattle grazing
Stiperstones NNR, Shropshire †			✓	✓	✓	Burning/cutting, sheep & cattle grazing
Ingleborough NNR, N. Yorkshire †			✓	✓	✓	Burning, sheep & cattle grazing
Kielderhead NNR & Whitelee SSSI, Northumberland †		✓	✓	✓	✓	Sheep & cattle grazing
Moorhouse & Upper Teesedale NNR, Cumbria & North'land †	✓			✓?	✓?	Burning, sheep grazing
Dunkery & Horner NNR, Somerset		✓	✓	✓	✓	Burning/cutting, sheep & cattle grazing

† - Environmental Change Network Biodiversity Network monitoring.

Appendix 3. Grazing assessment measures and percentage/frequency categories *

Upland sites

Measure	Absent	Light	Moderate	Heavy
Flowering dwarf shrubs		100-67	66-34	33-0
Grazed growth forms of *Calluna* [1]	0	1-5	6-15	16-100
Grazing of unpalatable species	0	1-5	6-15	16-100
Uprooted dwarf shrubs in recent burns		0	1-15	16-100
Herbivore dung	0	1-5	6-30	31-100
Trampled bare ground	0	1-5	6-30	31-100
Trampled *Sphagnum* hummocks	0	1-5	6-15	16-100
Width of heavy grazing zone		0 or <1m	1-10m	>10m

* All figures in percent or percent frequency except for width of heavy grazing zone.

[1] Grazed growth forms as a ratio grazed growth forms:normal growth.

ENGLISH NATURE

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

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

www.english-nature.org.uk

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

ISSN 0967-876X

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

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Peter Wakely/English Nature 17,396
Middle left: Co_2 experiment at Roudsea Wood and Mosses NNR, Lancashire.
Peter Wakely/English Nature 21,792
Bottom left: Radio tracking a hare on Pawlett Hams, Somerset.
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