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# Validation Network Project

# Lowland heathland monitoring: covering dry and wet heaths

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# Lowland heathland monitoring: covering dry and wet heaths

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# Cover note

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# Summary


1. In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as *A Statement on Common Standards in Monitoring*. The aim for each site is to maintain it in favourable condition, and condition is assessed on a set of key features of interest for the broad habitats within each site. New guidance on Common Standards Monitoring has been published (Joint Nature Conservation Committee 2004) which now forms the standard approach to monitoring statutorily designated sites.

2. The results of this regular monitoring against set targets enables management practices on these sites to be appraised and revised if required. Monitoring across a range of sites with similar habitats also allows some determination of the condition of the habitat resource as a whole, feeding into regional and national targets such as those identified within the UK Biodiversity Action Plan. This strategic monitoring forms the Validation Network Project, the aims of which are to validate condition monitoring, to establish control sites against which changes in interest features can be assessed, and to contribute to understanding the drivers of change in individual habitat types.

3. This report presents the results and conclusions of the analyses of data collected for lowland heathland sites within England, undertaken as part of the Validation Network Project.

4. Nine lowland heathland sites within England were selected for the monitoring of dry and wet heathland vegetation types. These were Cannock Chase SSSI (Staffordshire), Cavenham Heath NNR (Suffolk), Roydon Common NNR (Norfolk), Aylesbeare Heath SSSI (Devon), The Lizard NNR (Cornwall), Thursley NNR (Surrey), Lazonby Fell SSSI (Cumbria), the New Forest SSSI (Hampshire) and Hartland Moor NNR (Dorset).

5. Datasets collected for each area included the standard Condition Assessment field survey form for either dry or wet heath vegetation, quadrat-based data on composition and cover, and a range of measured variables also at the quadrat scale (eg vegetation height, litter cover, bryophyte cover). In addition, a range of variables were assessed at the plot scale (eg soil chemistry, slope, aspect, climate, aerial pollution).

6. Analyses of these data took four approaches: comparison of qualitative and quantitative datasets; assessment of botanical communities using C-S-R strategies and Suited Species Scores for acidity, moisture, grazing and nutrients; assessment of the significance of measured variables in differentiating favourable and unfavourable plots; multivariate analysis of vegetation community data.

7. The comparison of qualitative and quantitative methodologies indicated that in general the rapid (qualitative) assessment approach yielded similar results to the detailed quadrat-based (quantitative) approach. Many of the variables could be relatively accurately assessed using the rapid assessment approach, making this type of assessment a cost-effective and relatively robust way to assess vegetation

condition. However, the rapid assessments tended to under-estimate the number and abundance of negative indicator species and over-record the abundance of desirable grass species. The low failure threshold of *Molinia caerulea* appeared to cause failure in the graminoid attribute across all (both 'favourable' and 'unfavourable') wet heath plots.

8. The C-S-R model indicated that all vegetation communities showed the greatest affinity to the Stress-tolerator strategy (up to a 4% fit to this strategy) while there were much lower values in relation to Competitor or Ruderal strategies. However, this model provided a relatively poor approach to analysing the botanical data.

9. Suited Species Scores assessments of botanical composition indicated that the majority of plots had plant species that were tolerant of (ie 'suited to') acidic conditions, but intolerant of high nutrient concentrations. The associations with moisture were, however, more variable with no clear trends. In terms of favourable and unfavourable condition, the unfavourable plots were typically associated with relatively less acid, more nutrient enriched and slightly drier areas.

10. The assessment of vegetation and environment variables identified which variables were significantly different between pairs of favourable and unfavourable plots on a site. Some variables such as vegetation height and proportion of flowering *Calluna* showed significant differences between plots but with no consistent trends in terms of vegetation condition. Bryophyte, *Sphagnum* and lichen cover was associated with favourable plots on some sites, but not on others. The cover of *Calluna* did show a clear trend, with consistently greater cover on favourable vegetation plots. Increased litter cover was generally associated with unfavourable plots although the association was not strong.

11. The DCA multivariate analysis results indicated that the main variation in vegetation identified between favourable and unfavourable plots was in the proportions of typical heathland species (such as dwarf shrubs, sedges and mosses) and species indicative of modified heaths (such as trees and shrubs, bracken and significant amounts of grasses). The main variation in vegetation between sites was not easy to detect but there was an indication that geographical location was important for dry heaths while the wet – dry gradient was important for wet heaths.

12. In terms of the main environmental indicators of differences identified through CCA, in general only a small number of measured variables had a significant effect on the analysis. While these variables did differ somewhat between sites, there were some overall trends. Favourable plots tended to have greater cover of building and mature heather, along with more heather flowering. The bryophyte cover was higher while the acrocarpous moss cover was lower than for unfavourable plots. This suggests that regular monitoring of the dwarf shrub and moss components of a heathland should give a good indication of changes in terms of vegetation condition. Between sites, again the dwarf shrub variables gave consistently useful differences between dry heath sites, along with the degree of rabbit grazing. However, the variation between wet heath sites was not great and the majority of sites were clustered together.

13. The method for condition assessing lowland heathland vegetation generally appears to be robust and applicable in the field. The major discrepancies were where the rapid

assessment method under assessed the number and abundance of negative indicators and over recorded the abundance of desirable graminoids. Similar patterns have been seen with other habitats and have been ascribed to the difficulty of viewing smaller broad-leaved species through and under an ericoid canopy and the tendency for oblique viewing of graminoids during the more rapid assessments. In addition, the apparent low threshold of *Molinia caerulea* on wet heaths appears to be causing failure among otherwise favourable vegetation and should be reviewed.

14. Further training of officers undertaking field assessments in both species identification and consistency of recording should result in more accurate assessments of condition on both wet and dry lowland heathland habitats.

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# 1 Introduction

In May 2004, Penny Anderson Associates Ltd (PAA) was commissioned by English Nature to undertake a project to analyse and report on data collected for lowland heathland habitats at nine different lowland heathland sites within England.

Lowland heathland habitats are generally classified as areas of dwarf shrub dominated vegetation below approximately 300m in altitude (UK Biodiversity Steering Group 1995). The dwarf shrub species that characterise the habitats are heather (*Calluna vulgaris*), gorses (*Ulex* sp.) and cross-leaved heath (*Erica tetralix*). The vegetation communities typically reflect the variations in regional climate, soils and management. These large-scale changes are often overlain with smaller scale variation reflecting local changes in factors such as aspect, slope, soils and grazing.

Lowland heathland habitats are typically divided into two broad types, dry heath and wet heath with a third category of humid heath often also recognised (Rodwell 1991, Joint Nature Conservation Committee 2004). Dry heath vegetation is dominated by heather, gorse species, bell heather (*Erica cinerea*) and bilberry (*Vaccinium myrtillus*) with species such as sheep's fescue (*Festuca ovina*) or sand sedge (*Carex arenaria*) occurring where conditions favour them.

Wet heath vegetation occurs under similar nutrient poor, acidic substrates but where the drainage is significantly impeded. On these areas species such as cross-leaved heath, purple moor-grass (*Molinia caerulea*) and bristle bent (*Agrostis curtisii*) all become more frequently encountered within the community, and the Dorset heath (*Erica ciliaris*) is also present although geographically restricted. Bog mosses (typically *Sphagnum compactum* and *S. tenellum*) and other species typical of mires also occur.

The transition between wet and dry heath is often referred to as humid heath, and this community has characteristics of both wet and dry heath communities typically with either western gorse (*Ulex gallii*) or dwarf gorse (*Ulex minor*) being an important component. The Cornish heath (*Erica vagans*) community found on the Lizard is also classified as humid heath.

A summary of the National Vegetation Classification (NVC) communities associated with dry, wet and humid heaths is presented in the Common Standards Monitoring (CSM) guidance on lowland heath (Joint Nature Conservation Committee 2004). In addition, the transitions between NVC types and their distribution within the UK are presented in Rodwell (1991).

These data were collected through the Validation Network project that aims to ensure that data on the condition of individual features of interest on designated sites are accurate, consistent and scientifically robust.

## 1.1 Background

In 1998, the statutory nature conservation agencies, including English Nature, presented a framework for monitoring on designated sites. The outline framework is published as *A Statement on Common Standards in Monitoring* (Joint Nature Conservation Committee 1998).

The sites covered by this framework are Special Protection Areas (SPAs), candidate Special Areas of Conservation (cSACs), Ramsar Sites, Sites of Special Scientific Interest (SSSIs) and Areas of Special Scientific Interest (ASSIs).

The aim for each site is to maintain it in favourable condition, and condition is assessed on a set of key features of interest for the broad habitats within each site as outlined in the Joint Nature Conservation Committee (1998) report. It should be noted that new guidance on Common Standards Monitoring has now been published (Joint Nature Conservation Committee 2004) which now forms the standard approach to monitoring statutorily designated sites.

The monitoring of key features allows each site to be categorised as favourable maintained, favourable recovered, unfavourable recovering, unfavourable no change, unfavourable declining, partially destroyed or destroyed.

The results of regular monitoring enable management practices on these sites to be appraised and changed if appropriate. Monitoring across a range of sites with similar habitats also allows some determination of the condition of the habitat resource as a whole, feeding into to regional and national targets, including those identified within the UK Biodiversity Action Plan (UK Biodiversity Steering Group 1995).

## 1.2 Overall aims

The overall aims of the Validation Network project are to ensure that data on the condition of individual features on SSSIs are accurate, consistent and scientifically robust. The means to achieve this outcome are through a sample of sites on which quantitative monitoring is undertaken on a regular basis. This project operates in parallel with similar monitoring on other SSSIs.

The specific aims of this lowland heathland data analysis project are as follows:

- to validate the condition assessment methodology in England through testing the suitability of attributes and associated targets in assessing quality and trends in condition;
- to establish a set of control sites to ensure that individual site assessments match regional or national changes in feature conditions over time, and;
- to contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change.

## 1.3 Report structure

This report presents the results and conclusions of the analyses of data collected for lowland heathland monitoring sites within England, as part of the Validation Network project. The report briefly outlines the methods used to collect and analyse data, presents the analysis results in detail and discusses these results in relation to aims of the Validation Network project (as stated above). The report follows the format of previous ones in the series on other habitats (Bealey and Cox 2004; Bealey 2004).

Throughout the report nomenclature follows Stace (1997) for all higher plants, Dobson (2000) for lichens and Watson (1981) for bryophytes, except for species of *Sphagnum* whose nomenclature follows Daniels and Eddy (1985).

# 2 Methodology

## 2.1 Background

Methods for habitat monitoring have been derived from a combination of traditional quantitative methodologies, results from pilot studies and additional specialist advice. The basic strategy of the monitoring is to compare sets of quantitative data on attributes from plots that have been identified as either favourable or unfavourable according to English Nature's condition monitoring criteria (Joint Nature Conservation Committee 1998, 2004, Robertson and Jefferson 2000).

## 2.2 Selection of sites

Nine lowland heathland sites across England were selected for monitoring (Table 1). All the sites are designated statutory nature conservation sites, being either SSSIs or National Nature Reserves (NNRs) and are often also included within SPAs or SACs, and comprise:

- Cannock Chase SSSI, Staffordshire;
- Cavenham Heath NNR, Suffolk;
- Roydon Common NNR, Norfolk;
- Aylesbeare Heath SSSI (part of East Devon Pebble Bed Heaths SSSI), Devon;
- The Lizard NNR, Cornwall;
- Thursley NNR, Surrey;
- Lazonby Fell SSSI, Cumbria;
- New Forest SSSI, Hampshire;
- Hartland Moor NNR & Wytch Heath SSSI, Dorset.

Cannock Chase SSSI is a large (1264ha), diverse area of semi-natural vegetation comprising the most ecologically important parts of the former Royal Chase (Figure 1). The area of lowland heathland is the most extensive in the Midlands and occurs just north of Cannock. The site also includes woodland, scrub, acid grassland, streams and valley mires. The vegetation has developed over Triassic sandstone and marls. The site is managed in a variety of ways including heather cutting, scrub control and bracken management through herbicide application.

Cavenham Heath NNR (204ha) lies to the north-west of Bury St Edmunds close to Icklingham, and is included in the Cavenham/Icklington Heaths SSSI (Figure 2). The area has developed heathland, acid grassland and bracken (*Pteridium aquilinum*) over dry, acidic sandy soils. There are also areas of woodland and some open damp meadows. The site is managed through sheep grazing and scrub control.

Roydon Common NNR (Figure 3) covers 241ha and is part of Roydon Common SSSI. It lies east of Kings Lynn in Norfolk. The site is important for its mixture of dry and wet heath, valley mire, calcareous fen, rough pasture, and woodland. The site is considered to be one of the best examples of lowland mixed valley mires in Britain. Management includes scrub control and grazing.

Aylesbeare is part of the largest block of lowland heathland in Devon, collectively known as the East Devon Pebble Beds SSSI and found to the northeast of Budleigh (Figure 4). The site overlies the Triassic Bunter Pebblebeds with some New Red Sandstone and Permian Marl deposits, and is dominated by dry and wet heathland areas along with acid grasslands, bracken and scrub with some flushes and valley mire.

The Lizard NNR (Figure 5) is formed from a collection of smaller sites totalling 1662ha, comprising inland heathland and coastal grassland/heathland habitats in the west of Conwall. The site includes the rare Cornish heath (*Erica vagans*) and is very botanically diverse with several Red Data Book plant species. The area is managed using cattle and pony grazing to control the coarser grasses and reduce scrub invasion and rotational burning is also undertaken. This site is also partly included within the West Lizard SSSI, and the whole site is underlain by serpentine rock with minor occurrences of granite and schist, and in some places these deposits are overlain with windblown loess.

Thursley NNR, in Surrey, covers 326ha of Lower Greensand and is found to the south of Guildford (Figure 6). The area is also included in the larger Thursley, Hankley and Frensham Commons SSSI. The NNR comprises heathland and mire with smaller stands of scrub woodland and is a fragment of the once extensive Surrey heathlands. Rotational heather cutting, scrub removal, gorse coppicing and the control of bracken through cutting or herbicide application are all methods of management used on the site.

Lazonby Fell SSSI (Figure 7) comprises 149ha heathland situated north of the town of Penrith. The habitat has developed over New Red Sandstone deposits and although lowland heath in altitude (at approximately 230m), the vegetation includes cowberry (*Vaccinium vitis-idaea*) suggesting some affinities to heathland vegetation types more typical of upland areas.

The heathland of the New Forest SSSI, south of Romsey, Hampshire, is also included in this study (Figure 8a and 8b). The site has approximately 11,800ha of heathland and associated grassland, along with 3,300ha of wet heath and valley mire, and is managed through the use of grazing and scrub control. The geomorphology of the area is complex with a series of eroded terraces capped with flint gravel, brickearth and other deposits derived from the Bagshot and Bracklesham beds. Erosion has exposed some of these underlying Tertiary deposits in some areas, and localised exposure of the Headon beds loam and clay deposits support relatively species-rich habitats.

The final site included in the Validation Network monitoring project is Hartland Moor NNR & Wytch Heath SSSI, situated east of Wareham, Dorset (Figure 9). The site is 243ha and dominated by heather with cross-leaved heath and also includes the rare Dorset heath (*Erica ciliaris*). The vegetation has developed over the acidic and nutrient-poor sands and clays derived from the Bagshot beds. The NNR is also part of the slightly larger Hartland Moor SSSI (399ha).

### 2.2.1 Plot selection within sites

Monitoring was undertaken on examples of both dry and wet heath habitats across the nine lowland sites, including an example of humid heath. On three sites dry heath areas were selected for monitoring, on one site only wet heath plots were selected, and on the remaining five sites dry heath, humid heath and wet heath areas were used. At each dry, humid or wet heath site two paired plots were established. The plots were paired with one plot selected as an example of favourable condition and the other selected as an example of unfavourable condition within the same vegetation type although these ranks were relative rather than absolute. The allocation of dry, humid or wet heath plots at each site, and their division into favourable or unfavourable condition, are indicated in Table 2 and the approximate location of the plots on each site are presented in Figures 1 to 9.

Rather than undertaking a 'fully factorised' series of plots (which would have resulted in a large number of plots to monitor), plots were selected from within site condition monitoring units where vegetation was reasonably homogeneous in terms of community type and structure. For many of the units in which the monitoring plots were set, the ENSIS assessment of vegetation condition was based on a larger more heterogeneous vegetation type. This meant that the ENSIS condition assessment undertaken for CSM was not always comparable to the condition assessment undertaken for the Validation Network Project. While this limitation is acknowledged, the qualitative and quantitative methods were both collected at the same plot level and therefore comparison between these methods is acceptable. Indeed, if the data collection had taken place at the level of the ENSIS unit (rather than the plot scale) the heterogeneity of the unit is likely to have masked any other trends in the dataset.

The Validation Network project aims to test the methodologies targeted at monitoring particular NVC types or UK Biodiversity Action Plan (UK BAP) priority habitats. The CSM methodology cross-references the basic wet and dry heathland types to Phase 1 habitat survey types, NVC types and Annex I habitat equivalents within Annex 1 of the Common Standards Monitoring Guidance for Lowland Heathland (Joint Nature Conservation Committee 2004). The UK Biodiversity Action Plan (UK Biodiversity Steering Group 1995) also provides a link between the BAP priority habitats and the NVC. The location of each plot was therefore determined from a combination of information held by English Nature such as ENSIS survey data and NVC surveys, along with site visits. ENSIS data were found to be of limited use in selecting specific plots for monitoring as these data related to large areas of generally heterogeneous vegetation within a habitat type, rather than identifying NVC communities or sub-communities. Surveys that identified homogeneous vegetation areas, such as the NVC survey data, were more valuable in plot selection.

Once established, monitoring plots were mapped and marked with transponders or FENO survey markers to aid re-location. All major locations were also recorded with a Global Positioning System (GPS).

Within plots data were collected at both the plot scale and at the more detailed quadrat scale, with 30 quadrats per plot used to collect information on both vegetation community and habitat structure.

## 2.3 Data collection

### 2.3.1 Vegetation condition assessment

Vegetation Condition Monitoring was completed for each plot at each site using the standard English Nature assessment forms. The method followed English Nature guidelines and qualitative and quantitative datasets for any one plot were collected independently by different surveyors. Slightly different standard condition assessment forms have been developed for either dry or wet heaths to take account of the different nature of these vegetation types. No specific 'humid heath' assessment forms have been developed and the 'dry' heath assessment forms were completed for the humid heath plots.

### 2.3.2 Botanical composition and associated measures

Two attributes were assessed in the field under this general heading. These were botanical composition at the quadrat scale, and the cover of scrub, trees and bracken at the plot scale.

Botanical composition was recorded using 1mx1m quadrats. Quadrats were randomly stratified according to sub-habitat type, with thirty quadrats in total in each plot. All higher plants, together with those bryophytes and lichens able to be identified in the field, were recorded using estimated percent occurrence within the whole quadrat.

Particular attention was paid to identifying the presence/absence of positive and negative indicator species, as identified through the standard condition monitoring assessments. Positive indicator species include dwarf shrubs, some graminoids, desirable fords, bryophytes and lichens. Negative indicator species include exotic species, 'weed' species, trees and some scrub species, along with the invasive acrocarpous mosses. The species included in these assessments are presented on the standard monitoring forms used in the field.

Scrub, tree and bracken cover was assessed as an estimated percent cover across the whole plot, rather than at the quadrat scale.

### 2.3.3 Environmental and structural variables – quadrat scale

Several environmental and structural variables were measured at each quadrat location. The measurements included vegetation structure, heather age structure, plant litter, bare ground, and grazing levels. The methods used are briefly described below:

#### 2.3.3.1 Vegetation structure

This was assessed using vegetation height as an indicator of structure. A 200g drop disc was used to measure vegetation height at each quadrat location. Height measurements were taken in the centre of the quadrat on a graduated dowel passing through the centre of the disc.

#### 2.3.3.2 Plant litter and bare ground

These attributes were visually estimated as percent cover within each quadrat.

#### 2.3.3.3 Grazing levels

Evidence of grazing of sensitive species was assessed for each quadrat, together with a visual assessment of the proportion of flowering dwarf shrubs and heather growth form, both in an expanded 2mx2m quadrat. Animal dung quantity and origin (cattle, sheep, horse, rabbit or other animal) was also recorded at the quadrat level as an aid to the assessment of the relative importance of different grazing animals. Evidence of stock trampling was assessed at the plot level.

### 2.3.4 Environmental and structural variables – plot scale

A further number of environmental attributes were assessed or collated at the plot level. These were stock trampling, soil nutrient status, aspect, slope, climate and aerial pollution input (specifically, nitrogen precipitation). Each are briefly described as follows:

#### 2.3.4.1 Stock trampling

Evidence of stock trampling, such as poaching and broken stems of dwarf shrubs, was recorded in the plot.

#### 2.3.4.2 Soil nutrient status

Soil samples from the uppermost 75mm were collected for each quadrat using a ‘pot auger’ soil sampler (Steve Peel, ADAS pers. comm.) and bulked for a plot scale analysis. Lab analyses assessed organic matter content (loss on ignition), pH, and cation exchange capacity (CEC). In addition, the following were also analysed: extractable phosphate phosphorus ($PO_4$-P), hydrogen (H), sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), iron (Fe), aluminium (Al), and total nitrogen (N).

#### 2.3.4.3 Aspect and slope

Aspect was measured at the whole plot level using a hand-held compass, while slope was measured using a clinometer.

#### 2.3.4.4 Climate

Additional information on climate was obtained as monthly long-term averages (1971–2000) from the nearest Meteorological Station for each site. Data covers minimum and maximum temperature (°C), days of air frost, sunshine (hours), rainfall (mm) and number of days with more than 1mm rainfall. Details of the Meteorological Station used for each site are presented in Table 3.

#### 2.3.4.5 Aerial pollution inputs

Aerial pollution inputs were not measured directly in the field, but nitrogen critical loads for the 10km grid-square (or squares) which covered the site were obtained from the CEH Critical Loads Model under licence. These data can be used to indicate if the site might be relatively more or less vulnerable to nitrogen-based aerial pollution inputs. However, there are no data to indicate if these critical load levels have been exceeded on any of the sites

## 2.4 Data handling

Qualitative data were provided as standard field survey forms for each plot. In many cases a ‘pass’ or ‘fail’ had not been allocated to the data collected, therefore this was completed during this analysis. In addition, where a single criterion was comprised of several different measures (eg the age structure assessment for *Calluna*) then a ‘fail’ in any one of the multiple measures gave an overall ‘fail’ to that criterion. For example, if the plot had passed in terms of pioneer, building and mature *Calluna* proportions, but had failed in terms of degenerate *Calluna* proportion, then the then the 'vegetation structure (*Calluna*)' attribute failed overall.

All quantitative data were provided in the form of Excel spreadsheets created from field data collected for each plot, except for the meteorological datasets that were obtained direct form the Meteorological Office web page (www.metoffice.com/climate/uk/averages) and Critical Loads Data obtained from CEH web page under licence agreement (www.critloads.ceh.ac.uk).

Standard statistical analyses were undertaken using *Systat 10.2* (Systat Software Inc., USA) and multivariate analyses were undertaken using *Canoco 4.5* (Microcomputer Power, USA). Where required, data were transformed for statistical analyses to achieve a normal distribution, and the transformations carried out are detailed in the analysis methodology. Statistical tests also allowed for missing data and/or tied ranks where appropriate.

## 2.5 Data analysis

### 2.5.1 Comparison of qualitative and quantitative condition assessment data

Those data collected under both the qualitative and quantitative methods were assessed to identify which criteria met the targets set under the standard Condition Assessment monitoring scheme. The assessment approach varied between the qualitative and quantitative methods, and is outlined below.

Analysis of the qualitative dataset was completed using the information on the standard Condition Assessment forms. Development of the assessment methodology was undertaken over several years and slightly different versions of the standard monitoring forms were used over this period. To accommodate this, the main attributes have been simplified in this assessment and are in line with more recent versions of the form, rather than the slightly more complex earlier versions. Each lowland heathland attribute was then assessed against those criteria identified on the assessment form, and the number of attributes that met the target for each criterion was calculated for each plot.

Analysis of the quantitative data was undertaken by assessing the whole plot assessment data or the quadrat-derived data for those same attributes against the same criteria. Where quadrat-derived data were used, an average value was calculated from the total number of quadrats for a plot (generally 30 quadrats), and this value was then used to assess if that attribute met the target. Again, the number of attributes that met the target was calculated for each plot.

In some cases the calculation of the average value of the attribute from the quantitative data was straight forward (eg extent of community or percent dwarf shrub cover), but in many cases the approach was less clear and required some assumptions to be made. For clarity, the approach taken to derive the 'pass' or 'fail' for each quantitative attribute assessed is presented below:

- **Extent of community** – extracted from whole plot assessment dataset.
- **Bare ground** – calculated from quadrat dataset. Average percent bare ground calculated, but could not be divided into 'undisturbed' and 'heavily disturbed' categories. Therefore assume an average of 1-10% bare ground represents a pass.

- **Vegetation structure: dwarf shrubs** – calculated from quadrat-derived average for 'dwarf shrub' cover, and whole plot assessment category of '*Ulex* spp.' for dry heath. For wet heath, data used were calculated from quadrat-derived averages for 'dwarf shrub' and '*Sphagnum*' cover.
- **Vegetation structure: *Calluna* age** – average percent cover of each *Calluna* age class calculated from quadrat-derived data, then 'building' and 'mature' classes combined to give an overall average percent cover. In addition, for wet heaths the average percent cover for *Molinia* and *Schoenus* were extracted from species quadrat data. The average value was calculated from the arcsine transformed data and back-transformed to give an average percent value.
- **Vegetation composition: dwarf shrubs/graminoids/forbs** – extracted from species quadrat dataset for each target species listed. The following conversion used to assess DAFOR: present in 1-5 quadrats = rare; 6-10 = occasional; 11-20 = frequent; 20-30 = abundant; dominant category not separated out.
- **Vegetation composition: bryophytes/lichens** – average percent cover of bryophytes and lichens calculated for dry heath, and average percent cover *Sphagnum* and lichens calculated for wet heath. All derived from quadrat-based data.
- **Vegetation composition: local/rare species** – data extracted from quadrat dataset for each species where possible.
- **Negative indicators: signs of disturbance** – averages calculated for percent erosion and percent grazing from quadrat-derived data. For burning, percent cover was not usually assessed (only Y/N), therefore it is assumed that burning present in 3 or fewer quadrats (ie maximum of 10% of all quadrats) is a pass. Information on drains, pollution and trampling extracted from plot scale data.
- **Negative indicators: species** – data extracted from plot scale datasets as follows; 'non-native shrub' = *Rhododendron* and exotic spp target, 'native shrub' = trees/scrub target, 'bracken' = *Pteridium* target and '*Ulex europaeus'* = gorse target. Acrocarpous mosses assessed by calculating frequency occurrence of acrocarpous mosses from quadrat-derived data, with records for 10 or fewer quadrats considered a pass.

Once the number of attributes meeting the required target was calculated from both qualitative and quantitative datasets these datasets were compared on a plot-by-plot basis. Particular attention was paid to the number of mandatory attributes that passed/failed the targets set, as a failure on any one of these attributes leads to the classification of the plot as 'unfavourable'. For lowland heathland Condition Assessment monitoring, 10 of the 11 attributes are considered to be mandatory.

Following this data comparison, the results were assessed in terms of the robustness of the standard qualitative assessment versus the more detailed quantitative approach, and some recommendations to clarify the qualitative assessment data collection were made. Where possible, additional information on the degree to which the attribute had failed was identified to highlight those areas where marginal differences between qualitative and quantitative assessments had led to overall differences in allocation of a 'pass' or 'fail' to attributes.

### 2.5.2 Assessment of botanical composition

Botanical composition was assessed using the Modular Analysis of Vegetation and Interpretation System (MAVIS) developed by CEH. This package incorporates analysis of datasets against standard classifications including the National Vegetation Classification (NVC) (Rodwell 1991), the Countryside Vegetation System (CVS) (Bunce and others 1999), Competitor – Stress tolerator – Ruderal (C-S-R) characterisation (Grime 1979, Grime, Hodgson and Hunt 1988) and Ellenberg values for individual species (Ellenberg 1974).

In this analysis, species data were used to calculate average C-S-R percentage score for each plot using MAVIS Plot Analyser Version 1.00 (available to download from the CEH web page at www.ceh.ac.uk). This analysis provides a score for each of the three primary plant strategies for each plot, based upon the proportion of each species attributable to different parts of the C-S-R model. These percent scores were then used to identify which primary plant strategy had the greatest similarity to the botanical composition of each plot.

In addition, Suited Species Scores (Critchley 2000) were used to assess differences between plots. The scores used were Grazing, Nutrient and Moisture Suited Species Scores available for each species present within each plot. The Suited Species Scores for plant species within this dataset were kindly provided by Nigel Critchley and John Fowbert at ADAS.

The Suited Species Scores used for each species are presented in Table 4. Those species positively suited to the attribute were assigned a score of 1. Those species negatively suited to the attribute were given a score of –1. Those with neither a positive nor negative suitability are given a score of zero. Those species with no available scores were removed from the analysis.

Analysis of Suited Species Scores followed the methods of Robertson, Bingham and Slater (2000). A Suited Species Index was calculated for each quadrat by summing all species in the quadrat with a score of 1 or –1 and dividing the result by the total number of species in the quadrat. The average index for each plot was then calculated from the individual quadrat indices. The indices and their interpretation are presented in Table 5. These average indices were then analysed using the Mann-Whitney *U*-test to compare favourable and unfavourable pairs of plots.

### 2.5.3 Assessment of environmental and structural variables

A range of variables relating to vegetation structure, environmental conditions and soils were measured. The majority of variables were measured within each quadrat yielding a set of data for each plot. Soil nutrient status, and aspect and slope measurements were, however, taken at the plot (rather than quadrat) level, therefore the analysis approach differed slightly.

For quadrat-based data, the variables for each pair of plots were analysed using a t-test to assess significant differences between the plots in respect of each variable measured. In all cases, proportional data were arcsine transformed and height data were square root transformed to meet requirements for normal distribution (Sokal and Rohlf 1995). Where transformations did not achieve normal distributions, or datasets were small, a Mann-Whitney *U*-test was undertaken in preference to a t-test.

Soil nutrient status data were collected at the plot scale with a single measurement of each soil chemical parameter taken from a bulked soil sample from within the plot. These data are discussed in general terms for each site, and also included in a regression analysis undertaken as part of the multivariate analysis (detailed below) to further elucidate any potential drivers of change in the vegetation.

Meteorological data and nitrogen critical loads data were available at the site scale only, are discussed briefly and also included in a regression analysis undertaken as part of the multivariate analysis (detailed below) to further elucidate any potential drivers of change in the vegetation.

### 2.5.4 Multivariate analyses

Differences in species composition between pairs of plots were explored using Detrended Correspondence Analysis (DCA). The abundance data (estimated percent cover) for all species were arcsine transformed prior to analysis, and pairs of plots were analysed using a standard run within the DCA programme options. In all DCA ordinations rare species were down-weighted to reduce their influence on the resulting ordination diagram.

Median axis 1 and axis 2 scores were calculated from the DCA results using the median of the scores for quadrats falling within any one plot or site. These medians were then assessed against soil data, weather and the critical loads data (available at the plot or site scale) to identify any linear correlations between these data. This analysis was undertaken using Spearman rank regression.

In addition, the relationships between species composition and environmental variables were explored further using Canonical Correspondence Analysis (CCA), in which the environmental variables can be directly correlated with the main axes of the ordination diagram.

Within the CCA ordination diagram interpreting the angle between two variables on the ordination diagram can also assess the correlations between different environmental variables. An acute angle suggests a positive relationship between the two variables, while an obtuse angle indicates a negative relationship. In addition, the length of the arrow on the ordination diagram indicates the importance of that environmental variable in the separation of species and quadrats along the axes (Jongman, Ter Braak and Van Tongeran 1995).

To add weight to this evaluation of the importance of each environmental variable in the ordination, the CCA can be used to identify those environmental variables that are statistically significant in determining the species/quadrat ordination. This is done using forward selection procedures, which calculate the effect of a single variable on the CCA. These effects are known as the marginal effects.

Following the identification of the marginal effects, the conditional effect of each environmental variable can be calculated by ranking the variables based on their marginal effects, and again employing forward selection procedures. The conditional effects indicate the proportion of the variation in these data that can be attributed to each variable in a cumulative way. The significance of each variable in explaining the variation in these data was tested using an unrestricted Monte Carlo permutation test (using 199 permutations within the null hypothesis). The sub-set of environmental variables that explains a statistically significant amount of variation within the ordination diagram can then be identified (Jongman, Ter Braak and Van Tongeran 1995).

As for DCA, the CCA was undertaken on pairs of plots at each dry, humid or wet heath site. A maximum of 35 environmental variables were used in the analysis, however not all variables were relevant to every pair of plots, leading to the omission of these from the analysis. The number of variables analysed, therefore, varied between datasets but is typically around 10 to 15. Again, down-weighting of rare species was used to reduce their influence on the ordination.

As a final analysis, the dry heath sites were analysed using both DCA and CCA techniques, as a group to identify any trends across all sites. The wet heath sites were also analysed in this way.

The value of undertaking both a DCA and a CCA approach is that the DCA, as an unconstrained analysis technique, allows the main part of the variability in species composition. The CCA, a constrained analysis, will better highlight that part of the variability in these data that is related to the measured environmental variables (Leps and Smilaller 2003).

These results are presented as tri-plot ordination diagrams. In order to clarify the presentation of results those environmental variables that had very short arrows (ie were not significantly influencing the ordination diagram) were occasionally omitted from the figure. In both the CCA tri-plot and the DCA bi-plot ordinations, any species or samples that appeared at the edges of the ordination were not presented in the figure, again to enhance data presentation.

# 3 Results

## 3.1 Comparison of qualitative and quantitative vegetation condition data

The results of the comparisons of quantitative and qualitative approaches to assessing vegetation condition of each plot are presented in Table 6, with each site presented in a separate table (6a to 6n). Ten mandatory attributes were assessed, with only one non-mandatory attribute included (and the information for this attribute was not collected on most sites during the quantitative assessments and is therefore not assessed in any detail).

Cannock Chase, Roydon Common, Aylesbeare Common* wet heath, New Forest dry heath and New Forest wet heath all had different results in terms of numbers of mandatory passes for both favourable and unfavourable plots. Only Aylesbeare dry heath and Lazonby Fell had the same number of passes for both favourable and unfavourable plots. Cavenham Heath, The Lizard and Hartland Moor wet heath all showed differences between the unfavourable plots only, while Thursley and Hartland Moor dry heath showed differences in the favourable plots only.

In total, therefore, 10 out of 28 plots assessed (36%) had the same number of mandatory passes when comparing qualitative and quantitative passes. There were no obvious trends in terms of whether dry heaths or wet heaths, or whether favourable or unfavourable plots tended toward similar results. However, assessing the results in terms of individual attributes gave a more complete picture of where the differences were to be found in terms of qualitative and quantitative data.

In terms of the attributes themselves, the cover of bare ground was found to result in a ‘pass’ more often when using the qualitative assessments, with eight plots (29%) showing an incorrect ‘pass’ using this method. Interestingly, many ‘fails’ on the quantitative assessment data were the result of no (or <1%) bare ground being present, as the target is 1% to 10%. Only on rare occasions did the plot fail due to excessive bare ground cover (>10%).

For vegetation structure attributes, dwarf shrub cover was fairly consistently recorded between qualitative and quantitative methodologies. The qualitative assessment under-estimated the cover in only four plots (14%) resulting in additional plots being recorded as a 'fail' for this attribute. Only two plots (7%), Aylesbeare dry heath unfavourable and Thursley dry heath favourable, showed an erroneous 'pass' when quantitative data gave a 'fail'. *Calluna* age was fairly consistently recorded, with only six plots resulting in differences between methods. Where discrepancies did occur, the qualitative assessment was more likely to result in an overall 'fail'.

Generally, vegetation composition in terms of dwarf shrubs was consistently recorded between methodologies. The cover and variety of dwarf shrubs appeared to be a readily recorded attribute under the qualitative method. Measures of vegetation composition in relation to graminoids and forbs were also consistent in their assessments for individual plots. Only Cannock Chase dry heath (both favourable and unfavourable plots) was allocated a 'pass' for graminoid cover when using the qualitative data and a 'fail' using quantitative data. In terms of forbs, Cannock Chase dry heath (unfavourable plot) and the two plots on Cavenham Heath dry heath were also given an erroneous 'pass' using the qualitative method. In these cases, the qualitative data appeared to over-estimate the number of 'occasional' or 'frequent' species for both graminoids and forbs in the dry heath vegetation. In terms of evaluating lower plants, the methods yielded consistent results with only four plots differing in their allocation of 'pass' or 'fail'.

Indicators of negative factors (the presence of negative indicator species and factors relating to disturbance) were occasionally different between methods, particularly with the measure of negative indicator species, which tended to result in more passes using the qualitative approach. This discrepancy was observed in twelve plots (43%) while differences in assessments of disturbance were only observed in four plots. This suggests that disturbance factors were relatively easily assessed using the rapid qualitative method, but that this method was likely to under-record negative indicator species.

* Results for Aylesbere Common should be treated with caution due to small sample sizes.

## 3.2 Assessment of botanical condition

The assessment of botanical composition included an analysis of the C-S-R percentage scores derived from the MAVIS analysis and the Suited Species Scores for Acid, Grazing, Nutrient and Moisture. The results of each analysis approach are presented below.

### 3.2.1 Analysis using the Competitor – Stress tolerator – Ruderal (C-S-R) Model

The average percentage scores for each plot in terms of the occurrence of species with each of the primary plant strategies (Competitor, Stress-tolerator or Ruderal) are presented in Table 7. The majority of plots clearly show higher values (values between 3.00 and 4.08) for the Stress-tolerator primary plant strategy, indicating a greater number of species exhibiting this strategy are present in the vegetation. This reflects the typically nutrient poor and relatively acidic nature of lowland heathland habitats, with species adapted to these conditions.

In general, the Ruderal plant strategy shows the lowest values (typically values below 2.00) indicating this habitat is relatively unsuitable for species that require constant disturbance in order to take advantage of colonisations gaps.

The Competitor species scores vary greatly between plots (values between 1.75 and 3.40) but never attaining the higher values as found for the Stress-tolerator strategy. However, in some plots this Competitor plant strategy is obviously an important part of the current vegetation composition, namely Cannock Chase and Hartland Moor favourable plots. In these dry heath plots the analysis results in equal values of 3.00 for both Stress-tolerator and Competitor strategies. The results appear to reflect the frequency of *Pteridium aquilinum* in the dataset whose established life strategy is a Competitor and is also able to tolerate acid soil conditions (Grime, Hodgson and Hunt 1988).

At one site only, the Competitor value exceeds the Stress-tolerator value. This is for the Lazonby Fell unfavourable plot, also a dry heathland type. This plot has both *Pteridium aquilinum* and *Betula pendula*, the latter species having an established strategy is intermediate between Competitor and Stress-tolerator – Competitor and is also frequently associated with acid soils (Grime, Hodgson and Hunt 1988). Both these species are likely to influence the high value for the Competitor life strategy for this plot.

It is important to note that several species or groups of species were not included in the analyses as no data on their life strategy is available. These included *Vaccinium x intermedium*, *Ulex* spp., *Pinus* spp. and *Betula* spp. (where these are not given a species name) and several mosses, liverworts and lichens including *Sphagnum* and *Cladonia*.

### 3.2.2 Analysis using Suited Species Scores

The results of the Suited Species Scores analysis for each favourable of unfavourable lowland heathland plot are presented in Table 8. In each case a negative number indicates a greater number of plant species with a negative association with acidity, grazing, nutrients or moisture. In contrast, a positive number indicates a greater number of species with a positive association with these environmental factors. This is further detailed in Table 5.

The acidity Suited Species Score is a positive value for each plot reflecting the typically acidic nature of lowland heathland soils, and ranges from 0.9 (The Lizard, dry heath, favourable plot) to 6.1 (Thursley, wet heath, favourable plot). The majority of sites fall within the range of 3.0 to 4.0 irrespective of their vegetation condition. However, on a pair-by-pair basis, six areas have significantly different acidity scores, as shown by the Mann-Whitney *U*-test results (Table 9), and five of these sites show a significantly greater acidity score associated with the favourable plot. Only at the New Forest dry heathland site did the unfavourable plot score a significantly greater acidity value.

The Suited Species Score Index for grazing showed statistically significant differences between favourable and unfavourable plots for nine of the sites. However, there was no obvious trend in terms of vegetation condition, with five areas showing the unfavourable plots, and four areas showing the favourable plots to be associated with relatively more species tolerant of grazing. However, all grazing indices were either slightly negative or zero.

The values calculated for nutrient and moisture Suited Species Score Indices showed similar trends. In both cases there were a greater number of unfavourable plots associated with higher (ie positive or lower negative) values for nutrient and grazing suited species. This indicates that these unfavourable plots contain more species tolerant of higher nutrient concentrations and/or drier conditions. In many cases the plot is associated with both these factors.

## 3.3 Assessment of environmental and structural variables

Environmental and structural variables were collected at either the quadrat scale or at the plot scale. Quadrat scale variables were assessed using standard statistical analyses (two-sample t-tests or Mann-Whitney *U*-test depending on data type) to identify statistically significant differences between favourable and unfavourable plots from the same heathland area. For many of the variables there were insufficient data to undertake an analysis and this is indicated in the appropriate table. Plot scale variables are assessed briefly in this section, but are included in the multivariate analyses presented late in this report.

### 3.3.1 Quadrat scale variables

For each heathland area a total of 24 variables were assessed using t-tests, although there was typically only sufficient data to complete a successful analysis on up to 15 variables. A further 11 variables were assessed using Mann-Whitney *U*-tests. A summary of the results is presented in Tables 10 and 11. Full analysis results are presented in Appendix I (t-test results) and Appendix II (Mann-Whitney *U*-test results).

Vegetation height was often found to be significantly different between favourable and unfavourable plots, with 64% of paired plots (nine pairs from a total of 14) showing differences (Tables 10 and 11). However, the trend in terms of which plot had the taller vegetation was not consistent across the sites. Five plots had significantly taller vegetation in the favourable plot, while four plots had significantly taller vegetation in the unfavourable plot. This appeared to relate to the proportions of mature and building *Calluna*. Plots with more mature *Calluna* tended to have taller vegetation height, while those with a greater proportion of building *Calluna* tended to have shorter vegetation heights irrespective of plot vegetation condition. Analysis using correlation coefficients indicated that there was a significant negative correlation between vegetation height and building heather ($p = <0.05$), and a trend toward a positive relationship between vegetation height and mature *Calluna* cover although this was not statistically significant ($p = >0.05$).

The cover of dwarf shrub was found to exhibit a more consistent trend. Nine of the 14 plots (64%) showed significant differences in dwarf shrub cover, and all these had significantly more dwarf shrub cover in the favourable plot than in the unfavourable plot (Table 11). The standard deviation around the mean values were, however, large indicating that the data were highly variable.

The proportion of flowering on *Calluna* was also often found to be significantly different between favourable and unfavourable plots, with six of the 14 plots showing differences (Table 10). As with vegetation height, the trend as to which plot had the greater proportion of flowering *Calluna* was not consistent, with four sites showing a greater proportion of flowering on the favourable plots and two showing this on the unfavourable plot. The proportion of flowering did not appear to be related to age of *Calluna* or height of vegetation.

Cover of bryophytes, lichens and *Sphagnum* showed some significant differences between plots (Table 10), and all variables showed greater cover in the favourable plot where the difference was significant. *Sphagnum* cover was significantly greater in the favourable plot at Aylesbeare (wet heath), bryophyte cover was greater in the favourable plots at both Cannock Chase (dry heath) and Thursley (dry heath), and lichen cover was greater in the wet heath favourable plot at the New Forest.

Litter cover was also significantly different in five plots (36%), with the greater cover found in either favourable or unfavourable plots. However, it is noticeable that where litter cover is much greater in one plot compared to another, the large percent litter cover is consistently found within the unfavourable plot. This is seen at Roydon Common (wet heath), Thursley (dry heath) and Hartland Moor (wet heath) (Table 10).

### 3.3.2 Plot scale variables

#### 3.3.2.1 Soil data

Soil data collected for each plot are presented in Table 12. Measures of pH were similar across the majority of sites, being in the range 3.5 to 4.3 indicating an acidic environment as expected from heathland soils. The Lizard had the highest pH values, being above pH5 and many of the other chemical parameters were also greatest at this site.

Concentrations of Na, Ca and Mg at The Lizard are all substantially greater than on the other sites, and Mg concentrations in particular are extremely high. This is likely to relate to the underlying geology of the area that contains serpentine (a rock considered to be the metamorphosed remains of magnesium-rich igneous rock, most commonly peridotite, from the earth’s mantle). These high concentrations of cations account for the high CEC of this site.

Some of the lowest concentrations of Na and Mg occur at Cavenham Heath, and while Ca is also relatively low at Cavenham Heath it is at its lowest at Thursley. The sites have similarly low CEC.

In terms of nutrients, total N is significantly greater at The Lizard while extractable-P is greatest at Cavenham Heath. It is difficult from the information obtained to identify a potential cause of these high nutrient concentrations. However, one likely cause is nutrient inputs from external diffuse pollution sources such as agricultural practices. K is variable across sites with no one particular site having greater concentrations.

The Fe, Al and Mn concentrations are also variable across the sites showing no obvious pattern. These changes are likely to be linked to local variation in geology and soils. In particular all these ions become more mobile at high pH values and in some cases (especially on acid sandy soils) these mobile ions might be susceptible to loss through leeching.

#### 3.3.2.2 Aspect and slope

Slope and aspect as measured at each plot is presented in Table 13. The majority of plots are found on more or less level ground with the exception of Cannock Chase dry heath (favourable) plot, Aylesbeare dry heath (favourable) plot and Thursley dry heath (favourable) plot. It is perhaps not surprising that no wet heath plots occur on significantly sloping ground.

Aspect appears quite variable across the plots, however, there are far fewer plots occurring on southerly, south-easterly, south-westerly and westerly aspects (only one plot per aspect). Four to five plots occur on each of the north, east and north-east facing slopes. The majority of plots (eight) are found on north-westerly slopes. This suggests that cooler north-facing slopes appear to be preferential for heathland development, and although north-westerly facing slopes are the most frequent aspect (cool and wet) the westerly aspect (wetness) appears to not be as important as the northerly aspect (coolness). This might reflect the fact that the heathlands typically occur in areas of relatively high rainfall, and therefore the aspect does not significantly affect rainfall inputs as much as it might do in areas of lower rainfall.

#### 3.3.2.3 Climate

Climate data (long-term averages from 1971 to 2000) were collated from the Meteorological Office data available from the web page, using the nearest Meteorological Station to the site (as indicated in Table 3). These data are presented in Figure 10 and are used to identify any seasonal trends (in terms of the average monthly values) and to illustrate any similarities or differences between stations. Each lowland heath site has a unique Meteorological Station office except for the New Forest and Hartland Moor that are both nearest to Everton station.

Seasonal trends in maximum and minimum temperatures are very similar across all sites, however there is a 2°C to 4°C difference between highest and lowest average values for any one month. In general, maximum temperatures at Lazonby Fell are lowest (Figure 10a), while Thursley have some of the highest maximum temperatures particularly in the summer months. The Lizard shows less seasonal variation than the other sites, with warmer winter and cooler summer averages for maximum temperature. For average minimum temperatures The Lizard and Aylesbeare Heath show the highest minimum temperatures, with temperatures rarely dropping below 4°C (Figure 10b). Lazonby Fell exhibits the coldest temperatures of between 0°C and 2°C from December to February, consistent with its more northerly location and higher altitude.

The number of days of air frost reflect these differences, with the greater number of days been seen in the winter months at Lazonby Fell, and the least at The Lizard and Aylesbeare Heath (Figure 10c). No sites showed air frosts in June, July or August, but all sites except The Lizard and Aylesbeare Heath could be subject to frosts outside of these summer months. The recorded hours of sunshine are more or less the inverse of the number of days of air frost (Figure 10d) with the more northerly sites (Lazonby Fell and Cannock Chase) having the least hours of sunshine.

Measurements of rainfall and number of days of rainfall (Figures 10e and 10f) indicate the wettest sites are those on the more westerly side of the country (The Lizard and Lazonby Fell). Those sites on the eastern side have the lower rainfall data (Cavenham Heath, Roydon Common and Thursley).

#### 3.3.2.4 Aerial pollution inputs

Table 14 presents the data for the dwarf shrub heath critical loads for each site as obtained from the CEH web page (under licence). Interpretation of these data has followed guidance set out in reports prepared by the UK National Focal Centre (2003, 2004a,b). The aerial pollutants sulphur dioxide, nitrogen oxides and ammonia can contribute to the acidification of habitats, while nitrogen oxides and ammonia also contribute to eutrophication. These three aerial pollutants can therefore adversely affect semi-natural habitats and research has enabled critical loads to be set for these pollutants. The critical load is defined as ‘a quantitative estimate of the exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to our present knowledge’ (Nilsson and Grennfelt 1988, in UK National Focal Centre 2004a). In general terms, the lower the critical loads value is the greater the vulnerability of that habitat or area to the effects of pollution inputs.

Data was only available at the site level, and not the plot level, as data resolution is at 1km grid-square and the majority of plots occur within the same grid-square. However, some comment can be made on each site’s sensitivity to nutrient and acidity aerial pollution inputs.

In terms of nutrient nitrogen critical loads, Cannock Chase, The Lizard, Thursley and Lazonby Fell all occur in grid squares with lower critical load values indicating they are vulnerable to aerial pollution inputs from nitrogen oxides and ammonia. No data are available for the grid square relating to Cavenham Heath.

In terms of critical loads for acidity of soils, Cannock Chase, Roydon Common, Thursley, Lazonby Fell, New Forest and Hartland Moor are all at very low values of 0.1 keq/ha/yr. Aylesbeare Common and The Lizard have slightly higher values of 1.5 keq/ha/yr, while Cavenham Heath has the highest value of 4.0 keq/ha/yr which is at the maximum end of the scale of critical loads for acidity in UK soils.

The latest calculations from the UK National Focal Centre (2004b) indicate that for soil acidity 92.4% of dwarf shrub heath habitats (by area) in England exceed the acidity critical load, while in terms of nutrient nitrogen 93.7% of heathland habitats (by area) exceed the nitrogen critical loads. This highlights the overall vulnerability of heathland habitats to acidity and nutrient aerial pollution. In terms of the sites within this study, the more vulnerable sites are identified as those that have the lower critical load values for both nitrogen and acidity, ie those sites where the critical level would be exceeded more easily. These comprise Cannock Chase, Thursley and Lazonby Fell (Table 14). However, the critical loads data do not give any indication of existing nutrient pollution from other sources, and in particular The Lizard and Cavenham Heath appear to be at risk from nitrate and phosphate inputs, respectively, as indicated from soil analysis data (see above).

## 3.4 Analysis of individual sites using multivariate analyses

### 3.4.1 Detrended Correspondence Analysis (DCA)

The DCA results for each pair of plots are presented in Table 15 and the ordination diagrams are presented in Figures 11 to 24. The results indicate that the plots were separated out to some extent by the ordination, as indicated by the Eigenvalues. The majority of the data separation was related to the first two axes of the diagram, with these axes accounting for between approximately 30% and 66% of the variation in the dataset.

Some general trends can be drawn from these analyses. Those quadrats belonging to the favourable plot were generally found toward the left side of the ordination while those belonging to the unfavourable plot were located to the right side for many pairs of plots. The distribution of species along axis one and axis two could be related to this separation. Species associated more strongly with the favourable quadrats included the dwarf shrubs, *Sphagnum*, sedges and also species such as *Eriophorum* and *Trichophorum*. *Molinia* was also often associated with these quadrats indicating its prevalence in many of the sites. Those species more strongly associated with the unfavourable plots include grasses, bracken, shrub and tree species, rushes and bramble. The hypnaceous mosses, acrocarpous mosses and lichens appeared to vary in their location depending on the site rather than the plot. Those species that were rare within the dataset were typically found toward the edge of the ordination diagram. This included, for example, *Senecio jacobaea*, *Quercus petraea*, *Cladonia portentosa* and *Narthecium ossifragum*.

Although many pairs of plots showed fairly discrete clusters of favourable or unfavourable quadrats, several sites showed considerable overlap between the quadrats. Thursley dry heath, New Forest wet heath and Hartland Moor dry heath all had a number of unfavourable plot quadrats that occurred to the left side of the ordination and appeared to be more similar in species composition the favourable plot quadrats.

In terms of differences between wet and dry heathlands, there is in general a similar separation of the favourable and unfavourable quadrats in relation to species distributions on both heathland types. The trends follow those general trends described above. Differences appear to relate to site specific changes rather than wet or dry heath type.

### 3.4.2 Canonical Correspondence Analysis (CCA)

#### 3.4.2.1 General observations

Overall, the CCA of the pairs of favourable and unfavourable plots separated out the species and quadrats more effectively than the DCA, with less overlap between quadrats from different plots. An assessment of the Eigenvalues (Table 16) shows typically higher values than for the DCA, in particular in relation to the first and second axes of the ordination. This indicates that these two axes are the most effective at separating out the species and environment data than the third and fourth axes.

The cumulative percent variance of the species-environment relations (Table 16) gives an indication of the variance explained by each successive axis in the ordination diagram. The first two axes of the tri-plot generally account for the larger proportion of the variance in the species in relation to the environmental variables, being greater than 50% for all analyses, and often up to 80% or 90%. The remaining portion of the variance is largely explained by the third and fourth axes, although in some ordinations 10% to 20% of the variation remains unexplained by the analysis.

The effectiveness of the environmental variables in separating out the favourable and unfavourable plots is assessed in detail below for both the dry heaths and wet heaths. The resulting ordination diagrams are presented in Figures 25 to 38.

#### 3.4.2.2 Dry heath sites

Vegetation height shows a significant effect in separating out quadrats at four of the dry heath sites. Taller vegetation is associated with unfavourable plots, although in some of those sites where this variable is not statistically significant, there is an indication of increased vegetation height in the favourable plot.

Dwarf shrub cover is a consistently significant variable at all dry heath sites except for Lazonby Fell (Figure 30). An increase in dwarf shrub cover is clearly associated with the favourable plots even on the site where the data are not statistically significant. Graminoid cover shows a less strong effect, however, being significantly related to unfavourable plots at Hartland Moor (Figure 32). No other site shows a significant effect for graminoid cover. Increased litter cover is also associated with unfavourable plots but again this variable is only significant at Hartland Moor and Thursley (Figure 36).

In terms of *Calluna* age and condition, increases in the proportions of building and mature *Calluna* both show a trend toward being associated with favourable plots, but this is only significant at The Lizard (building phase) (Figure 28), Thursley and Lazonby Fell (mature phase). Thursley, Lazonby Fell and also Hartland Moor all show increased *Calluna* flowering on their favourable plots.

Increased bryophyte cover is a significant distinguishing variable at six of the eight dry heaths, being largely associated with favourable plots, but not always. This might relate to an underlying wet to dry gradient within the plot, as this variable is often associated with axis two of the ordination. Increased acrocarpous moss cover is associated with the unfavourable plot at Cavenham Heath (Figure 26) but the trend at Thursley where, it is also significant, is not as clear.

No other environmental variables are significant in separating out quadrats and species along the ordination plots.

#### 3.4.2.3 Wet heath sites

Vegetation height has a significant effect in the ordination results in four of the wet heath sites, and in all cases an increase in height is associated with the unfavourable plot. The sites are Hartland Moor (Figure 38), The Lizard (Figure 35), Aylesbeare Heath (Figure 34) and Roydon Common (Figure 33).

Dwarf shrub cover is again a consistently significant variable for all six wet heath sites and is associated with the favourable plots at all sites except for the Lizard. Graminoid cover is significant only in the Aylesbeare Common analysis, being associated with the unfavourable plots. Increased litter cover is also associated with unfavourable plots, being a significant variable at Aylesbeare Common, Thursley (Figure 36) and Roydon Common. Conversely, bare ground shows no trend in terms of vegetation condition, but is a significant variable at the New Forest (Figure 37), The Lizard and also Roydon Common.

Increased bryophyte cover is an important distinguishing variable at Hartland and Thursley, while increased *Sphagnum* cover is important at the New Forest and Aylesbeare Common plots. Bryophyte cover shows no clear trend in the dataset in terms of associations with vegetation condition, while *Sphagnum* is more clearly associated with the favourable plots. Acrocarpous mosses show a significant effect at Roydon Common only, where an increase is associated with the unfavourable plot.

Few other variables showed significant effects on the analysis results, or indicated trends in terms of favourable or unfavourable plot condition.

### 3.4.3 Regression analyses of soil, climate and aerial pollution data with median DCA axis scores

In terms of soil analyses, no significant linear correlations were found with the median DCA axis scores for either axis 1 or axis 2 (Table 17). Using a 2-tailed test at the 95% significance level, the Spearman rank correlation coefficient had to achieve a critical value of 0.375 or above (ignoring the minus sign) to be classed as significant (N = 28). Most correlation values were well below this critical value.

Climate parameters and aerial pollution data also showed no significant correlations with either axis 1 or axis 2 of the DCA (Table 17). No correlation coefficient achieved the critical value of 0.560 or above for a 2-tailed test at the 95% significance level (N = 13).

## 3.5 Combined analysis of wet and dry heathland sites using multivariate analysis

### 3.5.1 Combined sites DCA

#### 3.5.1.1 Dry heath sites

The DCA results for the dry heathland sites are summarised in Table 18 and the ordination diagram is presented in Figure 39. The results indicate that axis 1 and axis 2 the combined analysis of all dry heathland sites account for a total of 18.6% of the variance in the dataset. This is lower than the results for the analysis on a site by site basis, where the first two axes accounted for between 30% and 66% of the variation in these data. On the ordination diagram axis one is difficult to determine but appears to be related to geographical location, with the southwest sites (The Lizard, Aylesbeare Heath and Hartland Moor) all found to the right side of the plot, and the more northerly sites (Cannock Chase and Lazonby Fell) occurring to the left of the ordination. Axis two appears to relate to increasing occurrence of graminoid species and reduced numbers of dwarf shrub species.

The separation of quadrats on the ordination plot indicates that the favourable and unfavourable plots of one site tend to be more similar to each other than the favourable plots of different sites (or the unfavourable plots of different sites). Therefore the sites tend to have a wide range of heathland vegetation types and are relatively dissimilar, and the separation of quadrats appears to relate more strongly to the site than the plot type.

#### 3.5.1.2 Wet heath sites

The DCA ordination of all the wet heath sites (Figure 40) shows a greater proportion of the variation in this dataset was explained by axis one and axis two, a total of 25% (Table 18). This is still somewhat lower than the results for the analysis on a site by site basis, where the first two axes accounted for between 30% and 66% of the variation in these data. Axis one separates the quadrats along a wetter to drier gradient, with *Sphagnum* species being found toward the left of the diagram along with higher plant species more typical of wetter areas (eg *Eriophorum angustifolium, Narthecium ossifragum* and *Rhynchospora alba*). This also appears to reflect an ombrotrophic to minerotropic gradient, with species typical of bog habitats occurring more frequently in those quadrats on the left of the ordination diagram. Axis two is less easy to discern and no definite environmental gradient could be identified. The separation of The Lizard (serpentine geology) and Aylesbeare Heath (East Devon

Pebblebeds sandstone) suggests that underlying geology and soil type might influence the separation of quadrats along this axis of the ordination plot.

As with the dry heath DCA, the wet heath DCA indicates that the difference between sites is typically greater than the difference between favourable and unfavourable plots on any one site. However, the two southwest sites, The Lizard and Aylesbeare Heath, occur away from the main samples cluster and this suggests these areas have unusual species compliments in comparison to the other wet heath plots.

### 3.5.2 Combined sites CCA

#### 3.5.2.1 Dry heath sites

The combined analysis of all dry heathland plots resulted in the first two axes of the ordination plot accounting for 44% of the variation in the dataset (Table 18). This is slightly lower than the ordination results for individual sites, which tended to be above 50%.

The analysis indicated that the proportion of flowering on dwarf shrubs, the degree of rabbit grazing and the proportion of normal growth forms for dwarf shrubs where all important in separating out the quadrats within the ordination plot (Figure 41). In particular, the unfavourable plot at Cavenham Heath appeared to be strongly associated with increasing rabbit activity. Other significant variables were the proportion of degenerate and dead *Calluna*, the amount of dead wood and the occurrence of bryophytes. All these variables were positively associated with the unfavourable plot at Lazonby Fell and to a lesser degree with the unfavourable plot at Cannock Chase. As for the DCA, The Lizard samples were separated out from the main dry heath quadrats indicating their unusual species compliment. However, the Aylesbeare Heath quadrats were less distinct although some did occur mixed in with The Lizard suggesting at least some samples showed a similarity. The Lizard quadrats appeared to be negatively associated with many of the measured environmental variables except the proportion of litter and vegetation height.

Forward selection procedures combined with the Monte Carlo permutation analysis identified a total of 16 environmental variables that were significant in separating the quadrats. These are all shown on Figure 41 and summarised in Table 19. All other environmental variables did not have a significant effect on the ordination.

#### 3.5.2.2 Wet heath sites

The combined analysis of the wet heath plots using CCA resulted in 51.1% of the variation in the species being explained by the first two axes of the ordination diagram (Table 18). This is a similar proportion as resulted from the analysis on a site by site basis.

The ordination diagram (Figure 42) indicates that, as with the DCA of the wet heath plots, those quadrats associated with The Lizard and Aylesbeare Heath are separated out from the majority of the other wet heath sites. The Lizard is strongly positively correlated to the proportion of dead grass, while Aylesbeare Heath (and the unfavourable plot in particular) is positively correlated to vegetation height. There is also some indication that the Thursley favourable plot is correlated to increasing dwarf shrub cover, although this association is less clear. The remaining plots appear clustered together around the centre of the ordination diagram.

The analysis using forward selection identified a total of 16 environmental variables that had a significant effect on the ordination of the wet heath sites. These are included in the ordination diagram and presented in Table 19. Many, but not all of the variables were significant factors in both the wet and dry heath CCA. These predominantly include vegetation characteristics such as vegetation height, dwarf shrub cover, bryophyte cover, graminoid cover, litter cover and many of the characteristics relating to dwarf shrubs. *Sphagnum* cover is an important variable in the wet heath plots only, as might be expected. Rabbit grazing has an effect on both wet and dry heaths, but its significance is greater on the dry heath plots.

# 4 Conclusions

Nine lowland heathland sites within England were selected for the monitoring of dry and wet heathland vegetation types. These were Cannock Chase SSSI (Staffs), Cavenham Heath NNR (Suffolk), Roydon Common NNR (Norfolk), Aylesbeare Heath SSSI (Devon), The Lizard NNR (Cornwall), Thursley NNR (Surrey), Lazonby Fell SSSI (Cumbria), the New Forest SSSI (Hamps) and Hartland Moor NNR & Wytch Heath SSSI (Dorset).

On these sites areas of dry and wet heath vegetation were selected and a series of permanent plots established. Plots within a vegetation type were paired to provide one favourable and one unfavourable plot, following the terms of English Nature's Vegetation Condition Assessment Monitoring methodology. (Although in strict terms, both plots might be considered unfavourable on some sites but with one plot being regarded as relatively favourable for the purposes of this assessment).

Datasets collected for each area included the standard Condition Assessment field survey form for either dry or wet heath vegetation, quadrat-based data on composition and cover, and a range of measured variables also at the quadrat scale (eg vegetation height, litter cover, bryophyte cover). In addition, a range of variables were assessed at the plot scale (eg soil chemistry, slope, aspect, climate, aerial pollution).

Analyses of these data took four approaches: comparison of qualitative and quantitative datasets; assessment of botanical communities using C-S-R strategies and Suited Species Scores for acidity, moisture, grazing and nutrients; assessment of the significance of measured variables in differentiating favourable and unfavourable plots; multivariate analysis of vegetation community data.

The comparison of qualitative and quantitative methodologies indicated that in general the rapid (qualitative) assessment approach yielded similar results to the detailed quadrat-based (quantitative) approach. Many of the variables could be relatively accurately assessed using the rapid assessment approach, making this type of assessment a cost-effective and relatively robust way to assess vegetation condition. However, two main issues arose from this analysis. The rapid assessment tended to under-estimate the number and abundance of negative indicator species, suggesting these species might be more difficult to detect, possibly due to the dwarf shrub canopy. In addition, the rapid assessment method appeared to over-record the abundance of desirable grass species. This has been recorded before in similar, upland habitats, where oblique viewing of graminoids during the rapid assessment appeared to be the problem (Bealey and Cox 2004).

The C-S-R model provided a relatively poor approach to analysing the botanical data, with some species being absent from the model and therefore not accounted for in the resulting analysis. In general, however, the vegetation communities showed the greatest affinity to the Stress-tolerator strategy (up to a 4% fit to this strategy) while there were much lower values in relation to Competitor or Ruderal strategies. This is in line with both the autecological accounts of heathland species (Ritchie 1956, Gimingham 1960, Bannister 1965, 1966) and the knowledge that heathland habitats are typically nutrient limited systems (Heil and Bruggink 1987, Hayati and Proctor 1991) although the relationships between nutrient availability and plant uptake/growth response can be complex (Hayati and Proctor 1990).

Suited Species Scores assessments of botanical composition indicated that the majority of plots had plant species that were tolerant of (ie 'suited to') acidic conditions, but intolerant of high nutrient concentrations. This again confers with accepted theories on heathland systems being low pH and low nutrient systems. The associations with moisture were, however, more variable with no clear trends. In terms of favourable and unfavourable condition, the unfavourable plots were typically associated with relatively less acid, more nutrient enriched and slightly drier areas. This suggests the unfavourable plots had a greater occurrence of species that are not typical of heathland habitats.

The assessment of vegetation and environment variables identified which variables were significantly different between pairs of favourable and unfavourable plots on a site. Some variables such as vegetation height and proportion of flowering *Calluna* showed significant differences between plots but with no consistent trends in terms of vegetation condition. This suggests that differences between sites was a more significant factor in the development of vegetation communities that the difference within sites (ie between plots). The cover of *Calluna* did show a clear trend, with consistently greater cover on favourable vegetation plots. It is interesting to speculate whether a relatively closed canopy of *Calluna* might allow a range of other species indicative of a favourable heath to be retained on a site, perhaps through altered grazing regimes or changes in micro-climate. Published literature is unclear on the effects of a closed *Calluna* canopy over the long term. Studies indicate that some species of dwarf shrub (eg *Erica tetralix*) and grasses (eg *Festuca* and *Agrostis*) are less tolerant of shading and might be lost under a dense canopy, while others (eg *Vaccinium* species and *Erica cinerea*) are more tolerant (Grime and others 1988, Alonso and Hartley 1998). Bryophyte, *Sphagnum* and lichen cover was associated with favourable plots on some sites, but not on others.

Increased litter cover was generally associated with unfavourable plots although the association was not strong. Increased litter development is likely to limit the availability of recruitment gaps in the sward, resulting in those species that are able to expand through vegetative growth becoming more dominant within the community. Conversely those species that rely more heavily on seedling establishment, or are slower at vegetative expansion, might decline over time. The outcome of a lack of regeneration gaps will to a large degree depend on the vegetation composition in the surrounding area, and this might explain the relatively weak association between litter and unfavourable condition. If the vegetation is dominated by *Molinia* and the litter being built up is largely derived from this species, then the dense thatch that develops in unlikely to provide opportunities for dwarf shrub or herb species to colonise. Thus the site retains its unfavourable nature. However, a litter layer derived from *Calluna* plants (a 'mor humus' as defined by Watt 1955) might provide a suitable environment for *Calluna* layering (Gimingham 1995) where *Calluna* bushes form adventitious roots on those stems close to the ground. This allows continual vegetative regeneration of *Calluna* bushes. In all cases, the lack of colonisation gaps can reduce tree and scrub invasion (Legg 1995).

In terms of variables measured at the plot scale, some general comments can be made. Soil chemistry indicated a typically acidic, low nutrient environment and where similar across sites except for The Lizard which exhibited a soil chemistry that reflected the unusual geology in this area. Nitrogen was greatest at The Lizard and phosphate greatest at Cavenham Heath suggesting these sites might be subject to some nutrient enrichment. Slope did not vary greatly with the majority of sites being located on more or less flat ground. Aspect was more variable, the most common aspect being north-west suggesting some preference for cool wetter conditions (although local topography is likely to vary greatly and result in many subtle changes in aspect).

Climate information reflected the general trends typical of the UK, with the more westerly sites receiving greatest rainfall and the more southerly sites having more sunshine and fewer frost days. In terms of aerial pollution, those sites with lower calculated critical values for both nitrogen and acidity (and therefore more vulnerable to pollution inputs) are Cannock Chase, Thursley and Lazonby Fell. All sites had low critical values for nitrogen indicating they are all vulnerable to nitrogen oxide and ammonia aerial pollution inputs. However, the UK National Focal Centre (2004b) has estimated that the majority (>90%) of the remaining dwarf shrub heathland in England exceed their critical loads for both nitrogen and acidity.

The assessment using multivariate analysis techniques evaluated four main types of possible variation in the dataset. The DCA on a site by site basis identified the main variation in the species composition within a site (ie between each pair of favourable and unfavourable plots). The CCA on a site by site basis identified the main environmental variation between pairs of plots. However, the combined analysis was used largely to draw out differences between sites either in terms of species composition (DCA approach) or environmental variation (CCA approach). The assessment of data using multivariate analysis techniques (in particular, the CCA approach) aimed to identify possible indicators of change in vegetation condition on these lowland heaths that would most assist monitoring of favourable condition.

The DCA approach on a site by site basis resulted in a good separation of favourable and unfavourable plots along the first two axes of the ordination, and these axes accounted for between 30% and 66% of the variation in the samples. As might be expected, quadrats from the favourable plots were more strongly associated with dwarf shrub species, *Sphagnum, Carex, Eriophorum* and *Trichophorum* species. Unfavourable plots were more strongly associated with grasses, bracken, shrubs, trees and bramble, indicating heathland vegetation types that were modified in some way either through scrub, grass or bracken invasion. Such changes in vegetation composition can often be the result of lack of management or inappropriate management regimes, and changes in (or loss of) management is one of the contributory factors in the decline in both quality and extent of lowland heaths in England (Alonso and others 2003).

In general, the CCA ordination on a site by site basis provided a good separation of favourable and unfavourable plots along the ordination axes, and between 70% and 90% of the variation in the plant species distributions along the axes was related to the measured environmental variables. However, further analysis indicated that only a smaller number of the measured variables were actually significant in the separation of quadrats and species, with the remainder of environmental variables showing no significant effect on the resulting ordination. Those environmental variables that were found to be significant in the plot by plot analysis were not necessarily consistent across sites; instead each site appeared to be influenced by a slightly different suite of variables. Nevertheless some trends could be identified.

The environmental variables that had the greatest influence over the separation of favourable and unfavourable plots on a site by site basis were vegetation height, dwarf shrub cover, *Calluna* age (for dry heaths), bryophytes cover, acrocarpous moss cover, litter cover and *Sphagnum* cover (for wet heaths). Favourable plots on dry heaths tended to exhibit reduced vegetation height, increased dwarf shrub cover, increasing proportions of building or mature *Calluna*, increased proportion of *Calluna* flowering, a higher cover of bryophytes and a lower cover of acrocarpous mosses. Favourable wet heath plots showed reduced vegetation height, increased dwarf shrub cover, lower cover of litter, higher cover of *Sphagnum* and reduced cover of acrocarpous mosses. Surprisingly, graminoid cover was not consistently significant in the analysis for either dry or wet heaths.

The combined analysis of all dry heath plots using DCA resulted in a poor separation of quadrats. There was some indication that there was a separation of sites based on their geographical location, with the southwest sites being distinct from the north and northwest sites. For the wet heath DCA the separation of quadrats was somewhat improved but still rather poor. There appeared to be some separation of sites along a wet – dry gradient along axis one, but the second axis was difficult to interpret.

The CCA of all dry heath plots identified more fully the significant environmental factors, but again this reflected differences between sites rather than differences between favourable and unfavourable condition. The results indicated that the proportion of flowering on dwarf shrubs, the degree of rabbit grazing, and the proportion of normal growth form of *Calluna* were significant variables in the separation of quadrats. As for the DCA, the CCA appeared to indicate that geographical location was important in separating out the sites. The more northerly sites were associated with increasing degenerate and dead *Calluna*, increasing dead wood, and increasing bryophyte cover. This may reflect different biogeographical regions and also different regional management regimes. Sites in the southwest (The Lizard and Aylesbeare Heath) were positively associated with taller vegetation height and greater litter cover, which might both reflect relatively higher productivity in heaths occurring in these warmer, wetter regions of England.

Similar trends in significant environmental variables are seen for the combined wet heath CCA analysis, with The Lizard and Aylesbeare Heath positively correlated to increasing vegetation height and proportion of dead grass (which is likely to equate to litter). However, the remaining sites appear to cluster together indicating that for wet heaths the variation in vegetation composition across England might be less diverse than for dry heath vegetation types. This is, perhaps, also suggested by the fewer wet heath vegetation types identified within the National Vegetation Classification system (Rodwell 1991).

To summarise the multivariate analysis results, the main variation in vegetation identified between favourable and unfavourable plots was in the proportions of typical heathland species (such as dwarf shrubs, sedges and mosses) and species indicative of modified heaths (such as trees and shrubs, bracken and significant amounts of grasses). The main variation in vegetation between sites was not easy to detect but there was an indication that geographical location was important for dry heaths while the wet – dry gradient was important for wet heaths.

In terms of the main environmental indicators of differences, in general only a small number of measured variables had a significant effect on the analysis. While these variables did differ somewhat between sites, there were some overall trends. Favourable plots tended to have greater cover of building and mature heather, along with more heather flowering. The bryophyte cover was higher while the acrocarpous moss cover was lower than for unfavourable plots. This suggests that regular monitoring of the dwarf shrub and moss components of a heathland should give a good indication of changes in terms of vegetation condition. Between sites, again the dwarf shrub variables gave consistently useful differences between dry heath sites, along with the degree of rabbit grazing. However, the variation between wet heath sites was not great and the majority of sites were clustered together.

# 5 Recommendations

The method for condition assessing lowland heathland vegetation generally appears to be robust and applicable in the field. The major discrepancies were where the rapid assessment method under assessed the number and abundance of negative indicators and over recorded the abundance of desirable graminoids. Similar patterns have been seen with other habitats (Bealey and Cox 2004; Ross and others 2004) and have been ascribed to the difficulty of viewing smaller broad-leaved species through and under an ericoid canopy and the tendency for oblique viewing of graminoids during the more rapid assessments. This problem can be addressed through training.

The other significant problem appears to be with the frequency set as a favourable level for *Molinia caerulea* in wet heath. It would appear that this is too low and does not distinguish between the species occurring as an integral part of the sward (at relatively high frequency and low abundance) and where it is a potential or real problem (occurring at high abundance levels and often in dominant tussocks). It appears to be causing failure among otherwise favourable vegetation and should be reviewed.

It is recommended that guidance on field monitoring and subsequent assessment should aim to reduce these biases by:

- Training all officers who will be undertaking field assessments in consistent identification of key species and field assessment methodologies. Additional aids for species identification and field methods would aid this consistency.
- Increase the critical threshold of *Molinia caerulea* on wet heaths and possibly have an additional category for where the species is present in tussocks.

# 6 References


ALONSO, I., & HARTLEY, S.E. 1998. Effects of nutrient supply, light availablility and herbivory on the growth of heather and three competing grass species. *Plant Ecology,* 137, 203-212.

ALONSO, I., and others. 2003. Lowland heathland SSSIs: Guidance on conservation objectives setting and condition monitoring. *English Nature Research Reports*, No. 511.

BANNISTER, P. 1965. Biological flora of the British Isles. *Journal of Ecology*, 53, 527-542.

BANNISTER, P. 1966. Biological flora of the British Isles. *Journal of Ecology*, 54, 795-814.

BEALEY, C.E., & COX, J. 2004. 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*, No 564.

BUNCE, R.G.H., and others. 1999. Vegetation of the British countryside – the Countryside Vegetation System. *ECOFACT Volume 1*. London: Department of the Environment, Transport and the Regions.

CRITCHELY, C.N.R. 2000. Ecological assessment of plant communities by reference to species traits and habitat preferences. *Biodiversity and Conservation*, 9, 87-105.

DANIELS, R.E., & EDDY, A. 1985. *Handbook of European Sphagna*. London: HMSO.

DOBSON, F.S. 2000. Lichens. *An Illustrated Guide to the British and Irish Species*. Slough: The Richmond Printing Company Ltd.

ELLENBERG, H. 1974. Zeigerwerte der Gefasspflanzen Mitteleuropas. *Scripta Geobot*., 9, 1–97.

GIMINGHAM, C.H. 1960. Biological flora of the British Isles: *Calluna vulgaris* (L.) Hull. *Journal of Ecology*, 48, 455-483.

GIMINGHAM, C.H. 1995. Heaths and moorland: an overview of ecological change. *In*: THOMPSON, and others (eds). *Heaths and Moorlands: Cultural Landscapes*. Edinburgh: HMSO.

GRIME, J.P. 1979. *Plant Strategies and Vegetation Processes*. Chichester: Wiley Publishing.

GRIME, J.P., HODGSON, J.G., & HUNT, R. 1988. *Comparative plant ecology: a functional approach to common British species.* London: Unwin Hyman.

HAYATI, A.A., & PROCTOR, M.C.F. 1990. Plant distribution in relation to mineral nutrient availability and uptake on a wet-heath site in south-west England. *Journal of Ecology*, 78, 134-151.

HAYATI, A.A., & PROCTOR, M.C.F. 1991. Limiting nutrients in acid-mire vegetation: peat and plant analyses and experiments on plant responses to added nutrients. *Journal of Ecology*, 79, 75-95.

HEIL, G.W., & BRUGGINK, M. 1987. Competition for nutrients between *Calluna vulgaris* and *Molinia caerulea* L. *Oecologia*, 73, 105-107.

JOINT NATURE CONSERVATION COMMITTEE. 1998. *A Statement of Common Standards in Monitoring*. Peterborough: JNCC.

JOINT NATURE CONSERVATION COMMITTEE. 2004. *Common Standards for Monitoring Designated Sites*. Peterborough: JNCC.

JONGMAN, R.H.G., TER BRAAK, C.J.F., & VAN TONGEREN, O.F.R. 1995. *Data Analysis in Community and Landscape Ecology. Second Edition.* Cambridge: CUP.

LEGG, C. 1995. Heathland dynamics: a matter of scale. *In*: THOMPSON, and others (eds). *Heaths and Moorlands: Cultural Landscapes*. Edinburgh: HMSO.

LEPS, J., & SIMILALLER, P. 2003. *Multivariate Analysis of Ecological Data using CANOCO*. Cambridge: CUP..

RITCHIE, J.C. 1956. Biological flora of the British Isles: *Vaccinium myrtillus* L. *Journal of Ecology,* 44, 291-299.

ROBERTSON, H.J., & JEFFERSON, R.G. 2000. Monitoring the condition of lowland grassland SSSIs. I. English Nature's Rapid Assessment Methodology. *English Nature Research Reports*, No. 315.

ROBERTSON, H.J., BINGHAM, J., & SLATER, I., 2000. Monitoring the condition of lowland grassland SSSIs. II. A Test of the Rapid Assessment Approach. *English Nature Research Reports*, No. 315.

RODWELL, J.S. 1991. *British Plant Communities. Volume 2. Mires and Heaths.* Cambridge: CUP.

ROSS, S., BEALEY, C.E., & COX, J. 2004. Validation Network Project. Lowland calcareous grasslands: *Bromus erectus* (CG3) grasslands. *English Nature Research Reports*, No. 609.

SOKAL, R.R., & ROHLF, F.J. 1995. *Biometry. Third edition*. W H Freeman and Company.

STACE, C. 1997. *New flora of the British Isles*. Second edition. Cambridge: CUP.

UK BIODIVERSITY STEERING GROUP. 1995. *UK Biodiversity Action Plan. Volume 2 Action Plans*. London: HMSO.

UK NATIONAL FOCAL CENTRE. 2003. *Status of UK Critical Loads. Critical Loads Methods, Data and Maps.* February 2003.

UK NATIONAL FOCAL CENTRE. 2004a. *Update To: Status of UK Critical Loads. Critical Loads Methods, Data and Maps.* February 2004. Monks Wood, Huntingdon: CEH.

UK NATIONAL FOCAL CENTRE. 2004b. *Addendum: The Status of UK Critical Loads Exceedances.* April 2004. Monks Wood, Huntingdon: CEH.

WATSON, E.V. 1981. *British Mosses and Liverworts*. Third Edition. Cambridge: CUP.

WATT, A.S. 1955. Bracken versus heather, a study in plant sociology. *Journal of Ecology,* 43**,** 490-506.

# *Tables*

**Table 1 Summary of the sites included within the Lowland Heathland Validation Network Project**

| Site Name | County | Heathland Type(s) | National Grid Reference | Total Number of Plots |
|---|---|---|---|---|
| Cannock Chase SSSI | Staffordshire | Dry heath | SJ983183 | 2 |
| Cavenham Heath NNR | Suffolk | Dry heath | TL755725 | 2 |
| Roydon Common NNR | Norfolk | Wet heath | TF684225 | 2 |
| Aylesbeare Heath SSSI | Devon | Dry heath and wet heath | SY050880 | 4 |
| The Lizard NNR | Cornwall | Dry heath and wet heath | SW685135 | 4 |
| Thursley NNR | Surrey | Dry heath and wet heath | SU903406 | 4 |
| Lazonby Fell SSSI | Cumbria | Dry heath | NY520393 | 2 |
| New Forest SSSI | Hampshire | Dry heath and wet heath | SU298081 | 4 |
| Hartland Moor NNR | Dorset | Dry heath and wet heath | SY950850 | 4 |

**Table 2 Summary of the plots included within the Lowland Heathland Validation Network Project**

| Site Name | County | Plot Name | Heathland Type | Vegetation Condition |
|---|---|---|---|---|
| Cannock Chase SSSI | Staffordshire | Glacial Boulder Plot | Dry heath | Favourable |
| | | Brindley Heath Plot | Dry heath | Unfavourable |
| Cavenham Heath NNR | Suffolk | East Plot | Dry heath | Favourable |
| | | West Plot | Dry heath | Unfavourable |
| Roydon Common NNR | Norfolk | Plot 2 | Wet heath | Favourable |
| | | Plot 1 | Wet heath | Unfavourable |
| Aylesbeare Heath SSSI | Devon | Favourable Plot | Dry heath | Favourable |
| | | Unfavourable Plot | Dry heath | Unfavourable |
| | | Favourable Plot | Wet heath | Favourable |
| | | Unfavourable Plot | Wet heath | Unfavourable |
| The Lizard NNR | Cornwall | Mullion Cliff Plot B | Dry heath | Favourable |
| | | Mullion Cliff Plot A | Dry heath | Unfavourable |
| | | Goonhilly Downs Plot B | Wet heath | Favourable |
| | | Goonhilly Downs Plot A | Wet heath | Unfavourable |
| Thursley NNR | Surrey | Plot 1 | Dry heath | Favourable |
| | | Plot 2 | Dry heath | Unfavourable |
| | | Plot B | Wet heath | Favourable |
| | | Plot A | Wet heath | Unfavourable |
| Lazonby Fell SSSI | Cumbria | Favourable Plot | Dry heath | Favourable |
| | | Unfavourable Plot | Dry heath | Unfavourable |
| New Forest SSSI | Hampshire | Telegraph Hill Favourable | Dry (humid) heath | Favourable |
| | | Telegraph Hill Unfavourable | Dry (humid) heath | Unfavourable |
| | | Beaulieu Road Favourable | Wet heath | Favourable |
| | | Beaulieu Road Unfavourable | Wet heath | Unfavourable |
| Hartland Moor NNR | Dorset | Favourable Plot | Dry heath | Favourable |
| | | Unfavourable Plot | Dry heath | Unfavourable |
| | | Thrasher's Heath Plot | Wet heath | Favourable |
| | | Wytch Heath Plot | Wet heath | Unfavourable |

**Table 3 Meteorological station used for each site within the Lowland Heathland Validation Network Project**

| Site Name | Meteorological Station | |
|---|---|---|
| | Name | Altitude (m AMSL) |
| Cannock Chase | Penkridge | 101m |
| Cavenham Heath | Wattisham | 89m |
| Roydon Common | Marham | 21m |
| Aylesbeare Heath | Teignmouth | 3m |
| The Lizard | St. Mawgan | 103m |
| Thursley | Wisley | 38m |
| Lazonby Fell | Newton Rigg | 169m |
| New Forest | Everton | 16m |
| Hartland Moor | Everton | 16m |

**Table 4 Suited species scores for Acidity (A), Grazing (G), Nutrients (Nu) and Moisture (M)**

| Scientific Name | A | G | Nu | M |
|---|---|---|---|---|
| *Achillea millifolium* | 0 | 0 | 0 | -1 |
| *Agrostis canina* | 0 | 1 | -1 | 1 |
| *Agrostis capillaris* | 0 | 0 | -1 | 0 |
| *Agrostis curtisii* | 0 | 0 | -1 | 0 |
| *Agrostis stolonifera* | 0 | 0 | 1 | 0 |
| *Aira praecox* | 1 | 1 | -1 | -1 |
| *Anthoxathum odoratum* | 0 | 0 | 0 | 0 |
| *Armeria maritima* | 0 | 0 | -1 | -1 |
| *Aulacomnium palustre* | 0 | 0 | -1 | 1 |
| *Betula pendula* | 0 | -1 | 0 | 0 |
| *Betula* sp. | 1 | -1 | 0 | 0 |
| *Brachypodium sylvaticum* | 0 | 0 | -1 | 0 |
| *Brachythecium rutabulum* | 0 | 0 | 0 | 0 |
| *Calluna vulgaris* | 1 | -1 | -1 | 0 |
| *Campylopus flexuosus* | 1 | 0 | 0 | 0 |
| *Campylopus introflexus* | 1 | 0 | 0 | 0 |
| *Campylopus pyriformis* | 1 | 0 | 0 | 0 |
| *Carex binervis* | 1 | 0 | -1 | 0 |
| *Carex echinata* | 0 | 1 | -1 | 1 |
| *Carex flacca* | 0 | 0 | -1 | 1 |
| *Carex nigra* | 1 | 0 | -1 | 1 |
| *Carex panicea* | 0 | 0 | -1 | 1 |
| *Carex pilulifera* | 1 | 1 | -1 | 0 |
| *Carex pulicaris* | 0 | 0 | -1 | 1 |
| *Carex viridula* ssp. *oedocarpa* | 0 | 1 | -1 | 1 |
| *Cephaloziella divaricata* | 1 | 0 | 0 | 0 |
| *Cirsium dissectum* | 0 | 0 | -1 | 1 |
| *Cladonia furcata* | no data available | | | |
| *Cladonia portentosa* | no data available | | | |
| *Cladonia uncialis* | no data available | | | |
| *Dactylorhiza* sp. | 1 | 0 | -1 | 1 |
| *Danthonia decumbens* | 1 | 0 | -1 | 0 |
| *Daucus carota* | 0 | 0 | 0 | -1 |
| *Deschampsia flexuosa* | 1 | 0 | -1 | 0 |
| *Dicranum scoparium* | 0 | 0 | 0 | 0 |
| *Drosera intermedia* | 1 | 0 | -1 | 1 |

| Scientific Name | A | G | Nu | M |
|---|---|---|---|---|
| *Drosera rotundifolia* | 1 | 0 | -1 | 1 |
| *Dryopteris dilitata* | 1 | 0 | 0 | 0 |
| *Eleocharis multicaulis* | 0 | 0 | -1 | 1 |
| *Empetrum nigrum* | 1 | 0 | -1 | 0 |
| *Erica ciliaris* | 0 | 0 | 0 | 0 |
| *Erica cinerea* | 1 | 0 | -1 | 0 |
| *Erica tetralix* | 1 | 0 | -1 | 1 |
| *Erica vagans* | 0 | 0 | 0 | 0 |
| *Eriophorum angustifolium* | 1 | 0 | -1 | 1 |
| *Eurhynchium praelongum* | 0 | 0 | 0 | 1 |
| *Festuca ovina* | 1 | 0 | -1 | -1 |
| *Festuca rubra* | 0 | 0 | 0 | 0 |
| *Galium saxatile* | 1 | 1 | -1 | 0 |
| *Genista anglica* | 0 | 0 | -1 | 0 |
| *Hylocomium splendens* | 0 | 0 | 0 | 0 |
| *Hypericum pulchrum* | 0 | 0 | -1 | 0 |
| *Hypnum cupressiforme* agg. | 1 | 0 | 0 | 0 |
| *Hypnum jutlandicum* | 1 | 0 | 0 | 0 |
| *Hypnum* sp. | 0 | 0 | 0 | 0 |
| *Hypochaeris radicata* | 0 | 1 | -1 | 0 |
| *Juncus acutiflorus* | 0 | 0 | -1 | 1 |
| *Juncus bulbosus* | 0 | 1 | -1 | 1 |
| *Juncus effusus* | 0 | 0 | 0 | 1 |
| *Juncus squarrosus* | 1 | 1 | -1 | 1 |
| *Leontodon autumnalis* | 0 | 1 | 0 | 0 |
| *Leucobryum glaucum* | 0 | 0 | -1 | 0 |
| *Lonicera periclymenum* | 1 | -1 | 0 | 0 |
| *Lophocolia bidentata* | no data available | | | |
| *Luzula multiflora* | 0 | 1 | -1 | 0 |
| *Molinia caerulea* | 1 | 0 | -1 | 1 |
| *Myrica gale* | 0 | 0 | -1 | 1 |
| *Nardus stricta* | 1 | 0 | -1 | 0 |
| *Narthecium ossifragum* | 1 | 0 | -1 | 1 |
| *Odontoschisma sphagni* | 1 | 0 | -1 | 1 |
| *Pedicularis palustris* | 1 | 0 | -1 | 1 |
| *Pimpinella saxifraga* | 0 | 1 | -1 | -1 |
| *Pinus* sp. | 0 | 0 | 0 | 0 |
| *Pinus sylvestris* | 0 | -1 | 0 | 0 |
| *Plagiothecium undulatum* | 1 | 0 | 0 | 1 |
| *Pleurozium schreberi* | 1 | 0 | 0 | -1 |
| *Polygala serpyllifolia* | 1 | 1 | -1 | 0 |
| *Polytrichum commune* | 1 | 0 | 0 | 1 |
| *Polytrichum* sp. | 0 | 0 | 0 | 0 |
| *Potentilla erecta* | 1 | 0 | -1 | 0 |
| *Prunus spinosa* | 0 | -1 | 0 | 0 |
| *Pteridium aquilinum* | 1 | 0 | 0 | 0 |
| *Ptilidium ciliare* | 1 | 0 | 0 | 1 |
| *Quercus petraea* | 0 | 0 | 0 | 0 |
| *Quercus* sp. | 1 | -1 | 0 | 0 |
| *Rhamnus cathartica* | 0 | 0 | 0 | -1 |
| *Rhyncospora alba* | 0 | 0 | -1 | 1 |

| Scientific Name | A | G | Nu | M |
|---|---|---|---|---|
| *Rhytidiadelphus squarrosus* | 0 | 0 | 0 | 1 |
| *Rubus fruticosus* agg. | 1 | -1 | 0 | 0 |
| *Rumex acetosella* | 1 | 1 | -1 | 0 |
| *Salix repens* | 1 | -1 | -1 | 1 |
| *Salix* sp. | 0 | 0 | 0 | 0 |
| *Sanguisorba officinalis* | 0 | 0 | -1 | 1 |
| *Schoenus nigricans* | 0 | 0 | -1 | 1 |
| *Scleropodium purum* | 0 | 0 | 0 | 0 |
| *Scutellaria minor* | 0 | 0 | 0 | 1 |
| *Senecio jacobaea* | 0 | 0 | 1 | -1 |
| *Serratula tinctoria* | 0 | 0 | -1 | 1 |
| *Sphagnum compactum* | 1 | 0 | 0 | 1 |
| *Sphagnum cuspidatum* | 1 | 0 | -1 | 1 |
| *Sphagnum fimbriatum* | 1 | 0 | 0 | 1 |
| *Sphagnum inundatum* | 1 | 0 | 0 | 1 |
| *Sphagnum magellanicum* | 1 | 0 | -1 | 1 |
| *Sphagnum papillosum* | 1 | 0 | -1 | 1 |
| *Sphagnum recurvum* | 1 | 0 | -1 | 1 |
| *Sphagnum subnitens* | 1 | 0 | -1 | 1 |
| *Sphagnum tenellum* | 1 | 0 | -1 | 1 |
| *Succisa pratensis* | 0 | 1 | -1 | 1 |
| *Trichophorum cespitusum* | 1 | 0 | -1 | 1 |
| *Ulex europaeus* | 0 | 0 | 0 | 0 |
| *Ulex europaeus x gallii* | no data available | | | |
| *Ulex galii* | 1 | -1 | -1 | 0 |
| *Ulex minor* | 0 | 0 | 0 | 0 |
| *Vaccinium myrtillus* | 1 | 0 | -1 | 0 |
| *Vaccinium oxycoccus* | 0 | 0 | -1 | 1 |
| *Vaccinium vitis-idaea* | 1 | 0 | -1 | -1 |
| *Vaccinium x intermedium* | no data available | | | |
| *Viola riviniana* | 0 | 0 | -1 | 0 |

**Table 5 Interpretation of the suited species scores indices for Nutrient, Grazing and Moisture (from Robertson, Bingham and Slater 2000)**

| Index | Value | Interpretation |
|---|---|---|
| Nutrient | 1 | All species present suited by high nutrients |
| | 0 | Equal numbers of species most suited and not suited by high nutrients OR all species indifferent |
| | -1 | All species present not suited by high nutrients |
| Grazing | 1 | All species present suited by high grazing |
| | 0 | Equal numbers of species most suited and not suited by grazing OR all species indifferent |
| | -1 | All species present not suited by grazing |
| Moisture | 1 | All species present suited by wet conditions |
| | 0 | Equal numbers of species most suited and not suited by wet conditions OR all species indifferent |
| | -1 | All species present not suited by wet conditions |

**Table 6a Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute

F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin

N/A = not assessed due to incomplete data

| **Cannock Chase, Dry Heath, Favourable Condition** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | F | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***7*** | ***6*** | ***N*** |
| | | | |
| **Cannock Chase, Dry Heath, Unfavourable Condition** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | F | Y |
| *Vegetation structure (dwarf shrub %) | F | P | N |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | F | N |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | P | F | N |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***6*** | ***4*** | ***N*** |

**Table 6b Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Cavenham Heath, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | F | P | N |
| * Vegetation structure (*Calluna* age) | F | P | N |
| *Vegetation composition (dwarf shrubs) | F | F | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | P | F | N |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | P | N/A |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***5*** | ***5*** | ***Y*** |
| | | | |
| **Cavenham Heath, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | F | P | N |
| * Vegetation structure (*Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | F | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | P | F | N |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***6*** | ***4*** | ***N*** |

**Table 6c Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Roydon Common, Wet Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | P | N |
| *Vegetation structure (dwarf shrub %) | F | P | N |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | N/A | N/A |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***5*** | ***6*** | ***N*** |
| | | | |
| **Roydon Common, Wet Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***7*** | ***5*** | ***N*** |

**Table 6d Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Aylesbeare Heath, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***5*** | ***5*** | ***Y*** |
| | | | |
| **Aylesbeare Heath, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | F | N |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***4*** | ***4*** | ***Y*** |

**Table 6e Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Aylesbeare Heath, Wet heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | F | P | N |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | F | N |
| *Negative indicator (species) | F | F | Y |
| ***Total passes for mandatory attributes*** | ***3*** | ***4*** | ***N*** |
| | | | |
| **Aylesbeare Heath, Wet heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | F | F | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | F | F | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***3*** | ***4*** | ***N*** |

**Table 6f  Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **The Lizard, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | F | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | N/A | F | N/A |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | P | N/A |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***4*** | ***4*** | ***Y*** |
| | | | |
| **The Lizard, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | N/A | F | N/A |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | P | N/A |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***3*** | ***4*** | ***N*** |

**Table 6g Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **The Lizard, Wet Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P? | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | P | P | Y |
| *Vegetation composition (lower plants) | N/A | F | N/A |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | F | N/A |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***7*** | ***6*** | ***N*** |
| | | | |
| **The Lizard, Wet Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P? | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | P | P | Y |
| *Vegetation composition (lower plants) | N/A | F | N/A |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | F | N/A |
| *Negative indicator (species) | N/A | P | N/A |
| ***Total passes for mandatory attributes*** | ***6*** | ***6*** | ***Y*** |

**Table 6h  Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Thursley, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | P | F | N |
| * Vegetation structure *(Calluna* age) | P | F | N |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | F | N |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | P | N/A |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***6*** | ***4*** | ***N*** |
| | | | |
| **Thursley, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | N/A | P | N/A |
| *Negative indicator (species) | P | F | N/A |
| ***Total passes for mandatory attributes*** | ***5*** | ***5*** | ***Y*** |

**Table 6i Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Thursley, Wet Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| *Vegetation structure (*Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | P | F | N |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***8*** | ***6*** | ***N*** |
| | | | |
| **Thursley, Wet Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| *Vegetation structure (*Calluna* age) | F | P | N |
| *Vegetation composition (dwarf shrubs) | F | P | N |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | F | N |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***7*** | ***6*** | ***N*** |

**Table 6j Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Lazonby Fell, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | F | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | F | F | Y |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***6*** | ***6*** | ***Y*** |
| | | | |
| **Lazonby Fell, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | F | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | F | F | Y |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | F | F | Y |
| ***Total passes for mandatory attributes*** | ***5*** | ***5*** | ***Y*** |

**Table 6k Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **New Forest, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | (F) | P | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | (F) | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***6*** | ***7*** | ***N*** |
| | | | |
| **New Forest, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | (F) | P | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | P | N |
| *Vegetation composition (dwarf shrubs) | F | F | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | P | F | N |
| *Vegetation composition (lower plants) | P | P | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***6*** | ***7*** | ***N*** |

**Table 6l Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **New Forest, Wet Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | P | F | N |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | P | F | N |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | F | N |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***9*** | ***5*** | ***N*** |
| | | | |
| **New Forest, Wet Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | F | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | P | N |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | F | P | N |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***4*** | ***6*** | ***N*** |

**Table 6m Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute
F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin
N/A = not assessed due to incomplete data

| **Hartland Moor, Dry Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | P | Y |
| *Vegetation structure (dwarf shrub %) | (F) | F | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F ? | F | Y |
| *Vegetation composition (lower plants) | P | F | N |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***6*** | ***5*** | ***N*** |
| | | | |
| **Hartland Moor, Dry Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P ? | P | Y |
| *Bare ground (not rock) | (F) | P | N |
| *Vegetation structure (dwarf shrub %) | P ? | F | N |
| * Vegetation structure *(Calluna* age) | (F) | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F? | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | F | P | N |
| ***Total passes for mandatory attributes*** | ***5*** | ***5*** | ***Y*** |

**Table 6n Comparison of Qualitative and Quantitative Vegetation Condition Data, Lowland Heathlands**

* = mandatory attribute

F = attribute fails assessment; P = attribute passes assessment, (F) = attribute fails by a small margin

N/A = not assessed due to incomplete data

| **Hartland Moor, Wet Heath, Favourable** | | | |
|---|---|---|---|
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | P | N |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | P | F | N |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | P | N |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | P | P | Y |
| *Negative indicator (species) | P | P | Y |
| ***Total passes for mandatory attributes*** | ***7*** | ***7*** | ***Y*** |
| | | | |
| **Hartland Moor, Wet Heath, Unfavourable** | | | |
| **Site Attribute** | **Condition Assessment Result** | | **Comparable?** |
| | **Qualitative** | **Quantitative** | |
| *Extent of habitat | P | P | Y |
| *Bare ground (not rock) | P | F | N |
| *Vegetation structure (dwarf shrub %) | P | P | Y |
| * Vegetation structure *(Calluna* age) | F | F | Y |
| *Vegetation composition (dwarf shrubs) | P | P | Y |
| *Vegetation composition (graminoids) | F | F | Y |
| *Vegetation composition (forbs) | F | F | Y |
| *Vegetation composition (lower plants) | F | F | Y |
| Vegetation composition (rare species) | N/A | N/A | N/A |
| *Negative indicator (disturbance) | F | P | N |
| *Negative indicator (species) | P | F | N |
| ***Total passes for mandatory attributes*** | ***5*** | ***4*** | ***N*** |

**Table 7 Plant Strategy Values For Each Lowland Heathland Plot From MAVIS* Analysis**

| Site Name | Plot Condition | Plant Strategy Value | | |
|---|---|---|---|---|
| | | Competitor | Stress-Tolerator | Ruderal |
| Cannock Chase, Dry Heath | Favourable | 3.00 | 3.00 | 1.00 |
| | Unfavourable | 2.09 | 3.64 | 1.55 |
| Cavenham Heath, Dry Heath | Favourable | 1.88 | 3.38 | 2.13 |
| | Unfavourable | 1.75 | 3.88 | 1.75 |
| Royden Common, Wet Heath | Favourable | 2.50 | 3.50 | 1.00 |
| | Unfavourable | 2.57 | 3.43 | 1.00 |
| Aylesbeare Heath, Dry Heath | Favourable | 2.50 | 3.50 | 1.00 |
| | Unfavourable | 2.83 | 3.17 | 1.17 |
| Aylesbeare Heath, Wet Heath | Favourable | 2.09 | 3.82 | 1.27 |
| | Unfavourable | 2.86 | 3.14 | 1.36 |
| The Lizard, Dry Heath | Favourable | 2.40 | 3.30 | 1.60 |
| | Unfavourable | 2.30 | 3.40 | 1.40 |
| The Lizard, Wet Heath | Favourable | 2.00 | 4.00 | 1.30 |
| | Unfavourable | 1.92 | 4.08 | 1.25 |
| Thursley Moor Dry Heath | Favourable | 2.50 | 3.25 | 1.50 |
| | Unfavourable | 2.88 | 3.00 | 1.50 |
| Thursley Moor Wet Heath | Favourable | 2.50 | 3.50 | 1.00 |
| | Unfavourable | 2.89 | 3.11 | 1.00 |
| Lazonby Fell, Dry heath | Favourable | 2.67 | 3.33 | 1.17 |
| | Unfavourable | 3.40 | 2.60 | 1.00 |
| New Forest, Dry Heath | Favourable | 2.00 | 4.00 | 1.14 |
| | Unfavourable | 1.89 | 3.95 | 1.53 |
| New Forest, Wet Heath | Favourable | 2.29 | 3.71 | 1.00 |
| | Unfavourable | 2.13 | 3.88 | 1.13 |
| Hartland Moor, Dry Heath | Favourable | 3.00 | 3.00 | 1.00 |
| | Unfavourable | 2.83 | 3.17 | 1.00 |
| Hartland Moor, Wet Heath | Favourable | 2.43 | 3.57 | 1.29 |
| | Unfavourable | 2.50 | 3.50 | 1.25 |

* Modular Analysis of Vegetation and Interpretation System

**Table 8_ Average Suited Species Scores/Indices for each of the Plots Within The Lowland Heathland Analysis**

| Site | Heathland Type | Vegetation Condition | No. of Quadrats | Average Suited Species Score/Index | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sum Acidity Score | | Grazing Suited Species Index | | Nutrient Suited Species Index | | Moisture Suited Species Index | |
| | | | | *Average* | *StDev* | *Average* | *StDev* | *Average* | *StDev* | *Average* | *StDev* |
| Cannock Chase | Dry heath | Favourable | 30 | 4.1 | 0.91 | -0.2 | 0.09 | -0.7 | 0.13 | 0.0 | 0.18 |
| | Dry heath | Unfavourable | 30 | 3.1 | 1.01 | 0.0 | 0.19 | -0.9 | 0.21 | -0.3 | 0.18 |
| Cavenham Heath | Dry heath | Favourable | 30 | 3.5 | 0.78 | -0.1 | 0.17 | -0.5 | 0.15 | -0.2 | 0.12 |
| | Dry heath | Unfavourable | 30 | 3.9 | 0.87 | 0.0 | 0.10 | -0.7 | 0.10 | -0.2 | 0.03 |
| Roydon Common | Wet heath | Favourable | 30 | 3.7 | 1.12 | -0.2 | 0.15 | -1.0 | 0.08 | 0.8 | 0.15 |
| | Wet heath | Unfavourable | 30 | 3.3 | 1.25 | -0.3 | 0.15 | -0.7 | 0.23 | 0.4 | 0.24 |
| Aylesbeare Heath | Dry heath | Favourable | 30 | 4.7 | 0.65 | -0.4 | 0.09 | -0.6 | 0.11 | 0.4 | 0.05 |
| | Dry heath | Unfavourable | 30 | 3.5 | 0.73 | -0.5 | 0.13 | -0.3 | 0.17 | 0.1 | 0.12 |
| | Wet heath | Favourable | 30 | 5.6 | 1.67 | -0.3 | 0.18 | -0.6 | 0.14 | 0.6 | 0.10 |
| | Wet heath | Unfavourable | 30 | 5.0 | 1.35 | -0.4 | 0.19 | -0.3 | 0.20 | 0.4 | 0.18 |
| The Lizard | Dry heath | Favourable | 30 | 0.9 | 0.78 | 0.0 | 0.12 | -0.4 | 0.28 | 0.2 | 0.26 |
| | Dry heath | Unfavourable | 29 | 1.1 | 0.71 | -0.1 | 0.23 | -0.4 | 0.29 | 0.1 | 0.23 |
| | Wet heath | Favourable | 30 | 3.1 | 1.04 | 0.0 | 0.12 | -0.7 | 0.18 | 0.6 | 0.10 |
| | Wet heath | Unfavourable | 30 | 3.2 | 1.18 | 0.0 | 0.11 | -0.8 | 0.14 | 0.5 | 0.16 |
| Thursley | Dry heath | Favourable | 30 | 2.9 | 0.64 | -0.3 | 0.10 | -0.5 | 0.11 | 0.0 | 0.04 |
| | Dry heath | Unfavourable | 30 | 2.7 | 1.44 | -0.3 | 0.16 | -0.5 | 0.18 | 0.0 | 0.00 |
| | Wet heath | Favourable | 30 | 6.1 | 1.60 | -0.2 | 0.09 | -0.9 | 0.12 | 0.7 | 0.13 |
| | Wet heath | Unfavourable | 30 | 4.6 | 1.52 | -0.2 | 0.17 | -0.7 | 0.16 | 0.7 | 0.21 |
| Lazonby Fell | Dry heath | Favourable | 30 | 4.5 | 0.73 | -0.2 | 0.09 | -0.5 | 0.09 | -0.2 | 0.07 |
| | Dry heath | Unfavourable | 30 | 4.2 | 0.79 | -0.3 | 0.13 | -0.4 | 0.13 | -0.2 | 0.13 |
| New Forest | Dry (humid) heath | Favourable | 30 | 4.0 | 0.72 | -0.2 | 0.09 | -0.9 | 0.16 | 0.4 | 0.14 |
| | Dry (humid) heath | Unfavourable | 30 | 5.5 | 1.38 | -0.1 | 0.12 | -0.8 | 0.10 | 0.0 | 0.12 |
| | Wet heath | Favourable | 30 | 5.1 | 1.21 | -0.1 | 0.10 | -0.9 | 0.08 | 0.7 | 0.13 |
| | Wet heath | Unfavourable | 30 | 4.9 | 1.28 | -0.2 | 0.09 | -0.9 | 0.09 | 0.8 | 0.13 |
| Hartland Moor | Dry heath | Favourable | 30 | 2.3 | 0.76 | -0.3 | 0.17 | -0.7 | 0.14 | 0.0 | 0.10 |
| | Dry heath | Unfavourable | 30 | 2.3 | 1.03 | -0.2 | 0.15 | -0.7 | 0.21 | 0.1 | 0.12 |
| | Wet heath | Favourable | 30 | 3.4 | 0.89 | -0.2 | 0.07 | -0.8 | 0.15 | 0.2 | 0.11 |
| | Wet heath | Unfavourable | 30 | 1.3 | 0.45 | -0.1 | 0.12 | -0.6 | 0.14 | 0.5 | 0.15 |

**Table 9 Results of the Mann-Whitney U-Test Analysis Results For Average Suited Species Scores**

| Site | Variable | N | U-value | p-value |
|---|---|---|---|---|
| **Cannock Chase, Dry Heath** | Sum Acidity Score | 30, 30 | 661.00 | **0.001** |
| | Grazing Suited Species Index | 30, 30 | 133.00 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 686.50 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 785.50 | **0.000** |
| **Cavenham Heath, Dry Heath** | Sum Acidity Score | 30, 30 | 332.50 | 0.062 |
| | Grazing Suited Species Index | 30, 30 | 205.00 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 703.00 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 281.00 | **0.007** |
| **Roydon Common, Wet Heath** | Sum Acidity Score | 30, 30 | 554.50 | 0.097 |
| | Grazing Suited Species Index | 30, 30 | 648.50 | **0.002** |
| | Nutrient Suited Species Index | 30, 30 | 189.00 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 784.50 | **0.000** |
| **Aylesbeare Heath, Dry Heath** | Sum Acidity Score | 30, 30 | 800.00 | **0.000** |
| | Grazing Suited Species Index | 30, 30 | 710.00 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 61.50 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 883.00 | **0.000** |
| **Aylesbeare Heath, Wet Heath** | Sum Acidity Score | 30, 30 | 532.00 | 0.214 |
| | Grazing Suited Species Index | 30, 30 | 678.00 | **0.001** |
| | Nutrient Suited Species Index | 30, 30 | 103.00 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 759.50 | **0.000** |
| **The Lizard, Dry Heath** | Sum Acidity Score | 30, 30 | 392.00 | 0.342 |
| | Grazing Suited Species Index | 30, 29 | 548.00 | **0.022** |
| | Nutrient Suited Species Index | 30, 29 | 394.50 | 0.526 |
| | Moisture Suited Species Index | 30, 29 | 547.50 | 0.058 |
| **The Lizard, Wet Heath** | Sum Acidity Score | 30, 30 | 465.00 | 0.818 |
| | Grazing Suited Species Index | 30, 30 | 307.50 | **0.027** |
| | Nutrient Suited Species Index | 30, 30 | 604.00 | **0.015** |
| | Moisture Suited Species Index | 30, 30 | 630.50 | **0.006** |
| **Thursley, Dry Heath** | Sum Acidity Score | 30, 30 | 528.50 | 0.227 |
| | Grazing Suited Species Index | 30, 30 | 501.00 | 0.417 |
| | Nutrient Suited Species Index | 30, 30 | 634.50 | **0.005** |
| | Moisture Suited Species Index | 30, 30 | 465.00 | 0.317 |
| **Thursley, Wet Heath** | Sum Acidity Score | 30, 30 | 662.50 | **0.001** |
| | Grazing Suited Species Index | 30, 30 | 533.00 | 0.207 |
| | Nutrient Suited Species Index | 30, 30 | 233.00 | **0.001** |
| | Moisture Suited Species Index | 30, 30 | 574.00 | 0.062 |
| **Lazonby Fell, Dry Heath** | Sum Acidity Score | 30, 30 | 575.00 | **0.045** |
| | Grazing Suited Species Index | 30, 30 | 716.00 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 119.00 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 384.50 | 0.296 |
| **New Forest, Dry Heath** | Sum Acidity Score | 30, 30 | 161.00 | **0.000** |
| | Grazing Suited Species Index | 30, 30 | 156.50 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 347.00 | 0.112 |
| | Moisture Suited Species Index | 30, 30 | 884.00 | **0.000** |
| **New Forest, Wet Heath** | Sum Acidity Score | 30, 30 | 484.00 | 0.603 |
| | Grazing Suited Species Index | 30, 30 | 523.50 | 0.255 |
| | Nutrient Suited Species Index | 30, 30 | 404.00 | 0.436 |
| | Moisture Suited Species Index | 30, 30 | 426.00 | 0.699 |

| Site | Variable | N | U-value | p-value |
| --- | --- | --- | --- | --- |
| **Hartland Moor, Dry Heath** | Sum Acidity Score | 30, 30 | 432.00 | 0.770 |
| | Grazing Suited Species Index | 30, 30 | 325.00 | **0.029** |
| | Nutrient Suited Species Index | 30, 30 | 509.50 | 0.348 |
| | Moisture Suited Species Index | 30, 30 | 336.00 | **0.029** |
| **Hartland Moor, Wet Heath** | Sum Acidity Score | 30, 30 | 877.00 | **0.000** |
| | Grazing Suited Species Index | 30, 30 | 135.50 | **0.000** |
| | Nutrient Suited Species Index | 30, 30 | 160.00 | **0.000** |
| | Moisture Suited Species Index | 30, 30 | 36.50 | **0.000** |

**Table 10 Environmental Variables Showing Significant Differences Between Favourable and Unfavourable Plots on Lowland Heathland Sites, Following T-Test Analyses**

| Site | Variable | Favourable Plot | | Unfavourable Plot | | P-value |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | |
| Cannock Chase, Dry Heath | Vegetation height (cm) | 31.7 | 0.17 | 15.5 | 0.10 | 0.000 |
| | Bryophyte (%) | 7.4 | 0.09 | 2.5 | 0.04 | 0.008 |
| | Building heather (%) | 4.6 | 0.20 | 27.7 | 0.04 | 0.039 |
| | Mature heather (%) | 77.7 | 0.48 | 51.2 | 0.65 | 0.020 |
| | Proportion flowering (%) | 98.5 | 0.22 | 85.3 | 0.70 | 0.009 |
| Cavenham Heath, Dry Heath | Vegetation height (cm) | 14.2 | 0.11 | 4.4 | 0.02 | 0.000 |
| | Building heather (%) | 53.6 | 0.40 | 94.7 | 0.32 | 0.000 |
| | Dead heather (%) | 0.9 | 0.02 | 0.1 | 0.00 | 0.015 |
| | Proportion flowering (%) | 96.0 | 0.32 | 99.8 | 0.14 | 0.003 |
| | Litter (%) | 5.4 | 0.05 | 2.7 | 0.03 | 0.048 |
| Roydon Common, Wet Heath | Vegetation height (cm) | 21.6 | 0.06 | 3.3 | 0.17 | 0.002 |
| | Litter (%) | 4.9 | 0.02 | 12.5 | 0.13 | 0.007 |
| Aylesbeare, Dry Heath | Vegetation height (cm) | 20.7 | 0.14 | 73.0 | 0.56 | 0.000 |
| | Dead heather (%) | 1.7 | 0.03 | 0.3 | 0.02 | 0.048 |
| Aylesbeare, Wet Heath | Vegetation height (cm) | 20.7 | 0.14 | 14.0 | 0.55 | 0.000 |
| | *Sphagnum* (%) | 9.5 | 0.13 | 0.0 | 0.06 | 0.015 |
| | Proportion flowering (%) | 99.9 | 0.11 | 89.2 | 0.70 | 0.003 |
| | Proportion normal growth (%) | 100.0 | 0.06 | 93.0 | 0.67 | 0.006 |
| The Lizard, Dry Heath | no variables showed statistically significant differences between plots | | | | | |
| The Lizard, Wet Heath | no variables showed statistically significant differences between plots | | | | | |
| Thursley, Dry Heath | Vegetation height (cm) | 23.0 | 0.12 | 55.4 | 0.45 | 0.000 |
| | Bryophytes (%) | 6.5 | 0.06 | 0.2 | 0.01 | 0.000 |
| | Proportion flowering (%) | 93.0 | 0.27 | 98.1 | 0.30 | 0.025 |
| | Litter (%) | 2.3 | 0.03 | 62.6 | 0.61 | 0.000 |
| Thursley, Wet Heath | no variables showed statistically significant differences between plots | | | | | |
| Lazonby Fell, Dry Heath | Bryophyte (%) | 42.9 | 0.32 | 81.4 | 0.46 | 0.000 |
| | Degenerate heather (%) | 28.9 | 0.26 | 55.7 | 0.51 | 0.023 |
| | Proportion flowering (%) | 97.2 | 0.26 | 52.4 | 0.21 | 0.000 |
| New Forest, Dry Heath | Vegetation height (cm) | 31.3 | 0.12 | 8.4 | 0.04 | 0.000 |
| | Pioneer heather (%) | 0.5 | 0.01 | 33.2 | 0.49 | 0.001 |
| | Building heather (%) | 32.1 | 0.31 | 62.3 | 0.52 | 0.003 |
| | Mature heather (%) | 69.9 | 0.31 | 26.1 | 0.52 | 0.000 |
| | Proportion flowering (%) | 100.0 | 0.06 | 97.8 | 0.29 | 0.001 |
| New Forest, Wet Heath | Lichen (%) | 4.6 | 0.06 | 0.3 | 0.01 | 0.001 |
| | Bare ground (%) | 2.9 | 0.06 | 15.1 | 0.16 | 0.000 |
| | Litter (%) | 6.2 | 0.03 | 2.9 | 0.03 | 0.000 |
| Hartland Moor, Dry Heath | Building heather (%) | 16.6 | 0.31 | 51.0 | 0.67 | 0.012 |
| | Mature heather (%) | 78.6 | 0.44 | 49.4 | 0.58 | 0.006 |
| | Proportion normal growth (%) | 99.7 | 0.19 | 88.7 | 0.69 | 0.006 |
| | Vegetation height (cm) | 8.1 | 0.05 | 26.1 | 0.15 | 0.000 |

| Site | Variable | Favourable Plot | | Unfavourable Plot | | P-value |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | |
| Hartland Moor, Wet Heath | Graminoid (%) | 26.1 | 0.26 | 72.2 | 0.40 | 0.000 |
| | Building heather (%) | 73.0 | 0.58 | 43.2 | 0.71 | 0.030 |
| | Proportion normal growth (%) | 99.6 | 0.33 | 27.5 | 0.60 | 0.000 |
| | Litter (%) | 5.0 | 0.04 | 14.6 | 0.13 | 0.011 |

**Table 11 Environmental Variables Showing Significant Differences Between Favourable and Unfavourable Plots on Lowland Heathland Sites, Following Mann-Whitney U Analyses**

| Site | Variable | Favourable Plot | | Unfavourable Plot | | P-value |
|---|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD | |
| Cannock Chase, Dry Heath | Dwarf shrub cover (%) | 82.6 | 19.31 | 36.1 | 31.58 | 0.000 |
| Cavenham Heath, Dry Heath | Dwarf shrub cover (%) | 59.1 | 22.92 | 15.0 | 11.40 | 0.000 |
| | Rabbit dung (freq) | 0.5 | 0.51 | 0.9 | 0.25 | 0.000 |
| Roydon Common, Wet Heath | Dwarf shrub cover (%) | 8.2 | 10.76 | 60.3 | 31.02 | 0.021 |
| Aylesbeare, Dry Heath | Dwarf shrub cover (%) | 74.9 | 18.91 | 34.4 | 16.92 | 0.000 |
| Aylesbeare, Wet Heath | Dwarf shrub cover (%) | 39.9 | 17.92 | 14.7 | 15.36 | 0.000 |
| The Lizard, Dry Heath | no significant differences found between plots | | | | | |
| The Lizard, Wet Heath | no significant differences found between plots | | | | | |
| Thursley, Dry Heath | Rabbit dung (freq) | 0.2 | 0.38 | 0.0 | 0.00 | 0.034 |
| Thursley, Wet Heath | Dwarf shrub cover (%) | 48.5 | 31.31 | 16.3 | 23.63 | 0.042 |
| Lazonby Fell, Dry Heath | no significant differences found between plots | | | | | |
| New Forest, Dry Heath | Dwarf shrub cover (%) | 74.3 | 27.74 | 50.9 | 27.47 | 0.001 |
| | Horse dung (freq) | 0.1 | 0.31 | 0.5 | 0.51 | 0.001 |
| | Rabbit dung (freq) | 0.0 | 0.00 | 0.1 | 0.35 | 0.040 |
| New Forest, Wet Heath | no significant differences found between plots | | | | | |
| Hartland Moor, Dry Heath | Vegetation height (cm) | 24.9 | 12.82 | 57.0 | 58.39 | 0.009 |
| | Dwarf shrub cover (%) | 94.8 | 15.44 | 67.5 | 37.18 | 0.011 |
| Hartland Moor, Wet Heath | Dwarf shrub cover (%) | 64.8 | 16.85 | 42.1 | 20.25 | 0.000 |
| | Horse dung (freq) | 0.2 | 0.43 | 0.0 | 0.00 | 0.005 |
| | Rabbit dung (freq) | 0.1 | 0.35 | 0.0 | 0.00 | 0.040 |

**Table 12  Soil Data Collected From Bulk Soil Samples For Each Lowland Heathland Plot**

| Site | Heathland Type | Plot Condition | pH | OM | CEC | Total N | Extractable $PO_4$-P | K | Na | Ca | Mg | Fe | Al | Mn | P Index | K Index | Mg Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cannock Chase | Dry heath | Favourable | 3.6 | 27.8 | 7.8 | 6830 | 17.0 | 203 | 35 | 590 | 93 | 1058 | 15 | 46 | 2.1 | 2.6 | 2.8 |
| Cannock Chase | Dry heath | Unfavourable | 3.9 | 9.7 | 4.7 | 2900 | 10.0 | 96 | 19 | 335 | 49 | 1817 | 52 | 22 | 1.0 | 1.5 | 1.9 |
| | | | | | | | | | | | | | | | | | |
| Cavenham Heath | Dry heath | Favourable | 4.0 | 5.3 | 4.4 | 1540 | 34.0 | 50 | 15 | 320 | 35 | 859 | 28 | 19 | 3.4 | 0.8 | 1.3 |
| Cavenham Heath | Dry heath | Unfavourable | 4.0 | 5.0 | 2.9 | 1590 | 39.0 | 41 | 15 | 282 | 29 | 866 | 37 | 28 | 3.6 | 0.6 | 1.1 |
| | | | | | | | | | | | | | | | | | |
| Roydon Common | Wet heath | Favourable | 3.7 | 20.8 | 4.7 | 4320 | 9.0 | 63 | 36 | 328 | 63 | 450 | 22 | 12 | 0.9 | 1.0 | 2.2 |
| Roydon Common | Wet heath | Unfavourable | 3.5 | 16.4 | 4.6 | 3340 | 7.0 | 47 | 47 | 309 | 69 | 412 | 7 | 12 | 0.7 | 0.7 | 2.3 |
| | | | | | | | | | | | | | | | | | |
| Aylesbeare Heath | Dry heath | Favourable | 3.9 | 32.3 | 7.5 | 8040 | 5.0 | 112 | 49 | 473 | 155 | 325 | 9 | 15 | 0.5 | 1.8 | 3.7 |
| Aylesbeare Heath | Dry heath | Unfavourable | 4.2 | 21.9 | 6.6 | 7170 | 5.0 | 110 | 45 | 332 | 132 | 886 | 41 | 32 | 0.5 | 1.8 | 3.4 |
| Aylesbeare Heath | Wet heath | Favourable | 4.3 | 15.3 | 7.1 | 5250 | 6.0 | 84 | 48 | 512 | 89 | 853 | 143 | 48 | 0.6 | 1.3 | 2.7 |
| Aylesbeare Heath | Wet heath | Unfavourable | 4.3 | 21.6 | 7.5 | 8260 | 6.0 | 145 | 62 | 556 | 92 | 1347 | 230 | 76 | 0.6 | 2.2 | 2.8 |
| | | | | | | | | | | | | | | | | | |
| The Lizard | Dry heath | Favourable | 5.8 | 27.1 | 16.1 | 10100 | 6.0 | 145 | 194 | 678 | 1227 | 627 | 7 | 39 | 0.6 | 2.2 | 8.4 |
| The Lizard | Dry heath | Unfavourable | 5.3 | 23.3 | 16.3 | 8470 | 5.0 | 168 | 186 | 630 | 868 | 1086 | 19 | 61 | 0.5 | 2.3 | 7.6 |
| The Lizard | Wet heath | Favourable | 6.2 | 31.3 | 16.8 | 10800 | 3.0 | 98 | 120 | 879 | 1890 | 605 | 4 | 140 | 0.3 | 1.6 | 9.0 |
| The Lizard | Wet heath | Unfavourable | 6.2 | 30.7 | 14.8 | 11400 | 3.0 | 84 | 118 | 725 | 1745 | 497 | 5 | 70 | 0.3 | 1.3 | 9.0 |
| | | | | | | | | | | | | | | | | | |
| Thursley | Dry heath | Favourable | 4.0 | 5.1 | 4.3 | 1060 | 4.0 | 41 | 22 | 225 | 89 | 2065 | 9 | 12 | 0.4 | 0.6 | 2.7 |
| Thursley | Dry heath | Unfavourable | 3.9 | 8.3 | 4.6 | 2070 | 5.0 | 64 | 32 | 282 | 77 | 780 | 11 | 9 | 0.5 | 1.0 | 2.5 |
| Thursley | Wet heath | Favourable | 3.9 | 10.7 | 4.2 | 2130 | 5.0 | 57 | 30 | 239 | 59 | 1181 | 34 | 13 | 0.5 | 0.9 | 2.1 |
| Thursley | Wet heath | Unfavourable | 3.9 | 5.4 | 2.4 | 1050 | 4.0 | 38 | 26 | 165 | 36 | 1743 | 21 | 6 | 0.4 | 0.6 | 1.4 |
| | | | | | | | | | | | | | | | | | |
| Lazonby Fell | Dry heath | Favourable | 3.6 | 20.2 | 6.7 | 4160 | 5.0 | 62 | 33 | 411 | 116 | 617 | 8 | 20 | 0.5 | 1.0 | 3.2 |
| Lazonby Fell | Dry heath | Unfavourable | 3.5 | 14.2 | 4.9 | 3080 | 7.0 | 74 | 27 | 318 | 98 | 353 | 5 | 20 | 0.7 | 1.2 | 2.9 |
| | | | | | | | | | | | | | | | | | |
| New Forest | Dry heath | Favourable | 3.9 | 40.7 | 6.9 | 9760 | 6.0 | 110 | 37 | 413 | 127 | 722 | 6 | 13 | 0.6 | 1.8 | 3.3 |
| New Forest | Dry heath | Unfavourable | 3.9 | 17.1 | 6.5 | 4780 | 12.0 | 107 | 30 | 386 | 92 | 521 | 10 | 10 | 1.3 | 1.7 | 2.8 |
| New Forest | Wet heath | Favourable | 3.8 | 27.9 | 4.5 | 5570 | 5.0 | 70 | 46 | 234 | 96 | 267 | 24 | 10 | 0.5 | 1.1 | 2.9 |

| Site | Heathland Type | Plot Condition | pH | OM | CEC | Total N | Extractable $PO_4$-P | K | Na | Ca | Mg | Fe | Al | Mn | P Index | K Index | Mg Index |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Forest | Wet heath | Unfavourable | 3.8 | 19.0 | 4.6 | 4230 | 8.0 | 68 | 51 | 302 | 67 | 494 | 68 | 8 | 0.8 | 1.1 | 2.3 |
| | | | | | | | | | | | | | | | | | |
| Hartland Moor | Dry heath | Favourable | 3.7 | 16.5 | 6.6 | 3010 | 4.0 | 49 | 39 | 380 | 131 | 174 | 6 | 6 | 0.4 | 0.8 | 3.4 |
| Hartland Moor | Dry heath | Unfavourable | 4.0 | 20.0 | 7.3 | 4580 | 5.0 | 65 | 47 | 452 | 165 | 241 | 5 | 8 | 0.5 | 1.0 | 3.8 |
| Hartland Moor | Wet heath | Favourable | 3.8 | 15.8 | 4.2 | 3070 | 5.0 | 61 | 33 | 215 | 71 | 381 | 9 | 8 | 0.5 | 1.0 | 2.4 |
| Hartland Moor | Wet heath | Unfavourable | 4.0 | 27.9 | 9.3 | 7480 | 3.0 | 69 | 71 | 624 | 145 | 923 | 13 | 15 | 0.3 | 1.1 | 3.5 |

**Table 13 Slope and Aspect Measurements At The Plot Scale For All Lowland Heathland Sites**

| Site Name | Heath Type | Plot Condition | Slope (degrees) | Aspect (degrees) |
|---|---|---|---|---|
| Cannock Chase | Dry | F | 8 | 14 |
| Cannock Chase | Dry | U | 2 | 208 |
| Cavenham Heath | Dry | F | 3 | 328 |
| Cavenham Heath | Dry | U | 2 | 316 |
| Roydon Common | Wet | F | 2 | 100 |
| Roydon Common | Wet | U | 2 | 262 |
| Aylesbeare | Dry | F | 12 | 360 |
| Aylesbeare | Dry | U | 5 | 20 |
| Aylesbeare | Wet | F | 5 | 58 |
| Aylesbeare | Wet | U | 4 | 351 |
| The Lizard | Dry | F | 3 | 303 |
| The Lizard | Dry | U | 3 | 351 |
| The Lizard | Wet | F | 3 | 314 |
| The Lizard | Wet | U | 1 | 244 |
| Thursley | Dry | F | 4 | 344 |
| Thursley | Dry | U | 12 | 25 |
| Thursley | Wet | F | 1 | 100 |
| Thursley | Wet | U | 1 | 100 |
| Lazonby Fell | Dry | F | 2 | 315 |
| Lazonby Fell | Dry | U | 0 | 0 |
| New Forest | Dry | F | 0 | 0 |
| New Forest | Dry | U | 2 | 5 |
| New Forest | Wet | F | 4 | 180 |
| New Forest | Wet | U | 5 | 228 |
| Hartland Moor | Dry | F | 1 | 98 |
| Hartland Moor | Dry | U | 3 | 98 |
| Hartland Moor | Wet | F | 0 | 0 |
| Hartland Moor | Wet | U | 2 | 110 |

**Table 14 Critical Loads Data Collated For Each 10km Grid Square For All Lowland Heatheland Sites, as obtained from CEH**

| Site Name | Max. Critical Load for Nitrogen | Max. Critical Load for Sulphur | Min. Critical Load for Nitrogen | Nutrient Nitrogen Critical Load | Empirical Critical Load of Acidity for Soils |
|---|---|---|---|---|---|
| Cannock Chase | 1.642 | 0.25 | 1.392 | 0.857 | 0.1 |
| Cavenham Heath | n/a | n/a | n/a | n/a | 4 |
| Roydon Common | 0.852 | 0.21 | 0.642 | 1.071 | 0.1 |
| Aylesbeare Common | 2.284 | 1.57 | 0.714 | 1.071 | 1.5 |
| The Lizard | 3.034 | 1.57 | 1.464 | 0.857 | 1.5 |
| Thursley | 1.692 | 0.3 | 1.392 | 0.857 | 0.1 |
| Lazonby Fell | 1.582 | 0.19 | 1.392 | 0.857 | 0.1 |
| New Forest | 0.882 | 0.24 | 0.642 | 1.071 | 0.1 |
| Hartland Moor | 1.358 | 0.305 | 1.053 | 1.071 | 0.1 |

All values in units of kilo-equivalents per hectare per year (keq/ha/yr)

**Table 15 Summary Of The DCA Ordination Results For Lowland Heathland Plots**

**Cannock Chase, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.779 | 0.352 | 0.175 | 0.093 |
| Lengths of gradient | 4.030 | 2.401 | 1.955 | 1.826 |
| Cumulative percent variance of species data | 24.0 | 34.9 | 40.3 | 43.2 |

**Cavenham Heath, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.443 | 0.275 | 0.150 | 0.078 |
| Lengths of gradient | 2.754 | 2.831 | 1.903 | 1.212 |
| Cumulative percent variance of species data | 24.4 | 39.6 | 47.9 | 52.2 |

**Roydon Common, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.589 | 0.236 | 0.125 | 0.071 |
| Lengths of gradient | 2.522 | 2.118 | 2.009 | 1.200 |
| Cumulative percent variance of species data | 34.8 | 48.8 | 56.2 | 60.4 |

**Aylesbeare Heath, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.431 | 0.103 | 0.051 | 0.031 |
| Lengths of gradient | 2.150 | 1.980 | 1.103 | 0.955 |
| Cumulative percent variance of species data | 53.5 | 66.3 | 72.5 | 76.4 |

**Aylesbeare Heath, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.526 | 0.192 | 0.138 | 0.076 |
| Lengths of gradient | 3.271 | 2.117 | 2.246 | 1.841 |
| Cumulative percent variance of species data | 24.5 | 33.4 | 39.9 | 43.4 |

**The Lizard, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.345 | 0.146 | 0.112 | 0.065 |
| Lengths of gradient | 1.778 | 1.517 | 1.153 | 1.019 |
| Cumulative percent variance of species data | 29.1 | 41.4 | 50.8 | 56.3 |

**The Lizard, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.203 | 0.097 | 0.050 | 0.034 |
| Lengths of gradient | 1.617 | 1.823 | 0.853 | 0.867 |
| Cumulative percent variance of species data | 30.4 | 45.0 | 52.5 | 57.6 |

**Thursley, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.775 | 0.227 | 0.138 | 0.049 |
| Lengths of gradient | 2.489 | 1.770 | 1.547 | 1.050 |
| Cumulative percent variance of species data | 38.1 | 43.9 | 56.1 | 58.5 |

**Thursley, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.516 | 0.267 | 0.175 | 0.119 |
| Lengths of gradient | 3.292 | 2.112 | 2.186 | 2.074 |
| Cumulative percent variance of species data | 18.5 | 28.1 | 34.4 | 38.7 |

**Lazonby Fell, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.372 | 0.223 | 0.085 | 0.041 |
| Lengths of gradient | 2.403 | 2.159 | 1.378 | 1.285 |
| Cumulative percent variance of species data | 31.5 | 50.3 | 57.5 | 61.0 |

**New Forest, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.433 | 0.171 | 0.103 | 0.060 |
| Lengths of gradient | 2.855 | 2.172 | 1.413 | 1.205 |
| Cumulative percent variance of species data | 27.4 | 38.2 | 44.7 | 48.5 |

**New Forest, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.170 | 0.089 | 0.046 | 0.027 |
| Lengths of gradient | 1.614 | 1.090 | 1.400 | 0.821 |
| Cumulative percent variance of species data | 25.7 | 39.1 | 46.0 | 50.0 |

**Hartland Moor, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.741 | 0.176 | 0.127 | 0.069 |
| Lengths of gradient | 2.809 | 1.742 | 1.722 | 1.696 |
| Cumulative percent variance of species data | 40.8 | 50.5 | 57.5 | 61.2 |

**Hartland Moor, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.733 | 0.121 | 0.078 | 0.037 |
| Lengths of gradient | 3.385 | 1.358 | 1.299 | 1.161 |
| Cumulative percent variance of species data | 43.9 | 51.2 | 55.8 | 58.0 |

**Table 16 Summary Of The CCA Ordination Results For Lowland Heathland Plots**

**Cannock Chase, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.622 | 0.234 | 0.105 | 0.056 |
| Species environment correlations | 0.963 | 0.816 | 0.582 | 0.528 |
| Cumulative percent variance of species data | 19.2 | 26.4 | 29.7 | 31.4 |
| Cumulative percent variance of species environment data | 54.2 | 74.7 | 83.8 | 88.7 |

**Cavenham Heath, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.429 | 0.202 | 0.14 | 0.125 |
| Species environment correlations | 0.987 | 0.979 | 0.745 | 0.774 |
| Cumulative percent variance of species data | 23.6 | 34.8 | 42.5 | 49.3 |
| Cumulative percent variance of species environment data | 39.2 | 57.6 | 70.4 | 81.8 |

**Roydon Common, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.434 | 0.272 | 0.128 | 0.045 |
| Species environment correlations | 0.925 | 0.757 | 0.784 | 0.574 |
| Cumulative percent variance of species data | 25.7 | 41.8 | 49.3 | 52 |
| Cumulative percent variance of species environment data | 45.4 | 73.9 | 87.3 | 92 |

**Aylesbeare Heath, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.324 | 0.062 | 0.021 | 0.015 |
| Species environment correlations | 0.874 | 0.76 | 0.419 | 0.557 |
| Cumulative percent variance of species data | 40.2 | 48 | 50.5 | 52.4 |
| Cumulative percent variance of species environment data | 74.2 | 88.5 | 93.2 | 96.6 |

**Aylesbeare Heath, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.435 | 0.172 | 0.125 | 0.089 |
| Species environment correlations | 0.915 | 0.927 | 0.887 | 0.849 |
| Cumulative percent variance of species data | 20.2 | 28.2 | 34 | 38.2 |
| Cumulative percent variance of species environment data | 42.4 | 59.2 | 71.4 | 80.1 |

**The Lizard, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.276 | 0.118 | 0.045 | 0.025 |
| Species environment correlations | 0.914 | 0.841 | 0.67 | 0.735 |
| Cumulative percent variance of species data | 23.2 | 33.2 | 36.9 | 39.1 |
| Cumulative percent variance of species environment data | 54.5 | 77.8 | 86.6 | 91.6 |

**The Lizard, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Eigenvalues | 0.082 | 0.075 | 0.020 | 0.017 |
| Species environment correlations | 0.855 | 0.671 | 0.662 | 0.489 |
| Cumulative percent variance of species data | 12.3 | 23.5 | 26.4 | 29 |
| Cumulative percent variance of species environment data | 36.7 | 70.3 | 79 | 86.7 |

**Thursley, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.741 | 0.196 | 0.083 | 0.069 |
| **Species environment correlations** | 0.978 | 0.943 | 0.605 | 0.606 |
| **Cumulative percent variance of species data** | 36.4 | 46.1 | 5.02 | 53.6 |
| **Cumulative percent variance of species environment data** | 61.8 | 78.2 | 85.2 | 90.9 |

**Thursley, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.489 | 0.358 | 0.237 | 0.14 |
| **Species environment correlations** | 0.981 | 0.979 | 0.818 | 0.769 |
| **Cumulative percent variance of species data** | 17.0 | 30.4 | 38.9 | 43.9 |
| **Cumulative percent variance of species environment data** | 33.5 | 58 | 74.3 | 83.9 |

**Lazonby Fell, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.240 | 0.138 | 0.056 | 0.046 |
| **Species environment correlations** | 0.815 | 0.857 | 0.545 | 0.564 |
| **Cumulative percent variance of species data** | 20.3 | 32 | 36.7 | 40.6 |
| **Cumulative percent variance of species environment data** | 46.0 | 72.5 | 83.3 | 92.1 |

**New Forest, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.356 | 0.149 | 0.098 | 0.086 |
| **Species environment correlations** | 0.915 | 0.857 | 0.842 | 0.747 |
| **Cumulative percent variance of species data** | 22.6 | 32 | 38.2 | 43.6 |
| **Cumulative percent variance of species environment data** | 38.5 | 54.6 | 65.2 | 74.4 |

**New Forest, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.147 | 0.097 | 0.051 | 0.036 |
| **Species environment correlations** | 0.946 | 0.977 | 0.815 | 0.795 |
| **Cumulative percent variance of species data** | 22.2 | 36.9 | 44.5 | 49.9 |
| **Cumulative percent variance of species environment data** | 37.3 | 61.9 | 74.7 | 83.8 |

**Hartland Moor, Dry Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.710 | 0.266 | 0.131 | 0.053 |
| **Species environment correlations** | 0.980 | 0.913 | 0.8 | 0.6.1 |
| **Cumulative percent variance of species data** | 39.1 | 53.7 | 60.9 | 63.8 |
| **Cumulative percent variance of species environment data** | 55.0 | 75.5 | 85.7 | 89.8 |

**Hartland Moor, Wet Heath**

| Axes | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| **Eigenvalues** | 0.665 | 0.219 | 0.125 | 0.053 |
| **Species environment correlations** | 0.955 | 0.876 | 0.907 | 0.663 |
| **Cumulative percent variance of species data** | 39.8 | 53 | 60.5 | 63.7 |
| **Cumulative percent variance of species environment data** | 58.3 | 77.5 | 88.5 | 93.2 |

**Table 17. Spearman's Rank Correlation Coefficient for the Median DCA scores and Soil Chemical Parameters, Aerial Pollution and Long-term Yearly Average for Weather Data for each Lowland Heathland Site**

| | pH | Organic Matter | CEC | P Index | K Index | Mg Index |
|---|---|---|---|---|---|---|
| **Axis 1** | 0.030 | -0.201 | -0.225 | -0.016 | -0.177 | -0.142 |
| **Axis 2** | -0.099 | -0.152 | 0.220 | 0.020 | 0.022 | 0.051 |

| | Total N | Extractable $PO_4$-P | K | Na | Ca | Mg | Fe | Al | Mn |
|---|---|---|---|---|---|---|---|---|---|
| **Axis 1** | -0.123 | -0.016 | -0.186 | -0.110 | -0.219 | -0.146 | 0.083 | 0.053 | -0.153 |
| **Axis 2** | -0.071 | 0.020 | 0.028 | -0.211 | 0.264 | 0.059 | 0.097 | -0.283 | 0.203 |

| | Max Temp | Minimum Temp | Air Frost | Sunshine | Rainfall | Rainfall >1mm |
|---|---|---|---|---|---|---|
| **Axis 1** | 0.208 | -0.064 | 0.199 | 0.249 | -0.120 | -0.344 |
| **Axis 2** | -0.368 | -0.406 | 0.333 | -0.495 | 0.092 | 0.288 |

| | Max Crit Load N | Max Crit Load S | Min Crit Load N | Nutr N Crti Load | Crit Load Acidity |
|---|---|---|---|---|---|
| **Axis 1** | -0.396 | -0.238 | -0.400 | 0.412 | -0.267 |
| **Axis 2** | 0.113 | -0.187 | 0.397 | -0.454 | -0.134 |

**Table 18. Summary of the DCA and CCA Ordination Results for the Combined Dry and Wet Lowland Heathland Sites**

**DCA - Dry Heath Sites**

| **Axes** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Eigenvalues** | 0.875 | 0.557 | 0.503 | 0.384 |
| **Lengths of gradient** | 6.249 | 4.893 | 4.727 | 2.993 |
| **Cumulative percent variance of species data** | 11.4 | 18.6 | 25.2 | 30.2 |

**DCA - Wet Heath Sites**

| **Axes** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Eigenvalues** | 0.627 | 0.443 | 0.109 | 0.13 |
| **Lengths of gradient** | 3.657 | 3.966 | 2.607 | 2.169 |
| **Cumulative percent variance of species data** | 14.7 | 25.0 | 29.4 | 32.5 |

**CCA - Dry Heath Sites**

| **Axes** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Eigenvalues** | 0.591 | 0.525 | 0.416 | 0.258 |
| **Species environment correlations** | 0.833 | 0.851 | 0.853 | 0.675 |
| **Cumulative percent variance of species data** | 7.7 | 14.5 | 19.9 | 23.3 |
| **Cumulative percent variance of species environment data** | 23.3 | 44.0 | 60.5 | 70.6 |

**CCA - Wet Heath Sites**

| **Axes** | **1** | **2** | **3** | **4** |
|---|---|---|---|---|
| **Eigenvalues** | 0.513 | 0.299 | 0.225 | 0.161 |
| **Species environment correlations** | 0.908 | 0.803 | 0.752 | 0.727 |
| **Cumulative percent variance of species data** | 12.0 | 19.0 | 24.2 | 28.0 |
| **Cumulative percent variance of species environment data** | 32.3 | 51.1 | 65.2 | 75.4 |

**Table 19. Results of the Forward Selection Analysis of Environmental Variables for the CCA of Combined Heath Sites**

| Dry Heaths | | | | |
|---|---|---|---|---|
| **Variable** | **Var.N** | **LambdaA** | **P** | **F** |
| VegHt | 1 | 0.07 | **0.01** | 6.34 |
| DwShrb | 2 | 0.30 | **0.01** | 22.93 |
| Lich | 4 | 0.01 | 0.41 | 0.73 |
| Bryo | 5 | 0.04 | **0.01** | 4.00 |
| Acro | 6 | 0.13 | **0.01** | 10.55 |
| Gram | 7 | 0.07 | **0.01** | 5.35 |
| Pion | 8 | 0.01 | 0.40 | 0.87 |
| Build | 9 | 0.01 | 0.29 | 1.08 |
| Matu | 10 | 0.05 | **0.01** | 4.58 |
| Dege | 11 | 0.07 | **0.01** | 5.83 |
| Dead | 12 | 0.11 | **0.01** | 9.63 |
| Flow | 13 | 0.33 | **0.01** | 23.93 |
| Norm | 14 | 0.42 | **0.01** | 27.76 |
| DStk | 15 | 0.00 | 0.84 | 0.49 |
| Topi | 16 | 0.03 | **0.04** | 2.73 |
| Carpt | 17 | 0.10 | **0.01** | 7.76 |
| Shp | 22 | 0.01 | 0.65 | 0.52 |
| Catt | 23 | 0.02 | 0.27 | 0.96 |
| Hrse | 24 | 0.00 | 0.81 | 0.27 |
| Rabb | 25 | 0.38 | **0.01** | 26.50 |
| Othr | 26 | 0.02 | 0.15 | 1.54 |
| BG | 27 | 0.01 | 0.22 | 1.28 |
| Er | 28 | 0.01 | 0.55 | 0.88 |
| Eros | 29 | 0.02 | **0.04** | 2.05 |
| Burn | 30 | 0.00 | 0.78 | 0.32 |
| Byr | 31 | 0.01 | 0.30 | 0.97 |
| Litt | 32 | 0.23 | **0.01** | 17.34 |
| DdWd | 34 | 0.05 | **0.01** | 3.79 |
| Ston | 35 | 0.02 | 0.14 | 1.57 |

| Wet Heaths | | | | |
|---|---|---|---|---|
| **Variable** | **Var.N** | **LambdaA** | **P** | **F** |
| VegHt | 1 | 0.23 | **0.01** | 22.21 |
| DwShrb | 2 | 0.14 | **0.01** | 15.00 |
| Sph | 3 | 0.06 | **0.01** | 6.20 |
| Lich | 4 | 0.02 | **0.03** | 2.24 |
| Bryo | 5 | 0.14 | **0.01** | 15.10 |
| Acro | 6 | 0.02 | 0.06 | 1.89 |
| Gram | 7 | 0.16 | **0.01** | 16.36 |
| Pion | 8 | 0.04 | **0.01** | 4.15 |
| Build | 9 | 0.01 | 0.22 | 1.21 |
| Matu | 10 | 0.03 | **0.01** | 3.62 |
| Dege | 11 | 0.03 | **0.01** | 3.18 |
| Dead | 12 | 0.13 | **0.01** | 15.03 |
| Flow | 13 | 0.02 | **0.01** | 2.37 |
| Norm | 14 | 0.06 | **0.01** | 6.87 |
| Topi | 16 | 0.01 | 0.10 | 1.92 |

| Wet Heaths | | | | |
|---|---|---|---|---|
| **Variable** | **Var.N** | **LambdaA** | **P** | **F** |
| Catt | 23 | 0.01 | 0.31 | 1.16 |
| Hrse | 24 | 0.01 | 0.23 | 1.16 |
| Rabb | 25 | 0.02 | **0.03** | 2.61 |
| Othr | 26 | 0.01 | 0.12 | 1.95 |
| BG | 27 | 0.03 | **0.01** | 4.10 |
| Er | 28 | 0.01 | 0.39 | 0.87 |
| Litt | 32 | 0.04 | **0.01** | 5.73 |
| DdGr | 33 | 0.36 | **0.01** | 32.56 |

# *Figures*

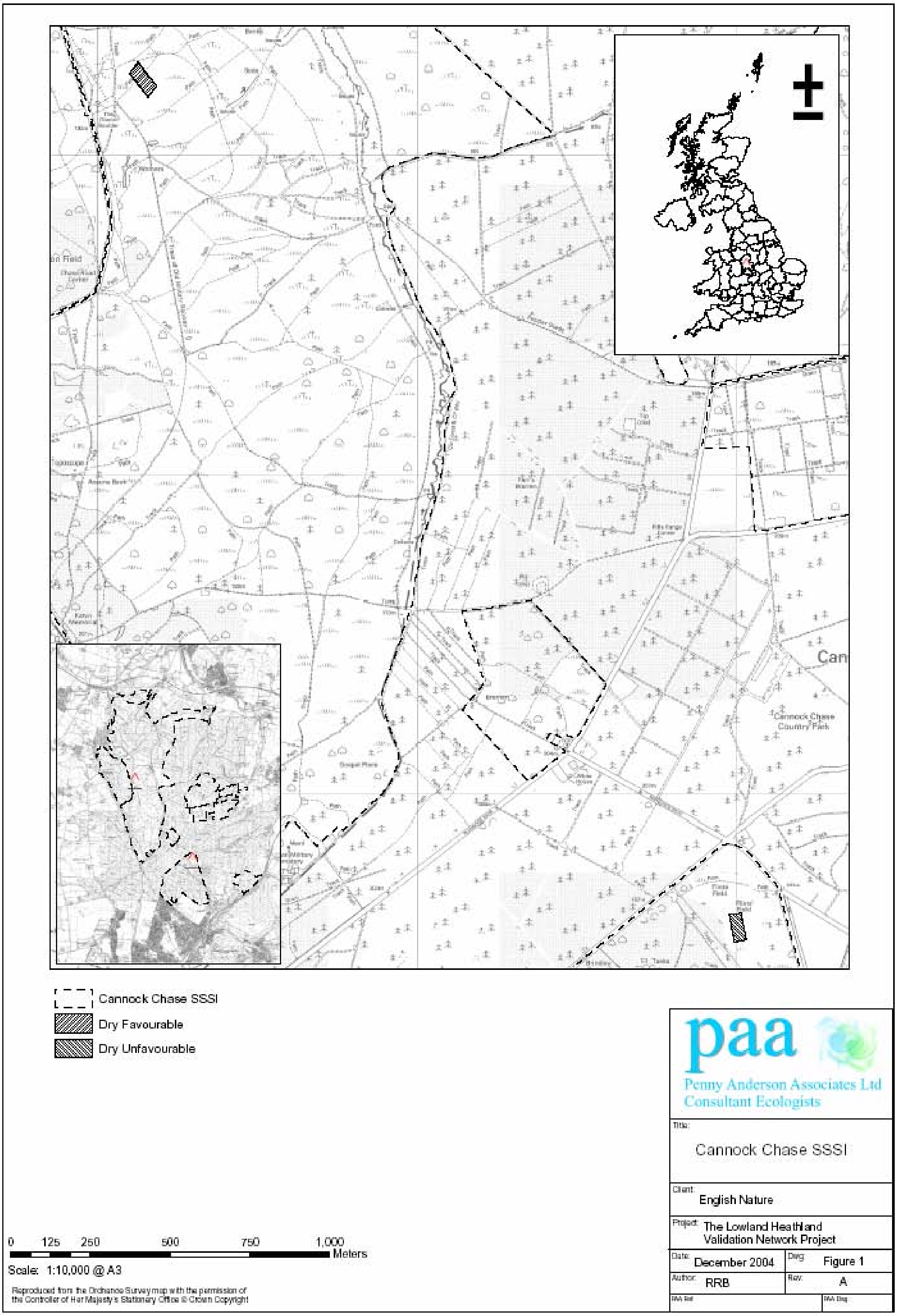



**Figure 1 Cannock Chase SSSI**

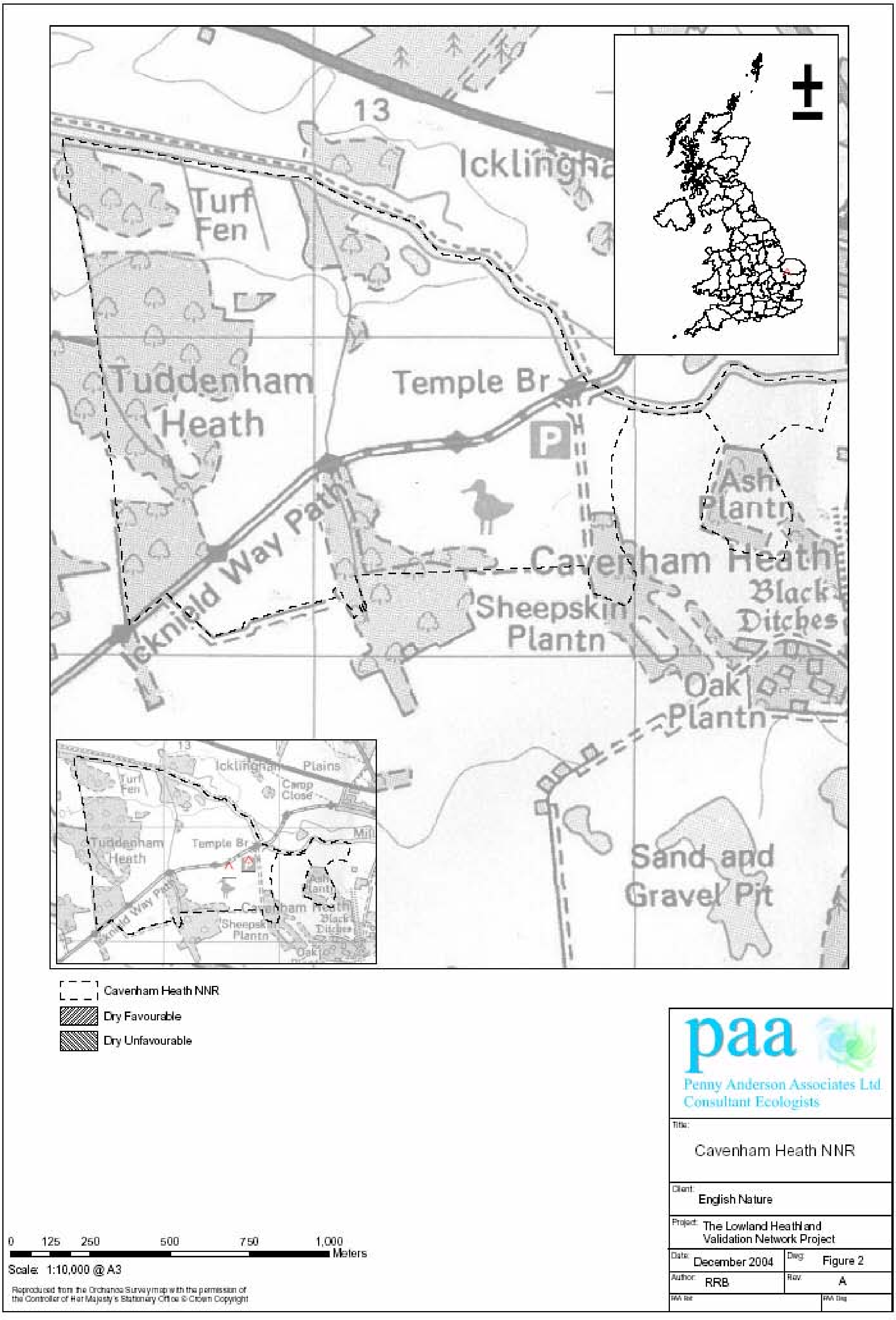



**Figure 2 Cavenham Heath NNR**

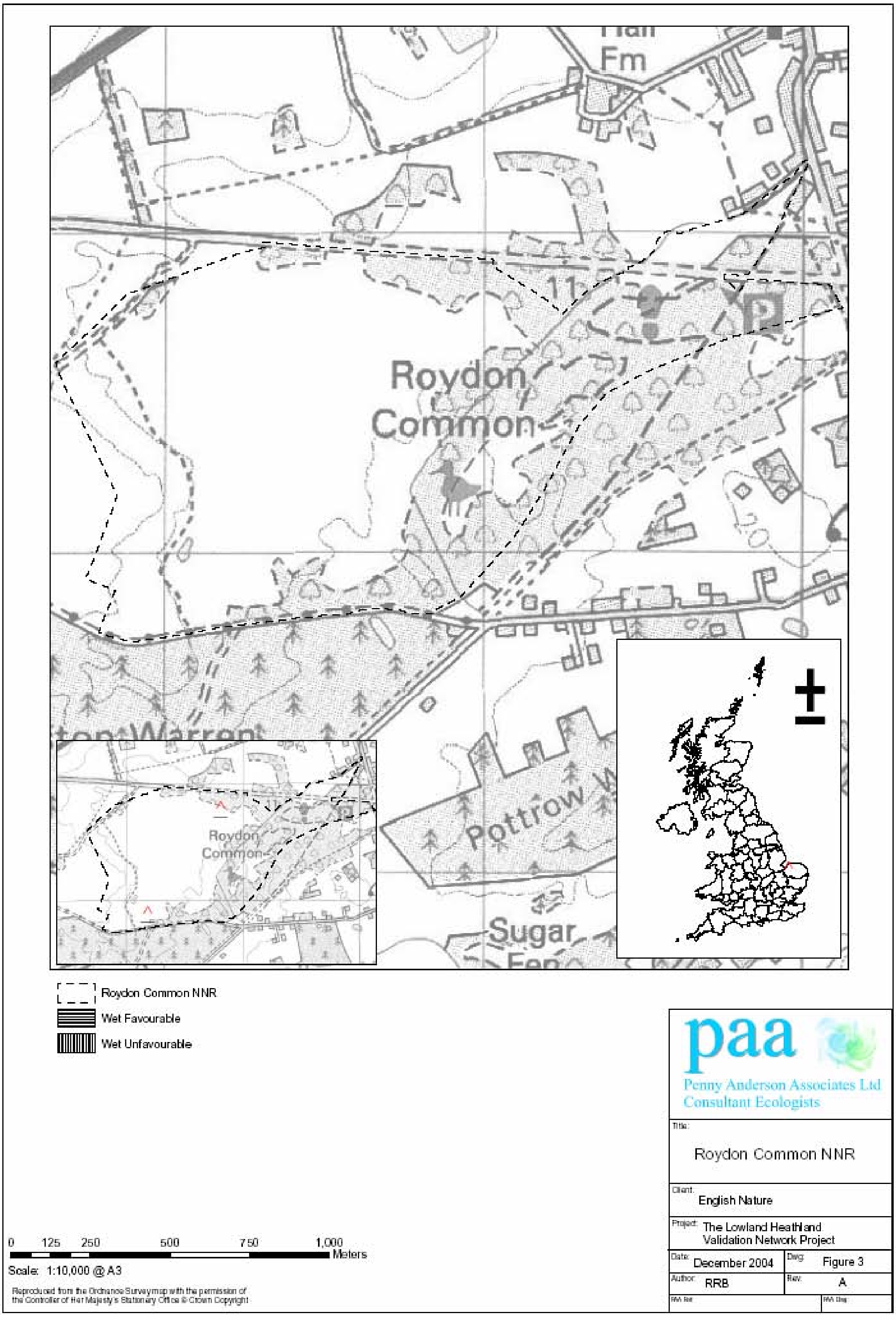



**Figure 3 Roydon Common NNR**

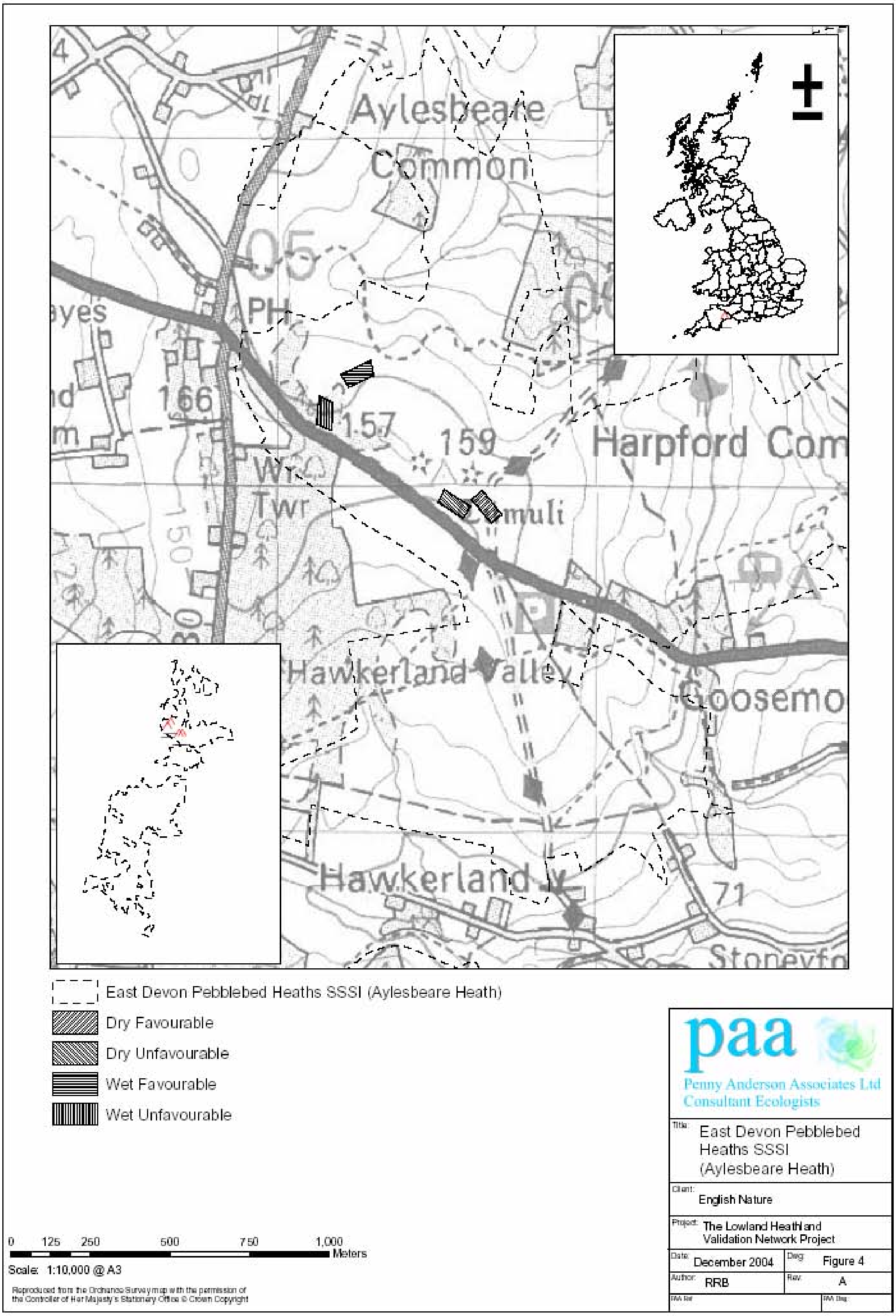



**Figure 4 Aylesbeare Heath (part of the East Devon Pebble Bed Heaths SSSI)**

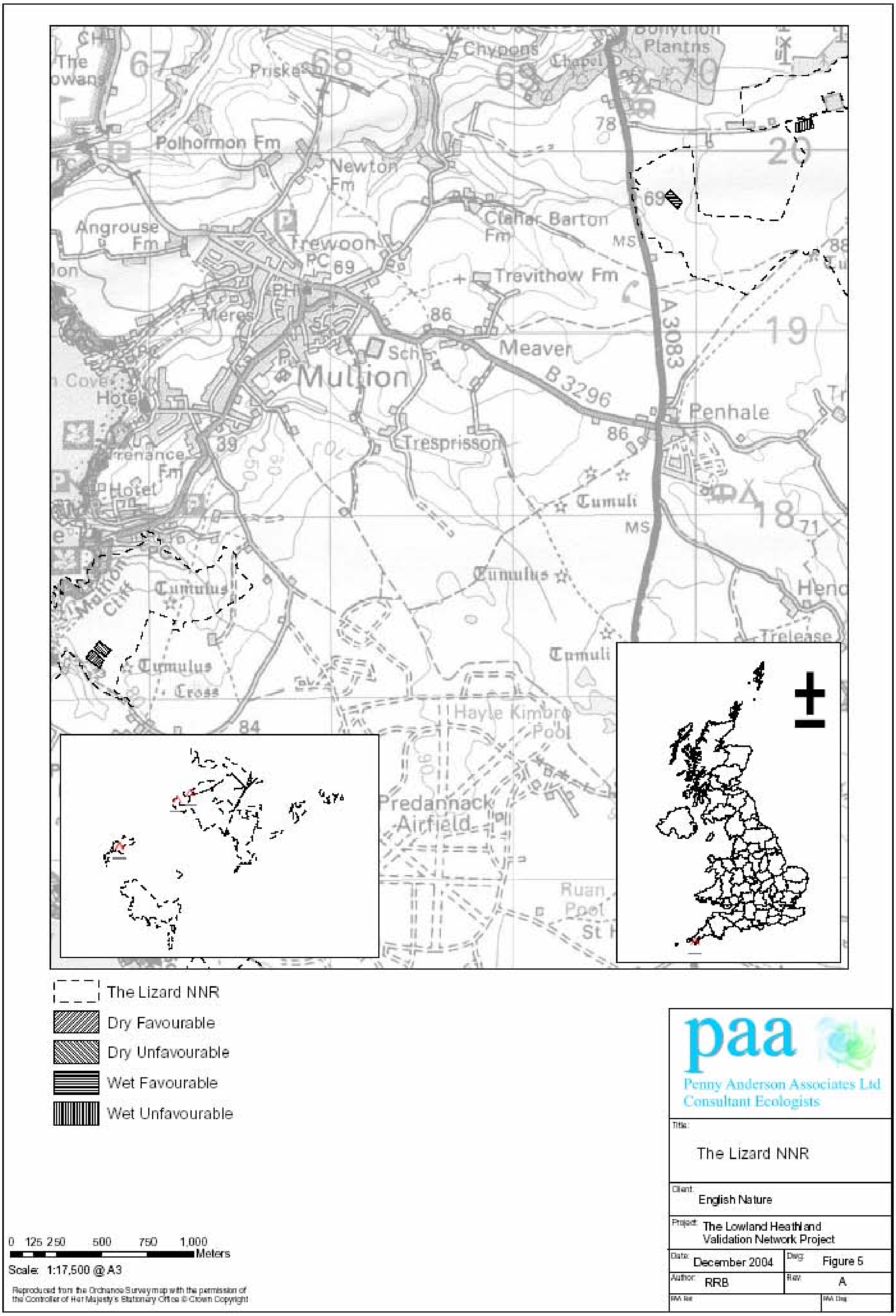



**Figure 5 The Lizard NNR**


**Figure 6 Thursley NNR**

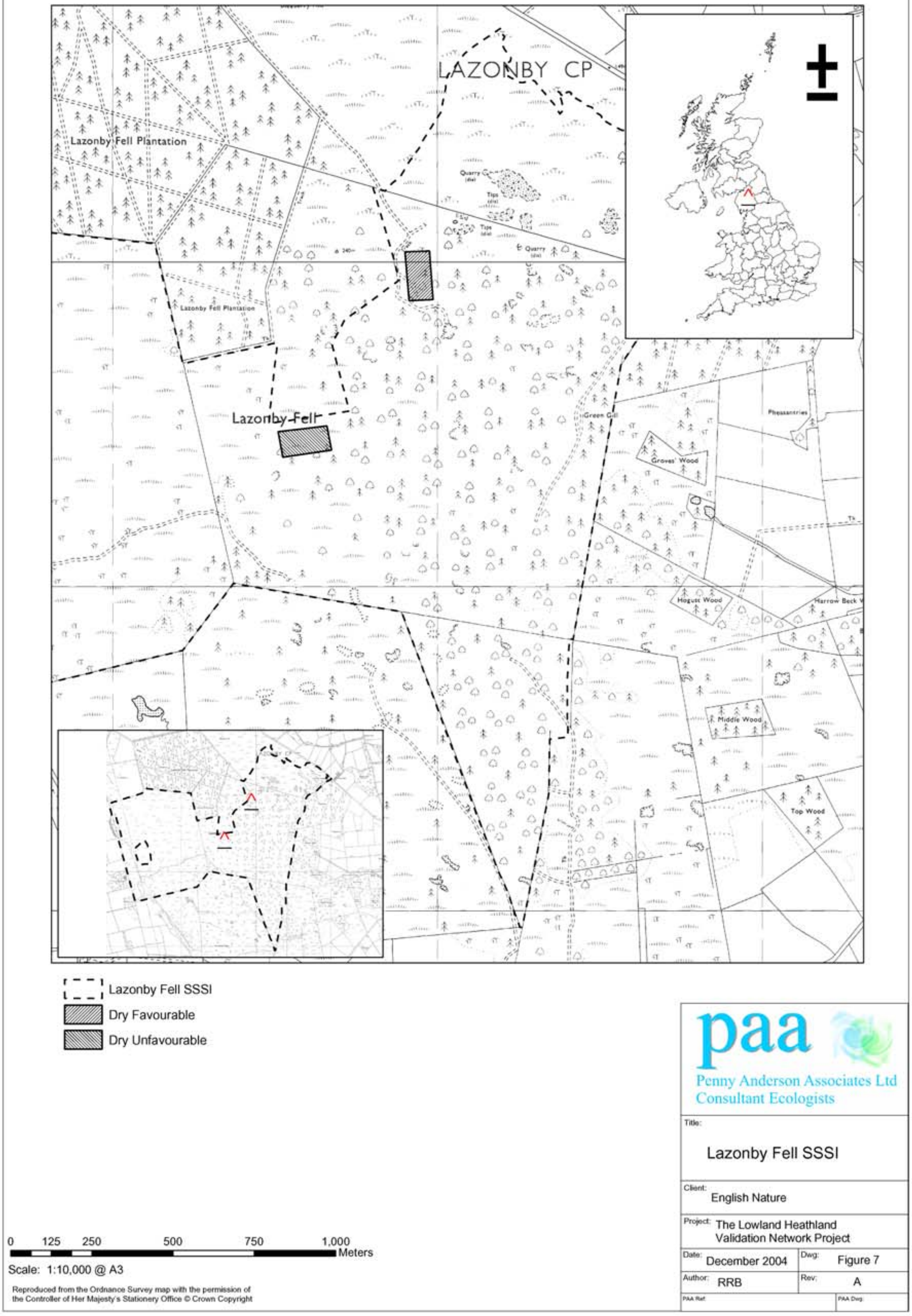



**Figure 7 Lazonby Fell SSSI**

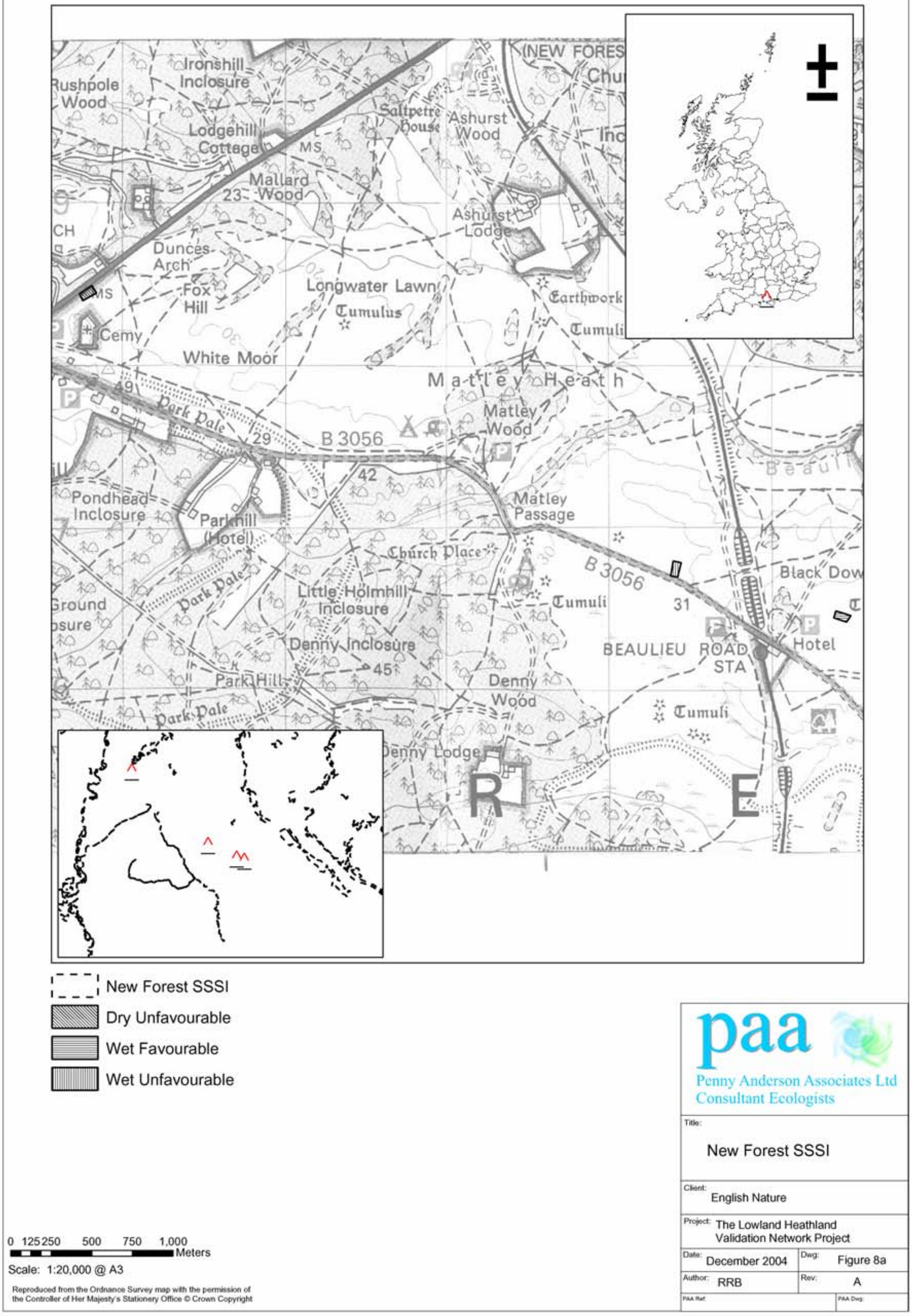



**Figure 8a New Forest SSSI**

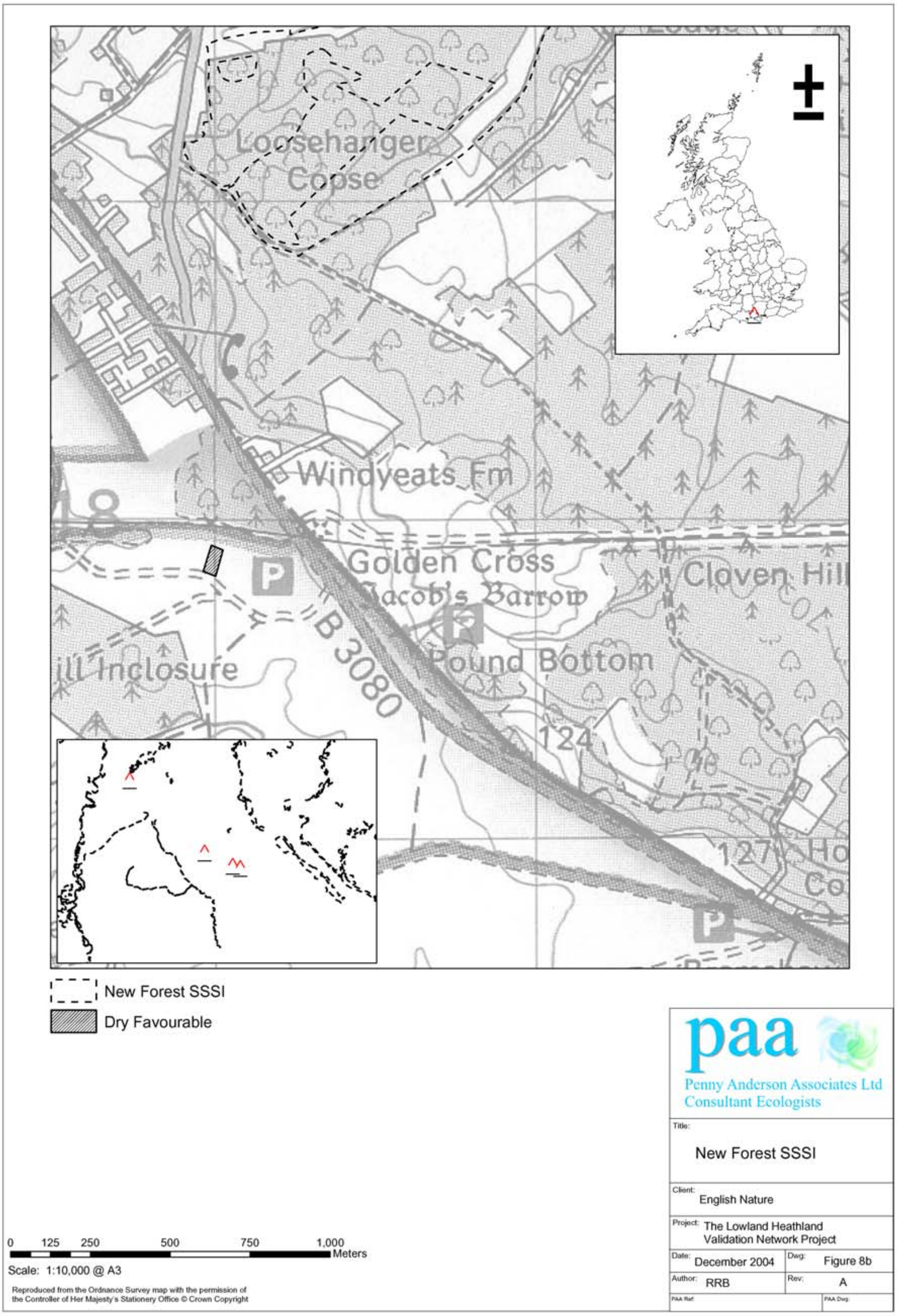
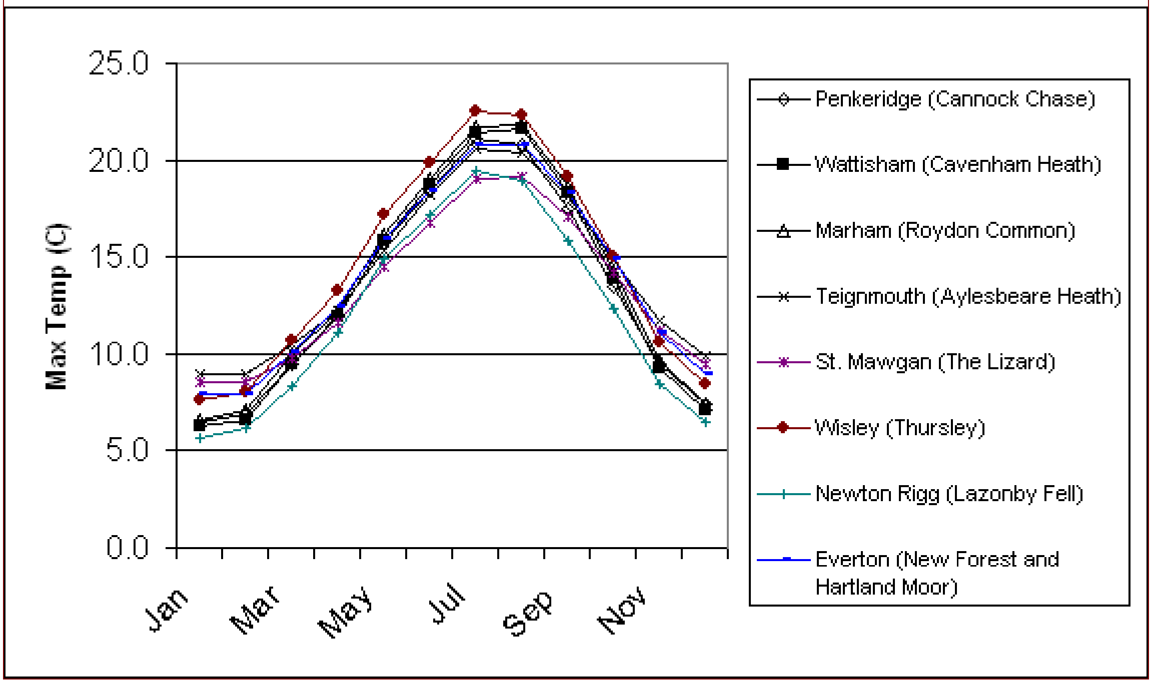


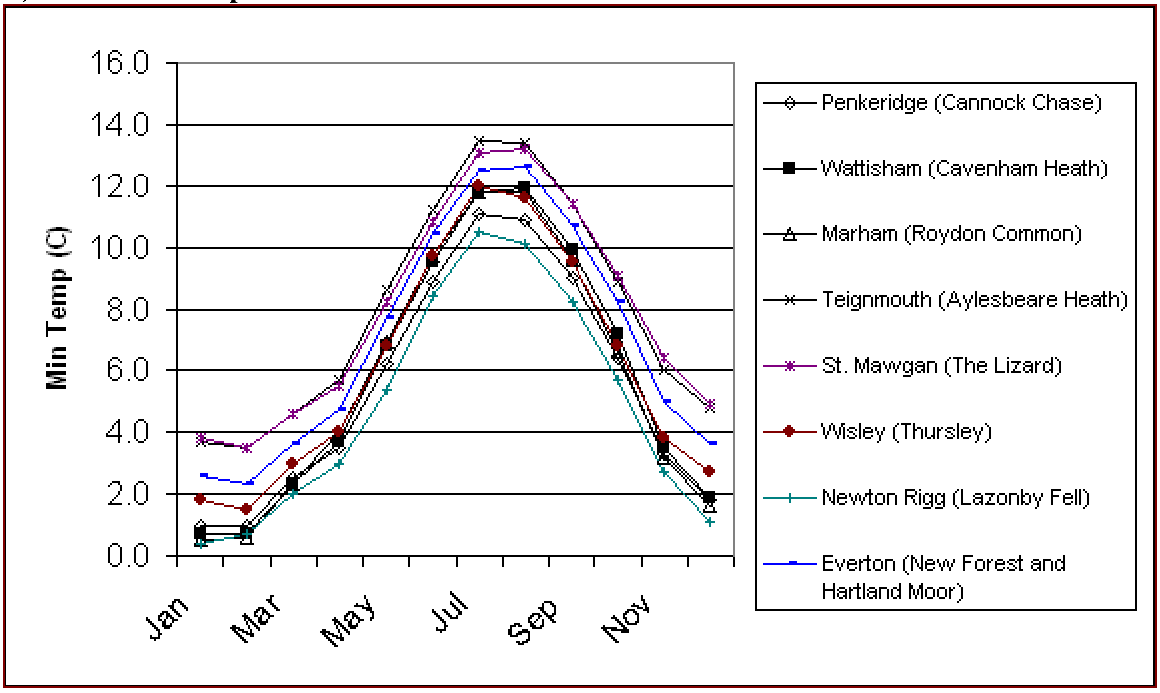

**Figure 8b New Forest SSSI**


**Figure 9 Hartland Moor NNR & Wytch Heath SSSI**

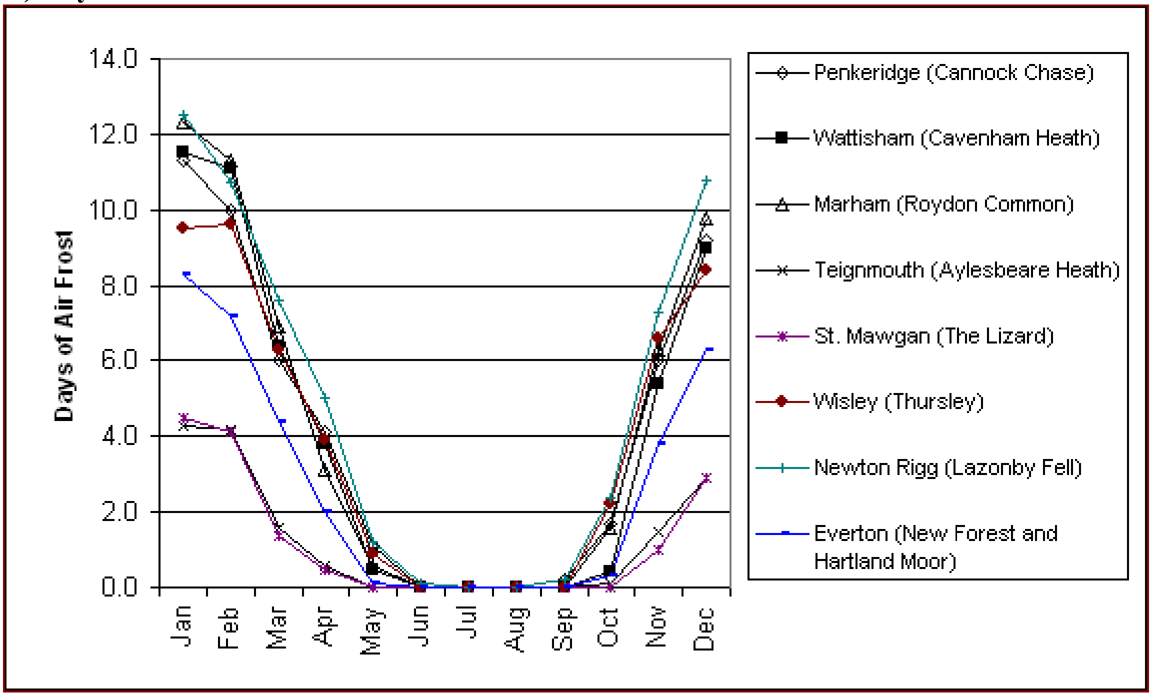
A) Maximum Temperature



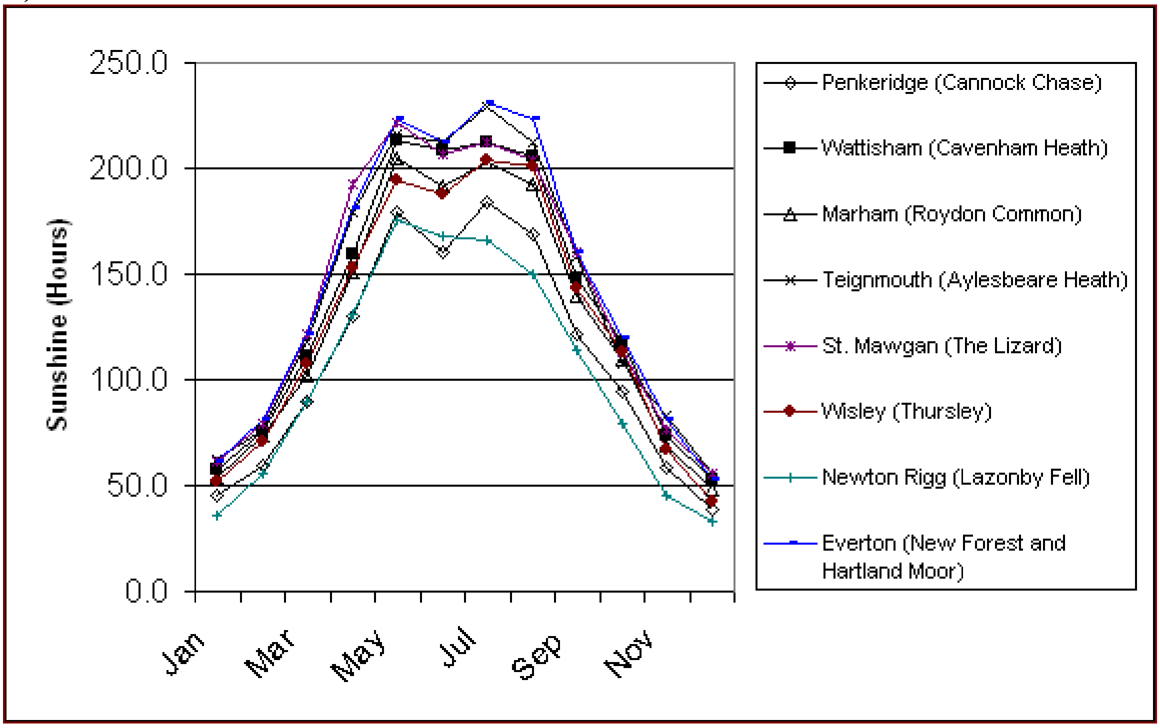

B) Minimum Temperature



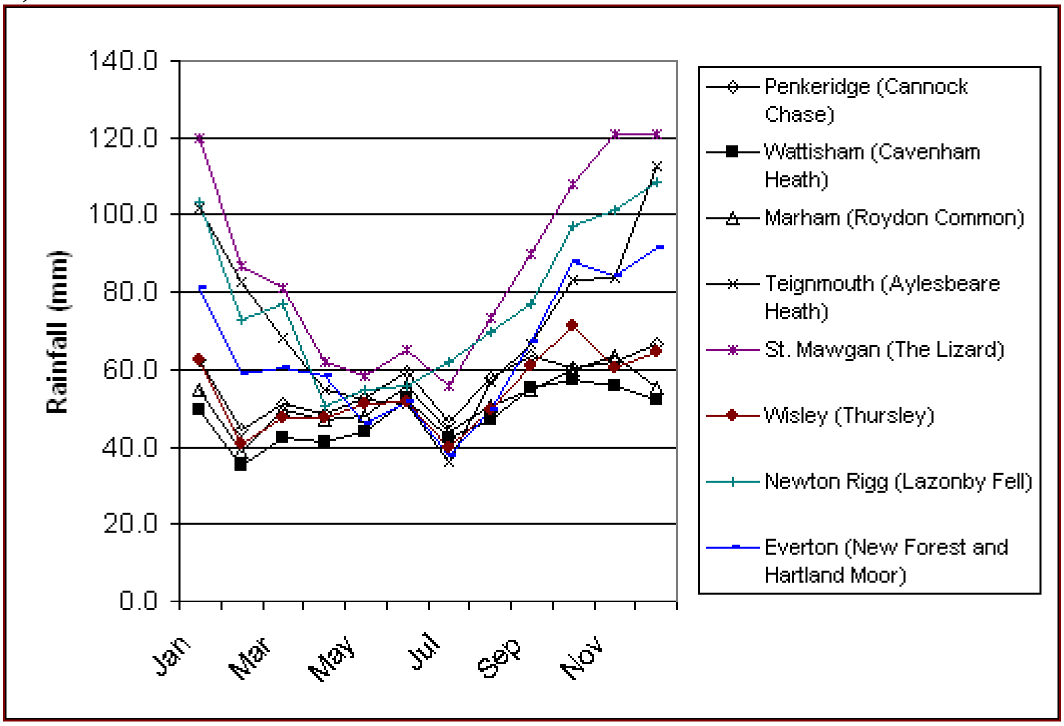
**C) Days of Air Frost**




**D) Hours of Sunshine**



E) Rainfall




F) Days of Rainfall >1mm

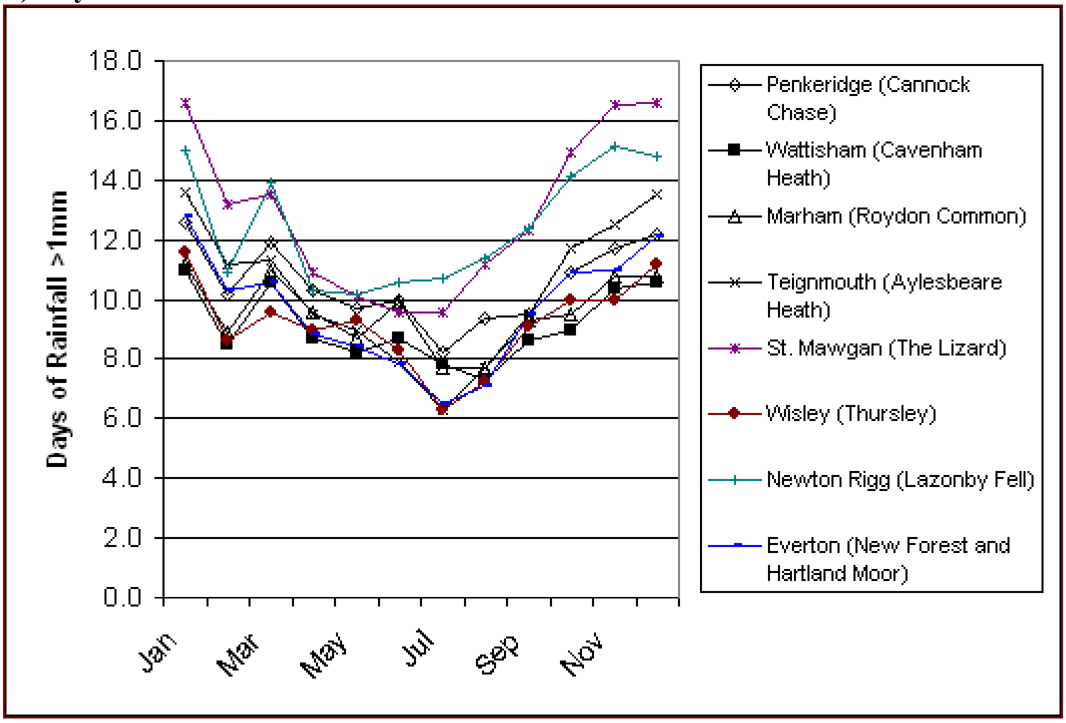



**Figure 10 Long Term Averages (1971 - 2000) for Selected Meteorological Data**

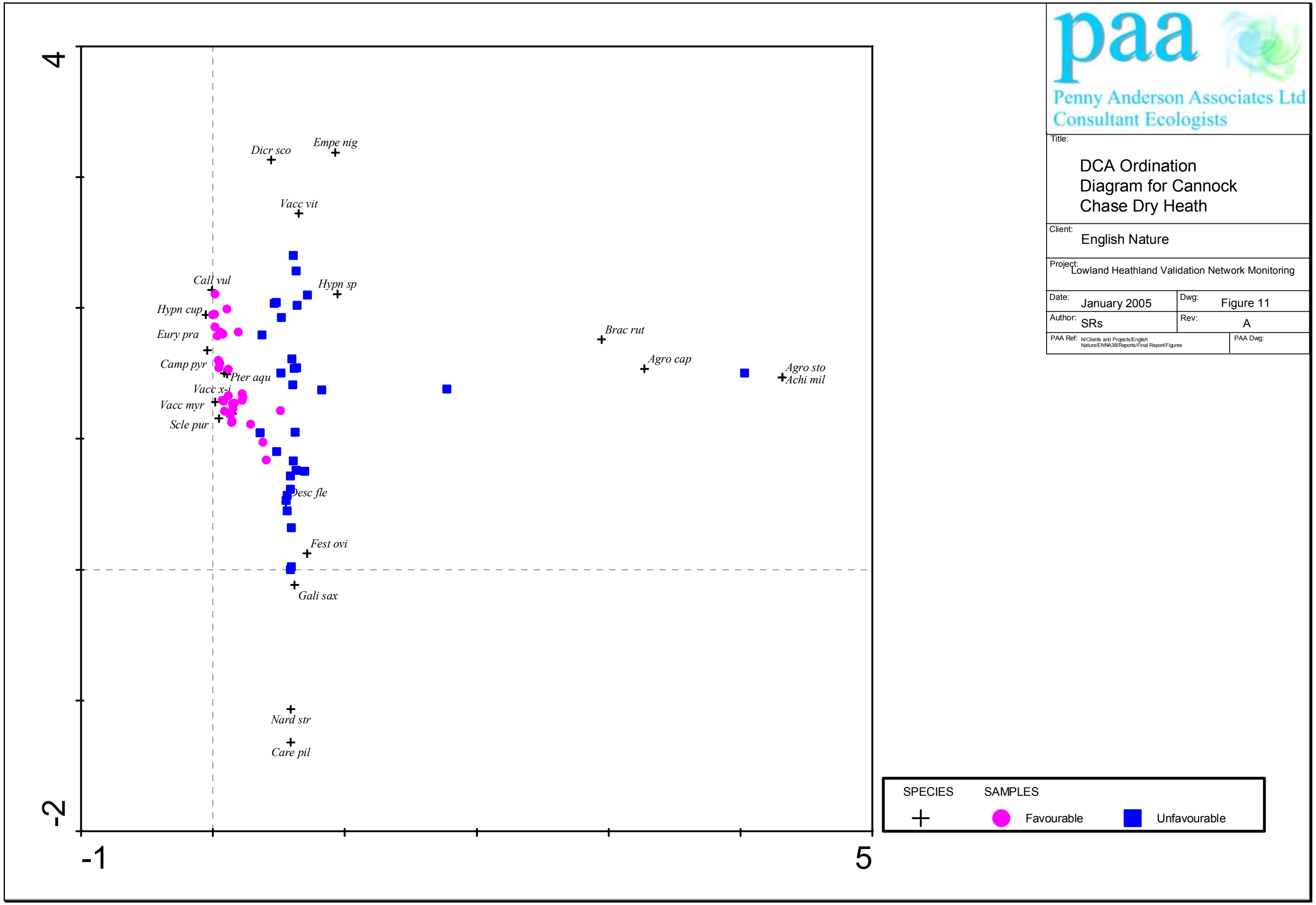



**Figure 11 DCA Ordination diagram for Cannock Chase Dry Heath**

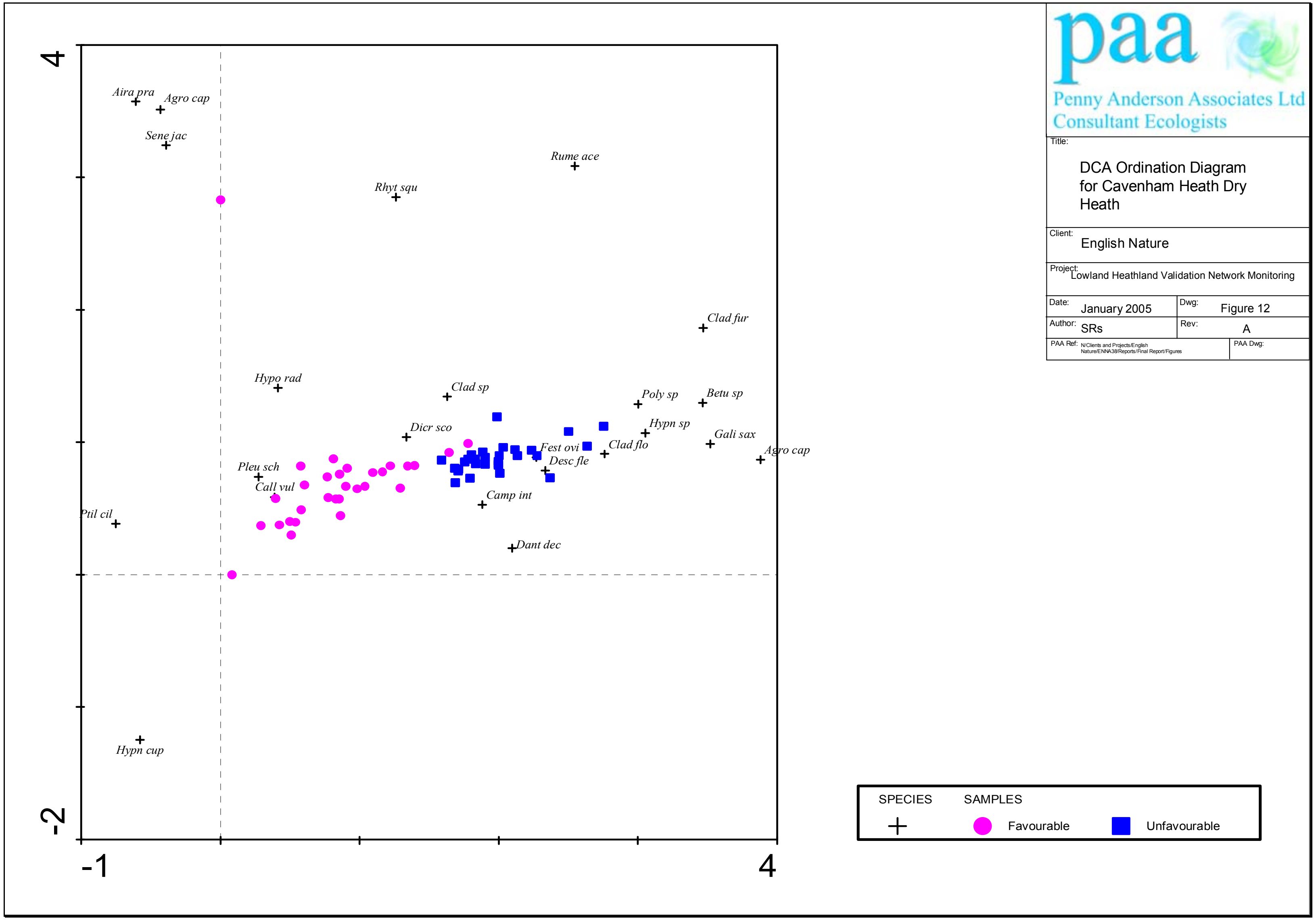



**Figure 12 DCA Ordination diagram for Cavenham Heath Dry Heath**

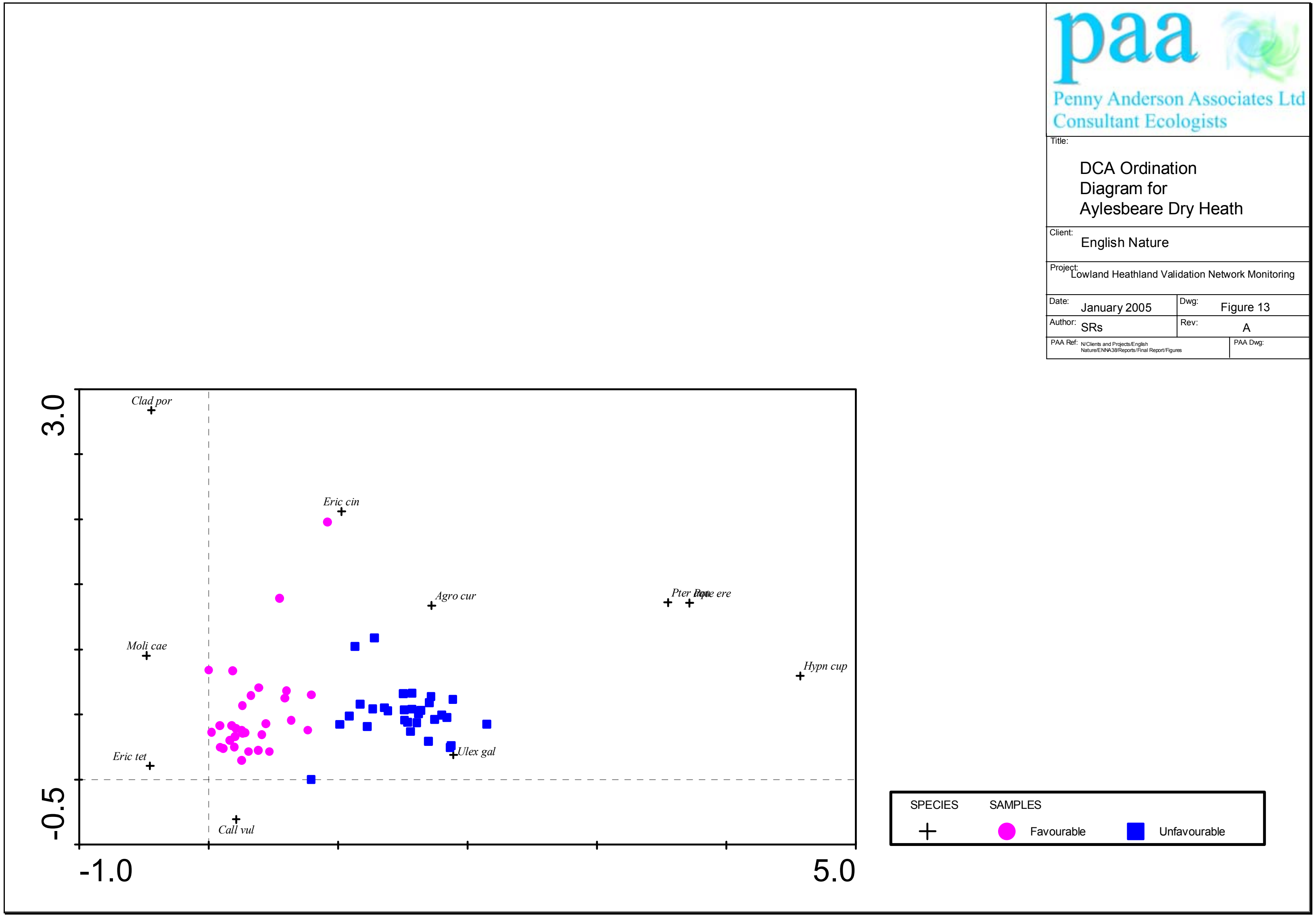



**Figure 13 DCA Ordination diagram for Aylesbeare Heath Dry Heath**

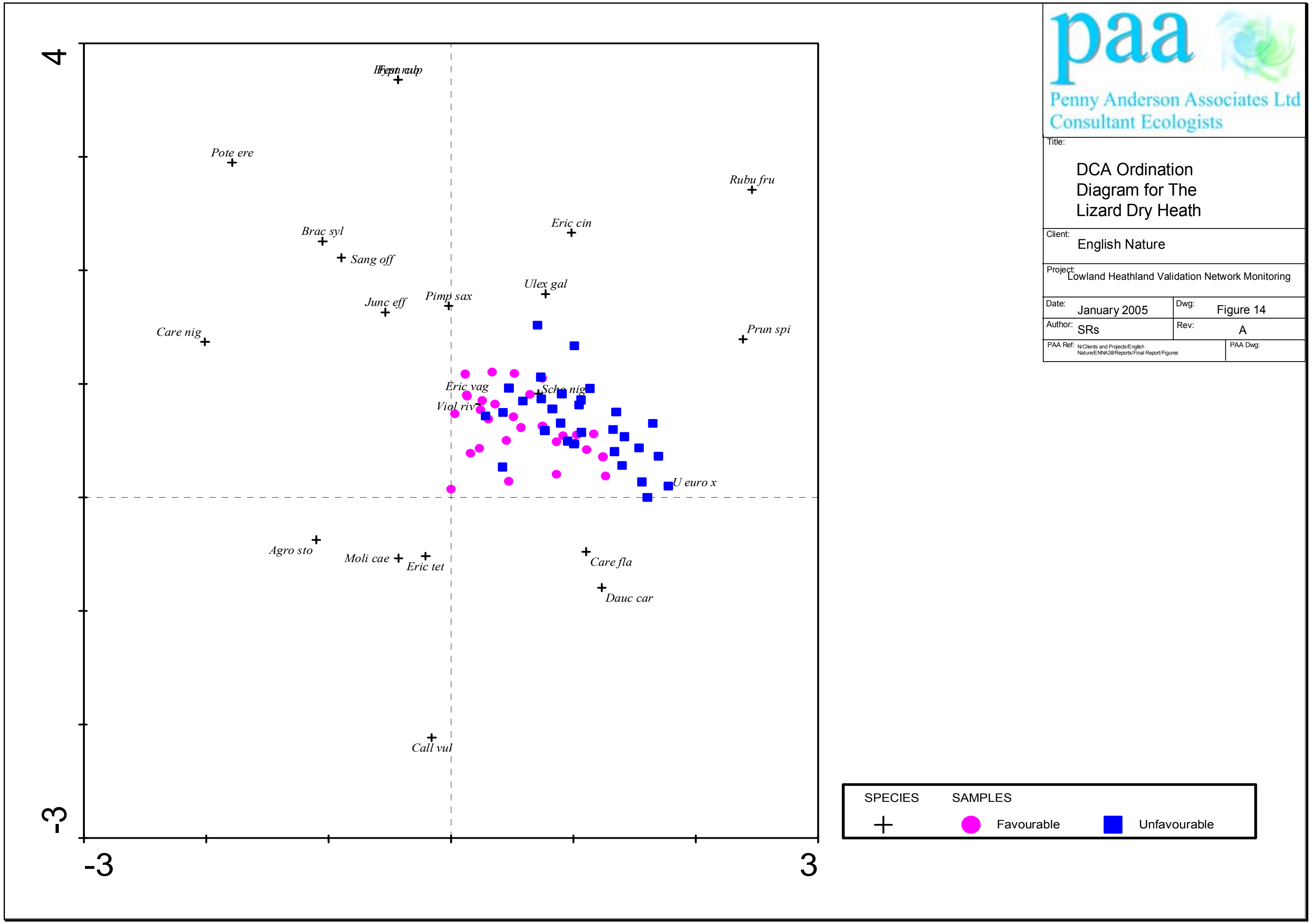



**Figure 14 DCA Ordination diagram for The Lizard Dry Heath**

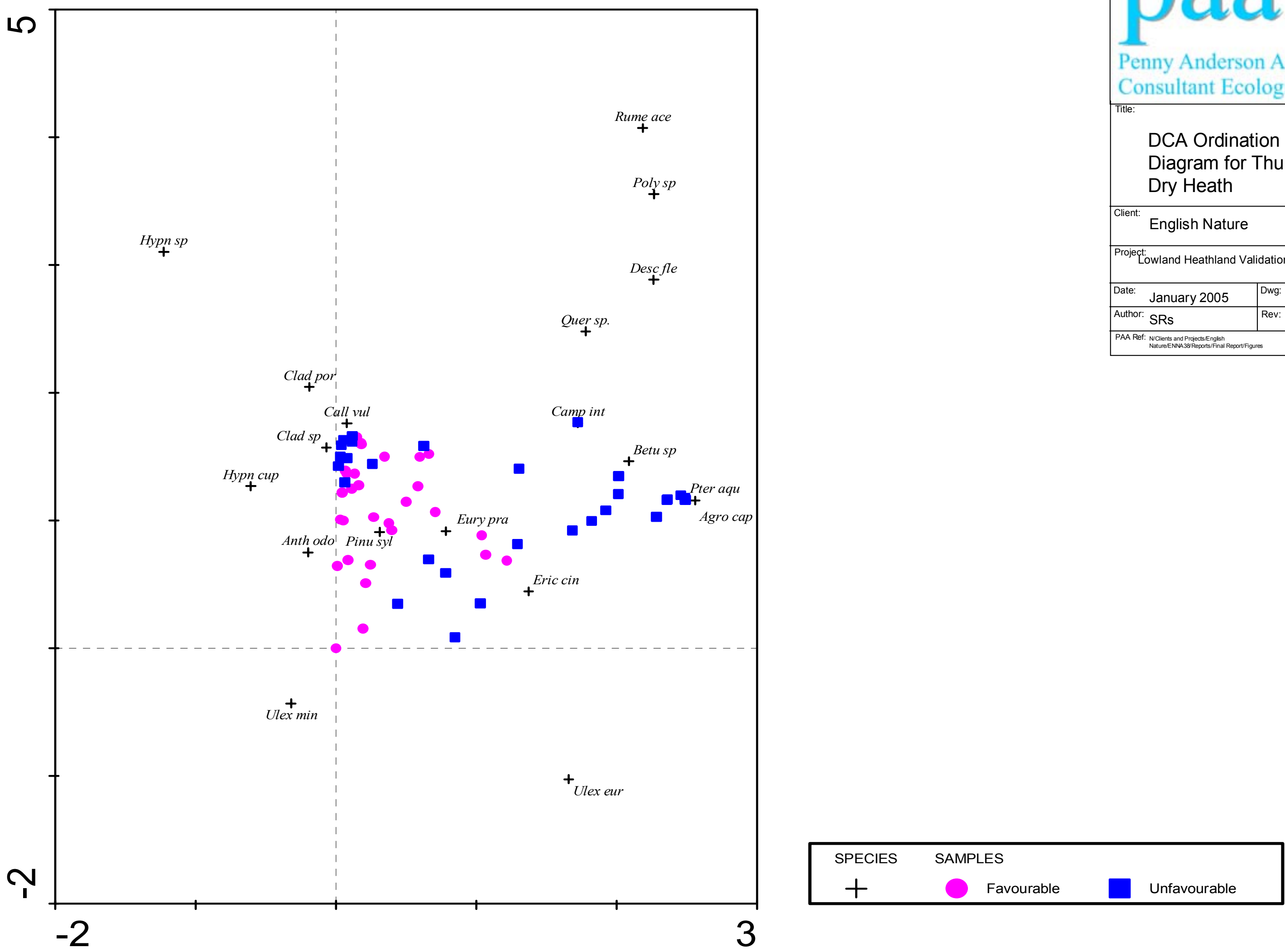



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**Figure 15 DCA Ordination diagram for Thursley Dry Heath**

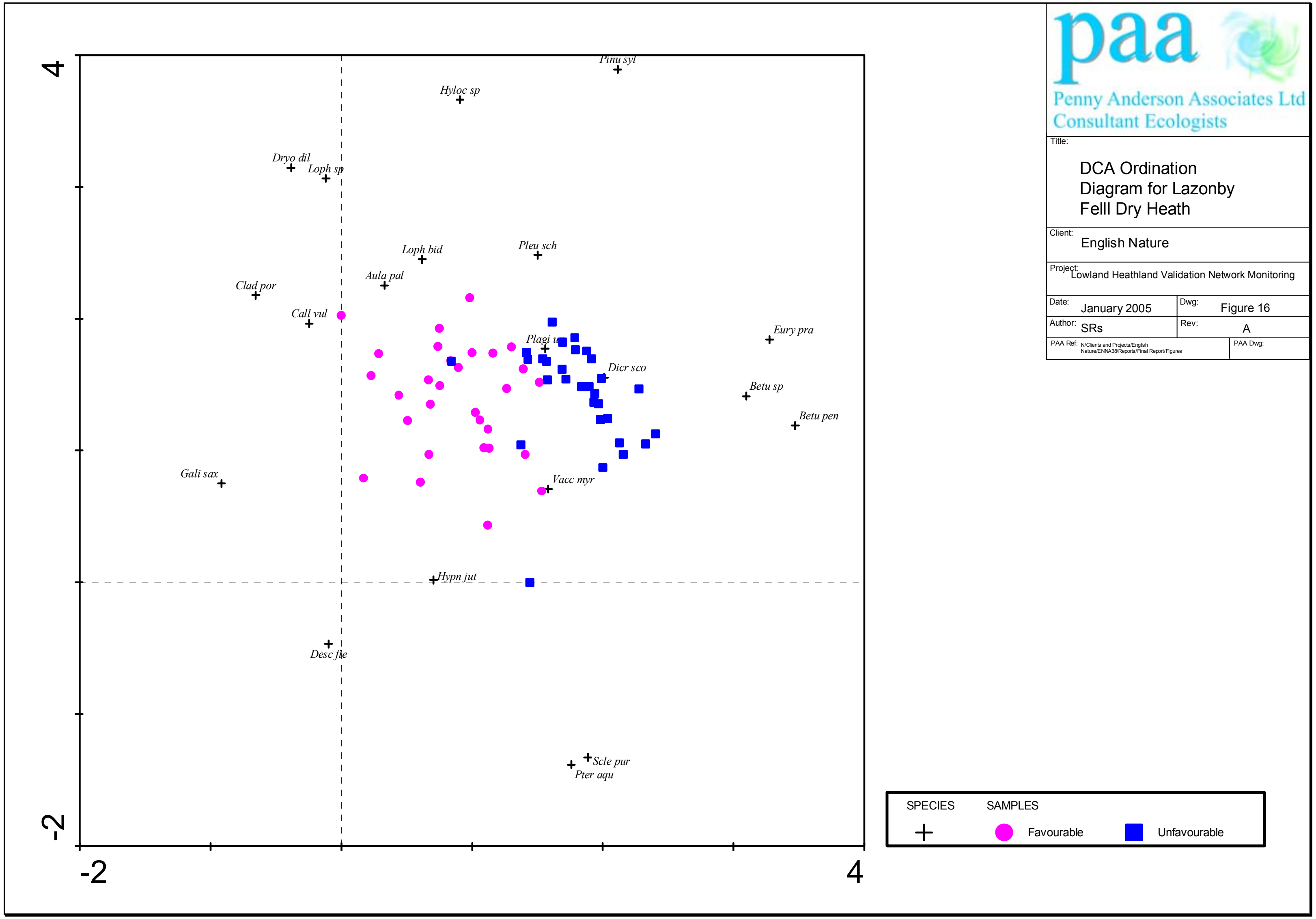


**Figure 16  DCA Ordination diagram for Lazonby Fell Dry Heath**

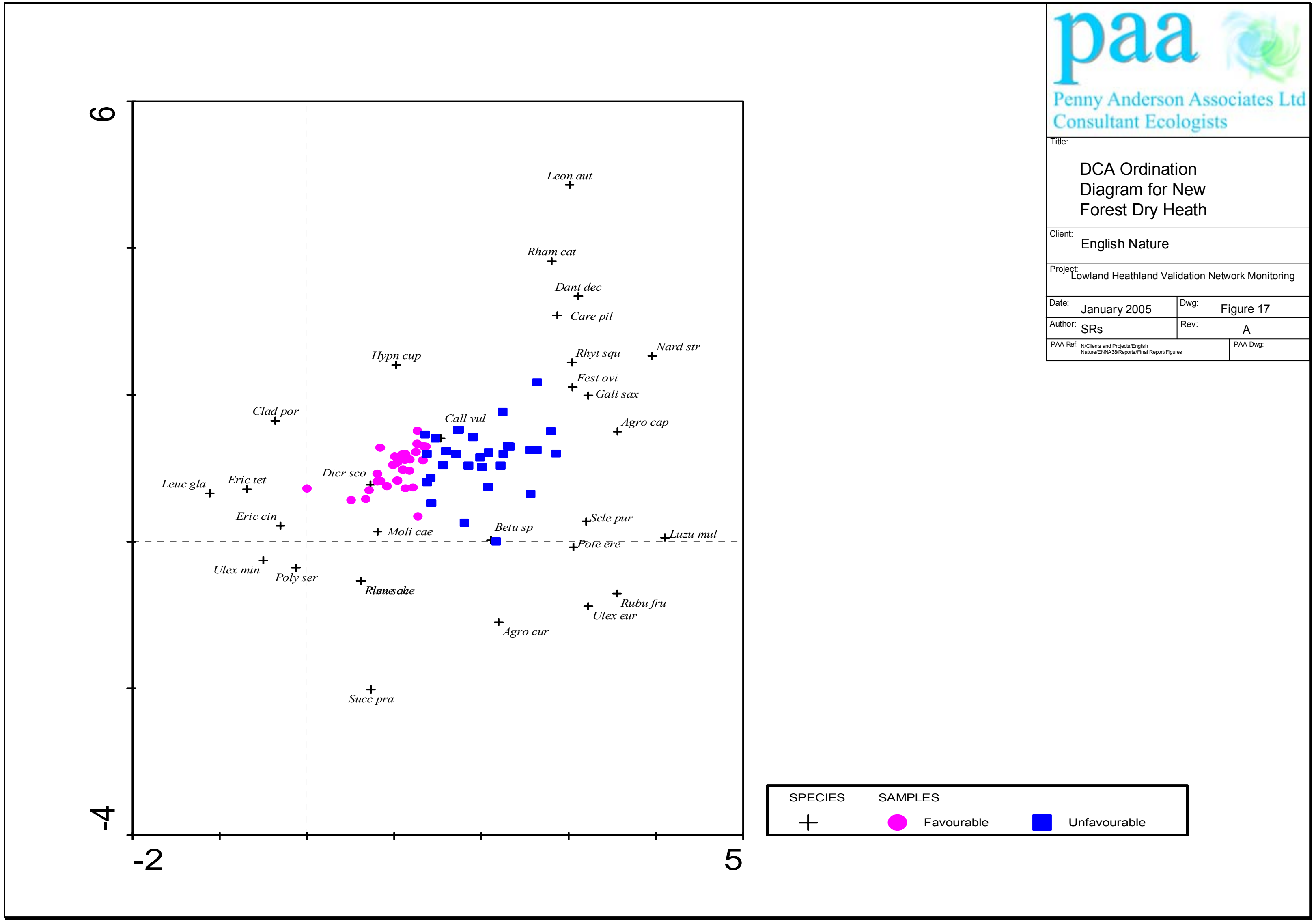


**Figure 17 DCA Ordination diagram for New Forest Dry Heath**

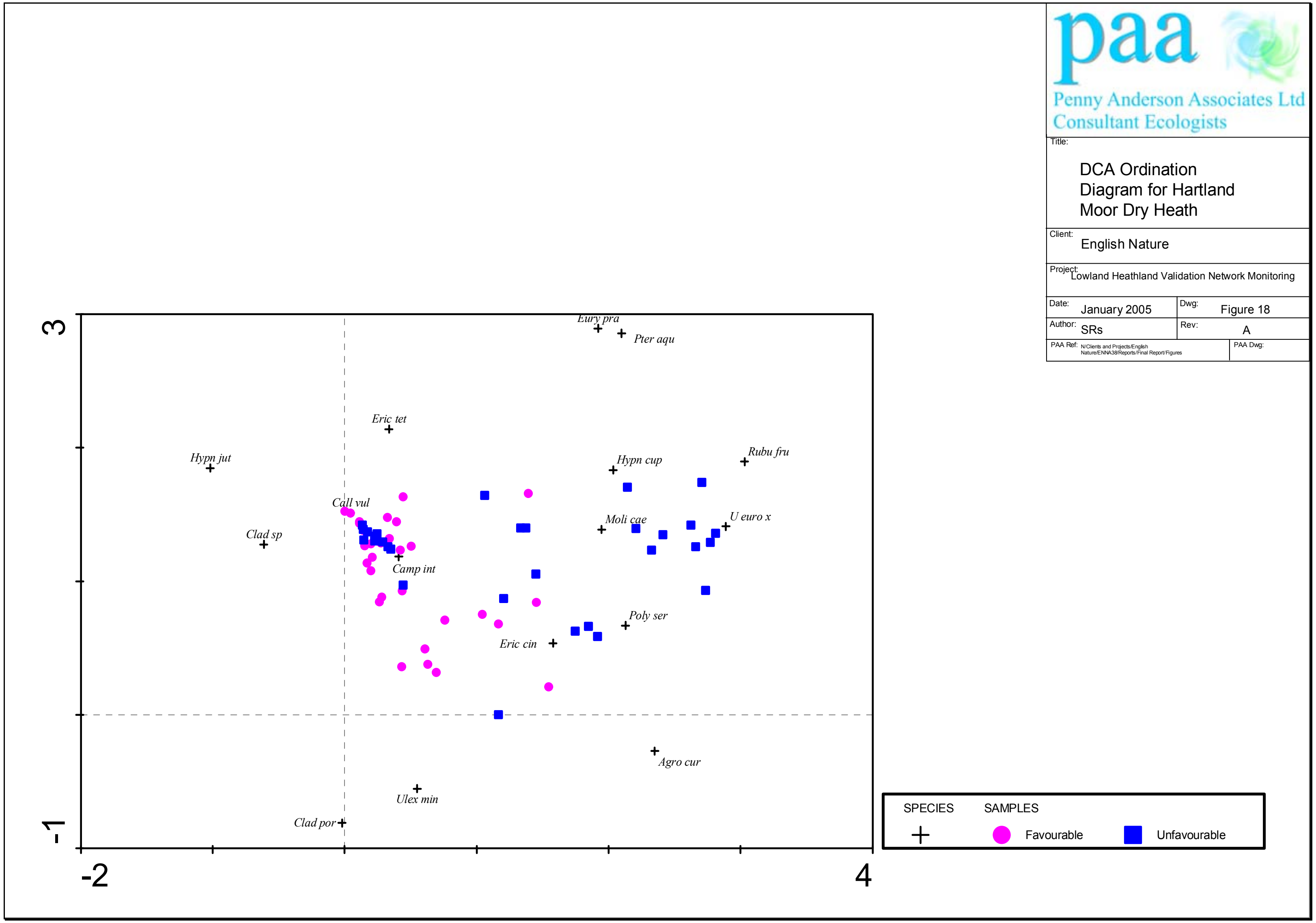


**Figure 18 DCA Ordination diagram for Hartland Moor & Wytch Heath Dry Heath**

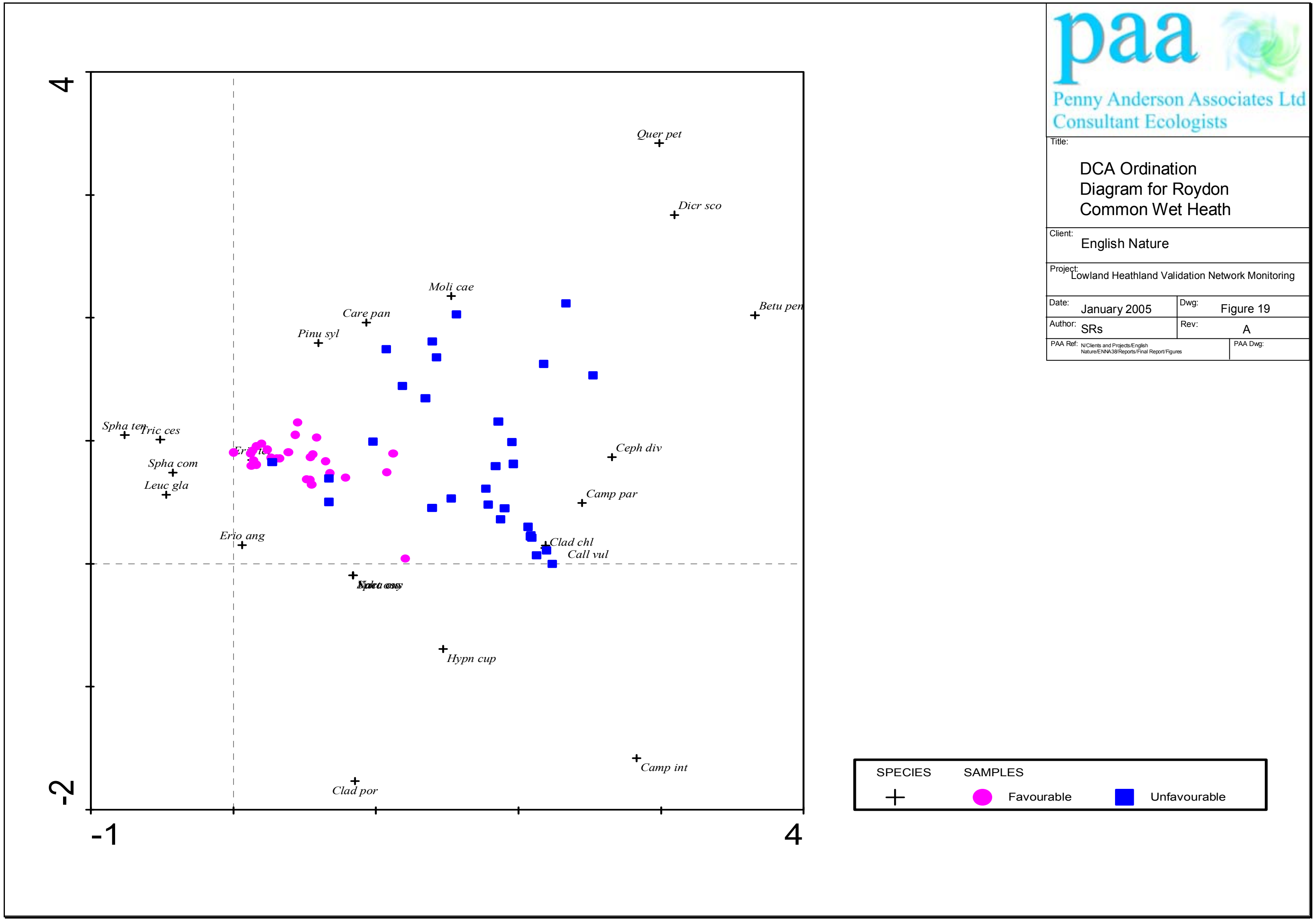


**Figure 19 DCA Ordination diagram for Roydon Common Wet Heath**

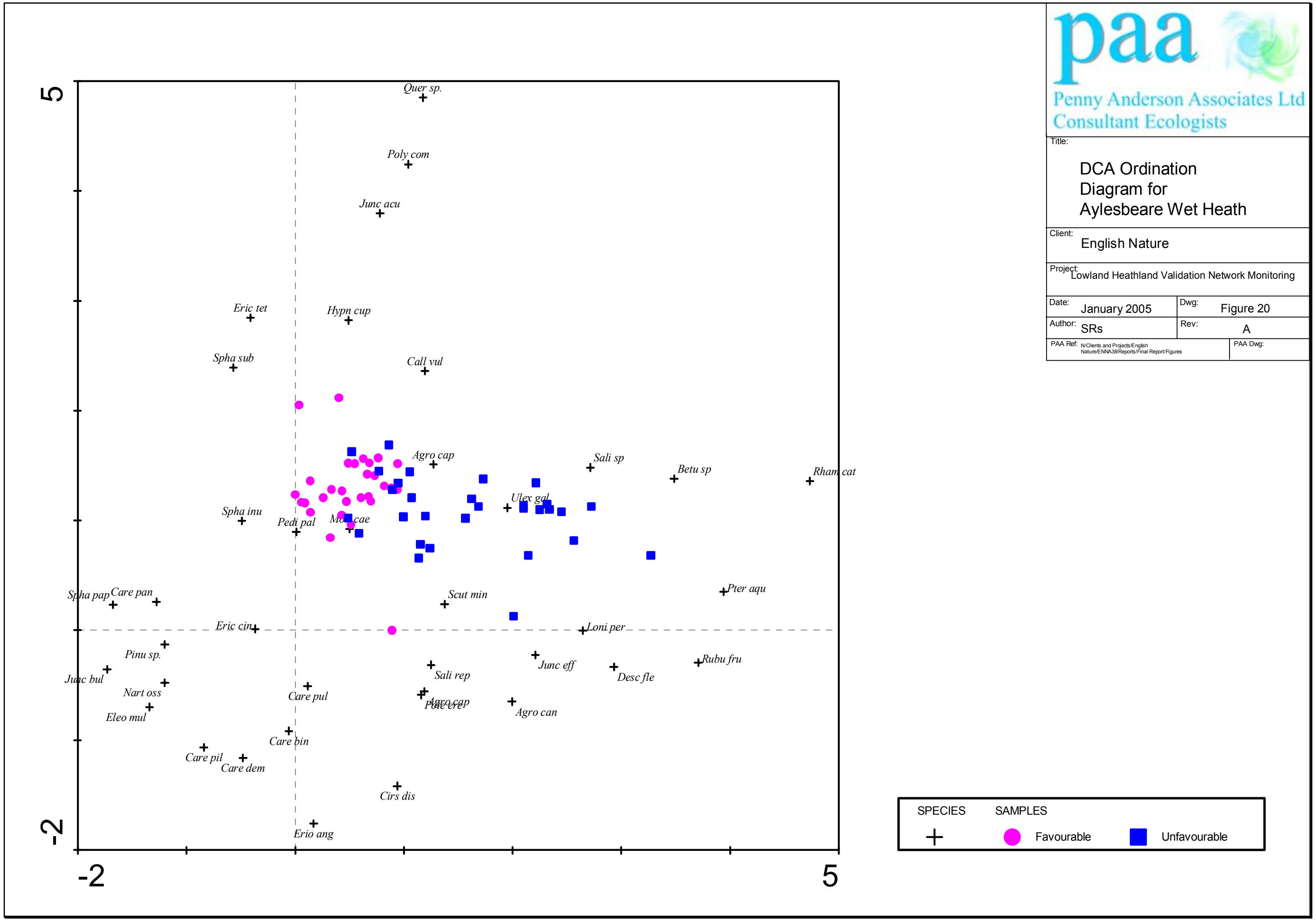


**Figure 20 DCA Ordination diagram for Aylesbeare Heath Wet Heath**

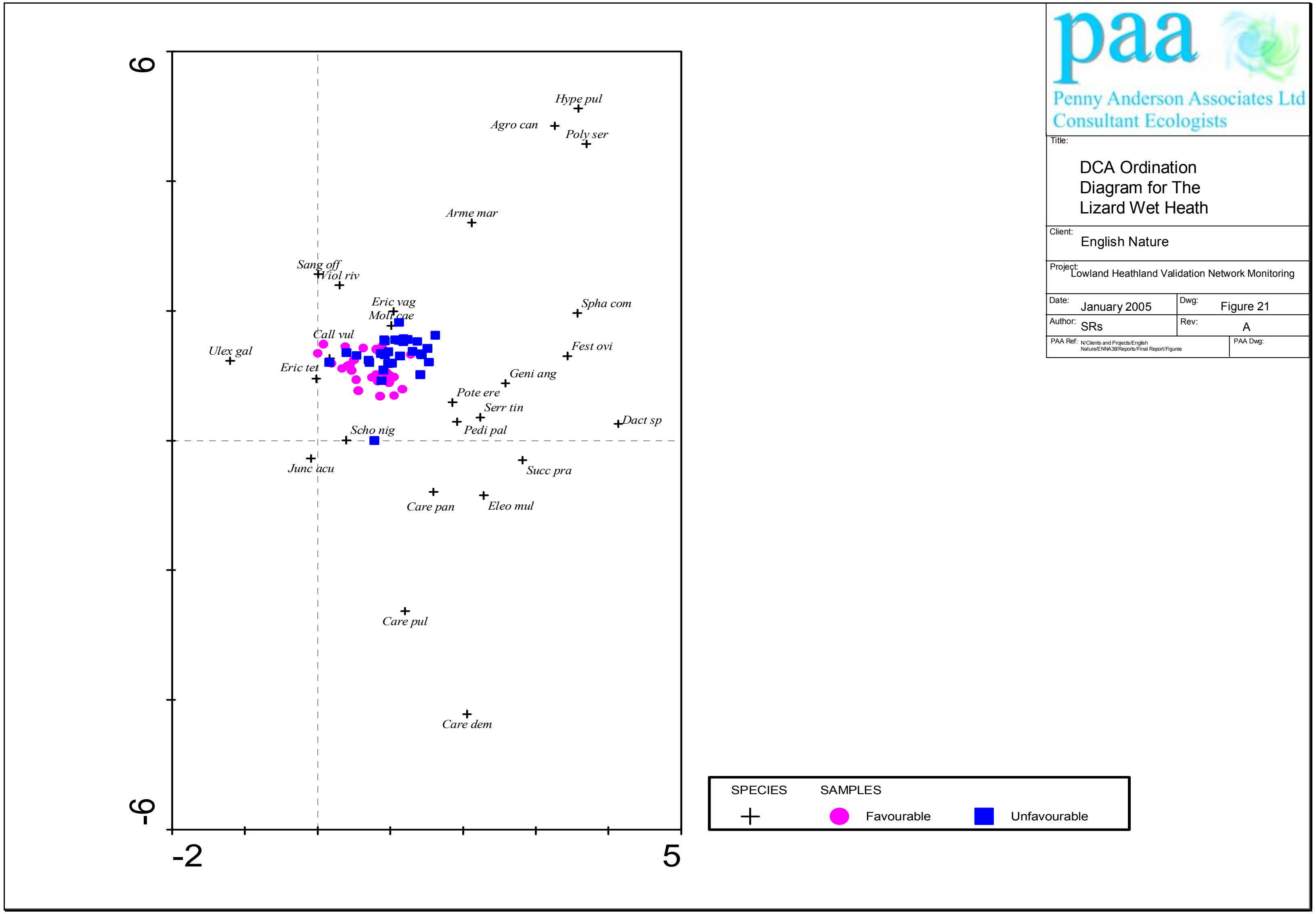


**Figure 21 DCA Ordination diagram for The Lizard Wet Heath**

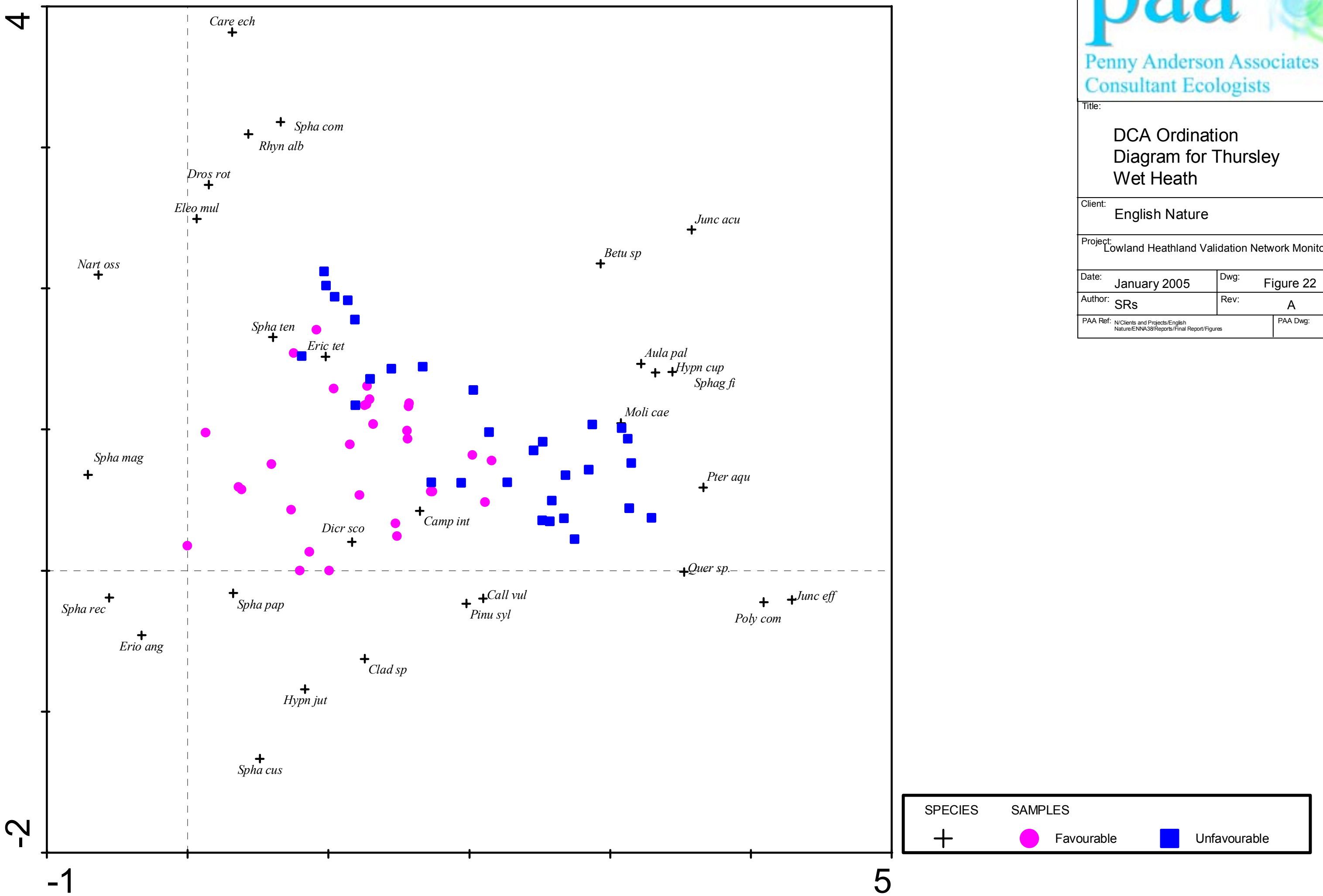


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**Figure 22 DCA Ordination diagram for Thursley Wet Heath**

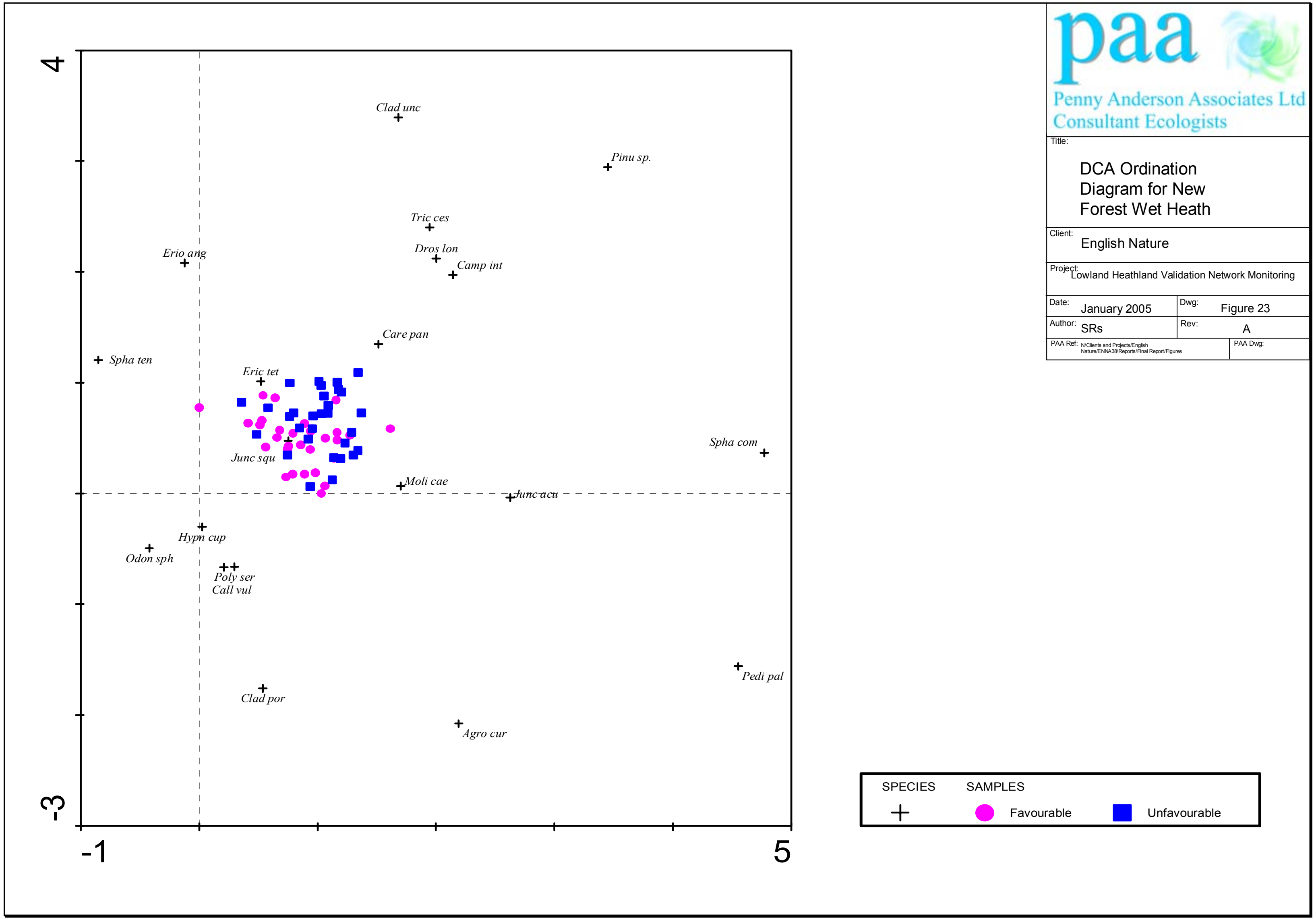
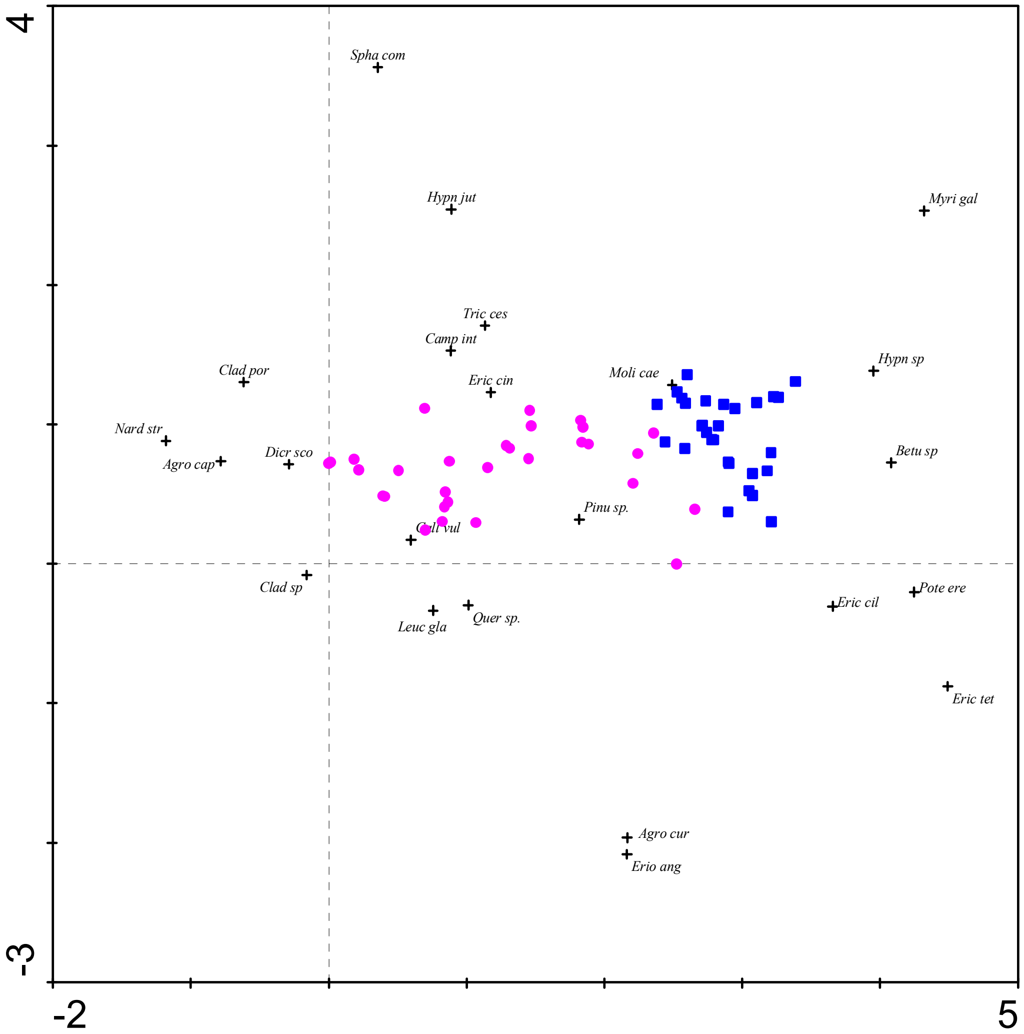



**Figure 23  DCA Ordination diagram for New Forest Wet Heath**





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Title: DCA Ordination Diagram for Hartland Moor Wet Heath

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Project: Lowland Heathland Validation Network Monitoring

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|---|---|
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**Figure 24 DCA Ordination diagram for Hartland Moor & Wytch Heath Wet Heath**

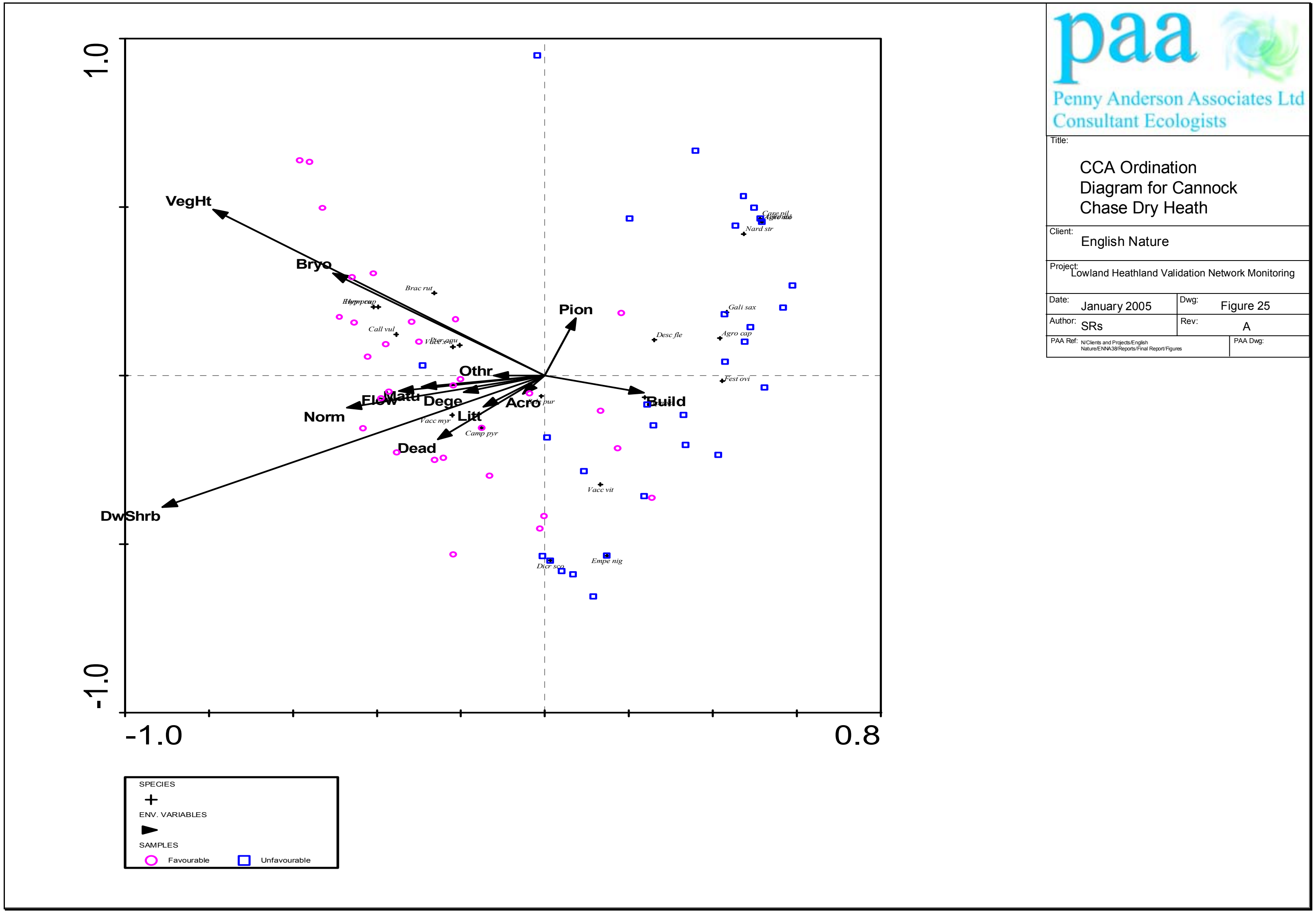



**Figure 25 CCA Ordination diagram for Cannock Chase Dry Heath**

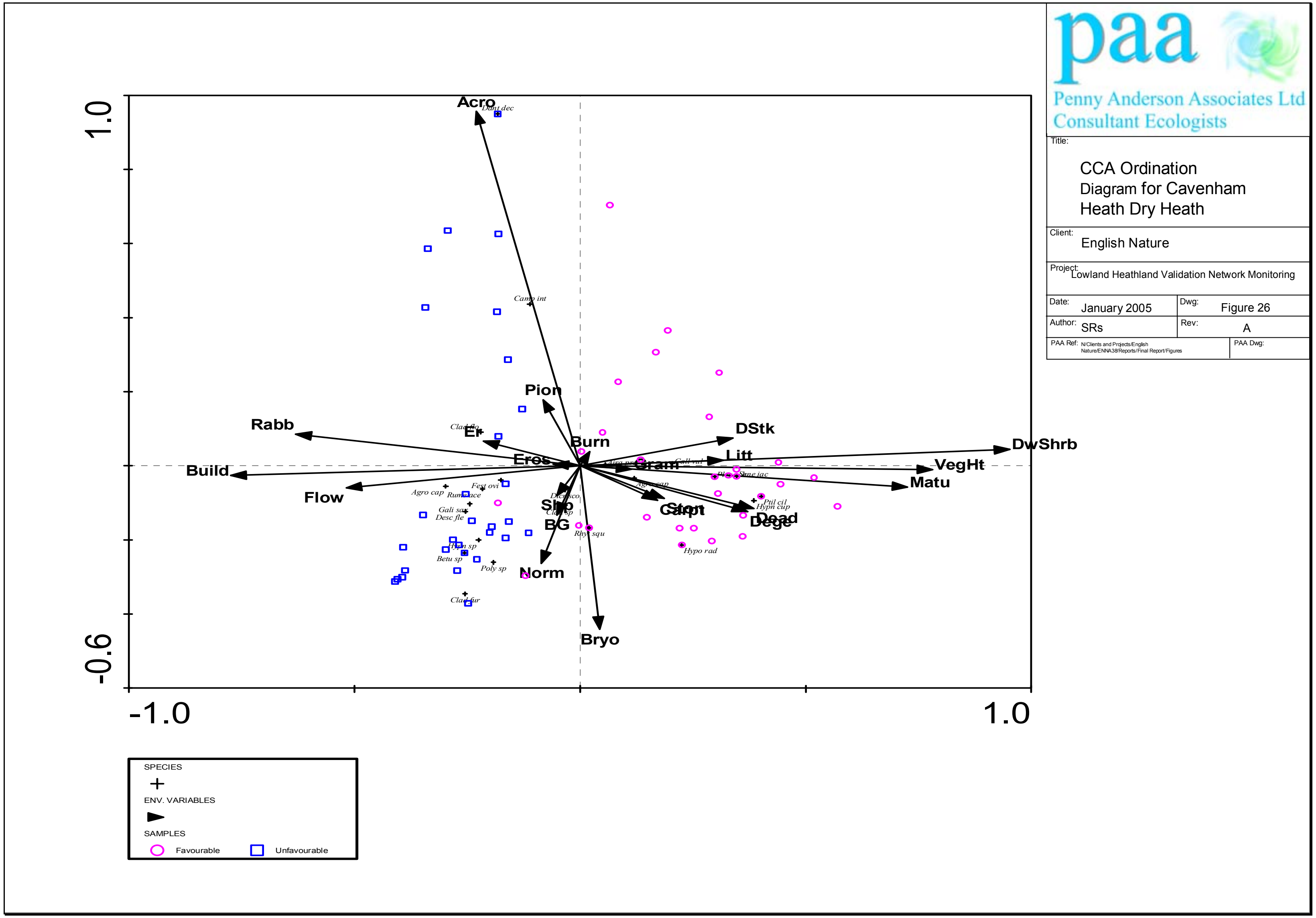



Figure 26 CCA Ordination diagram for Cavenham Heath Dry Heath

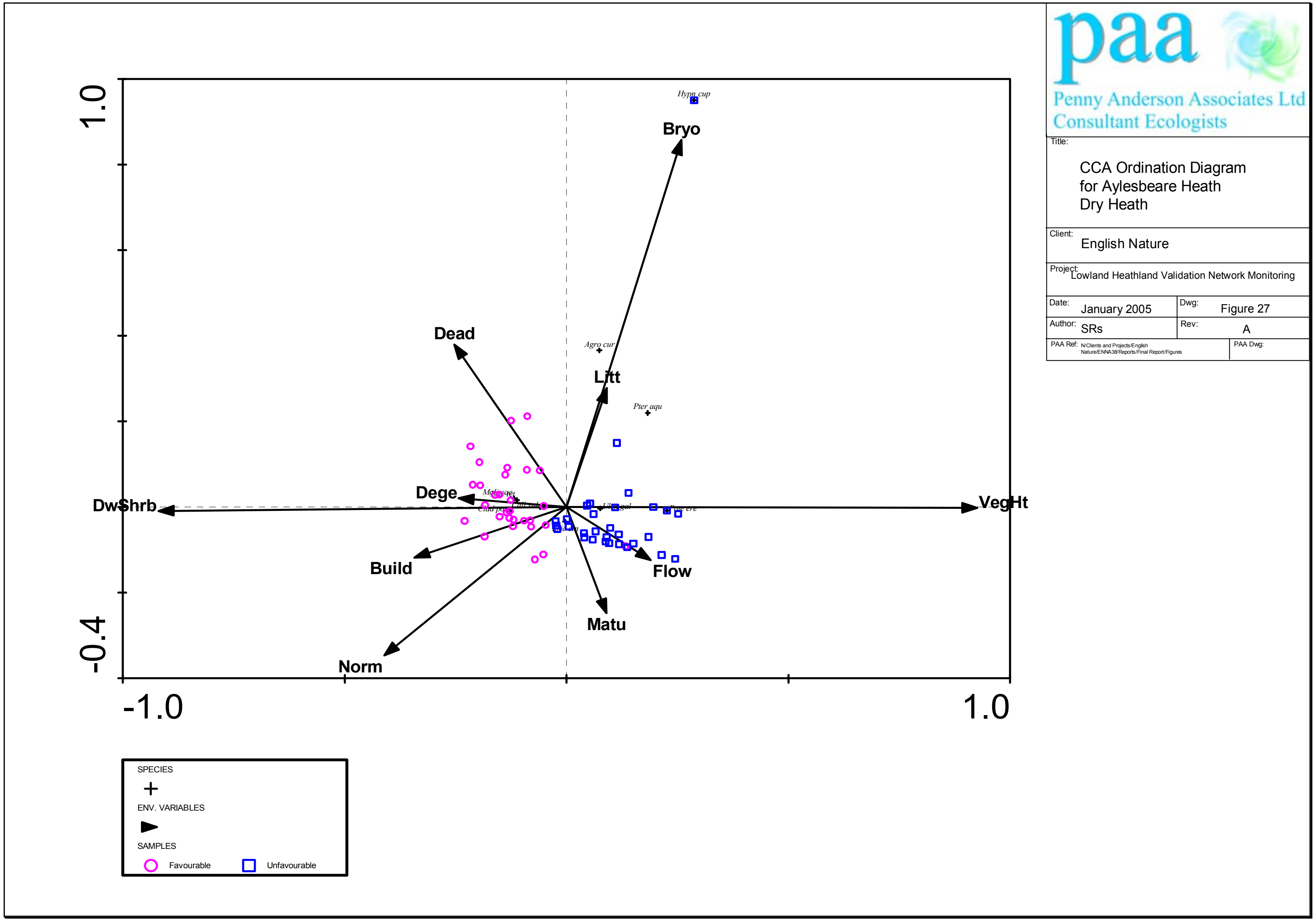
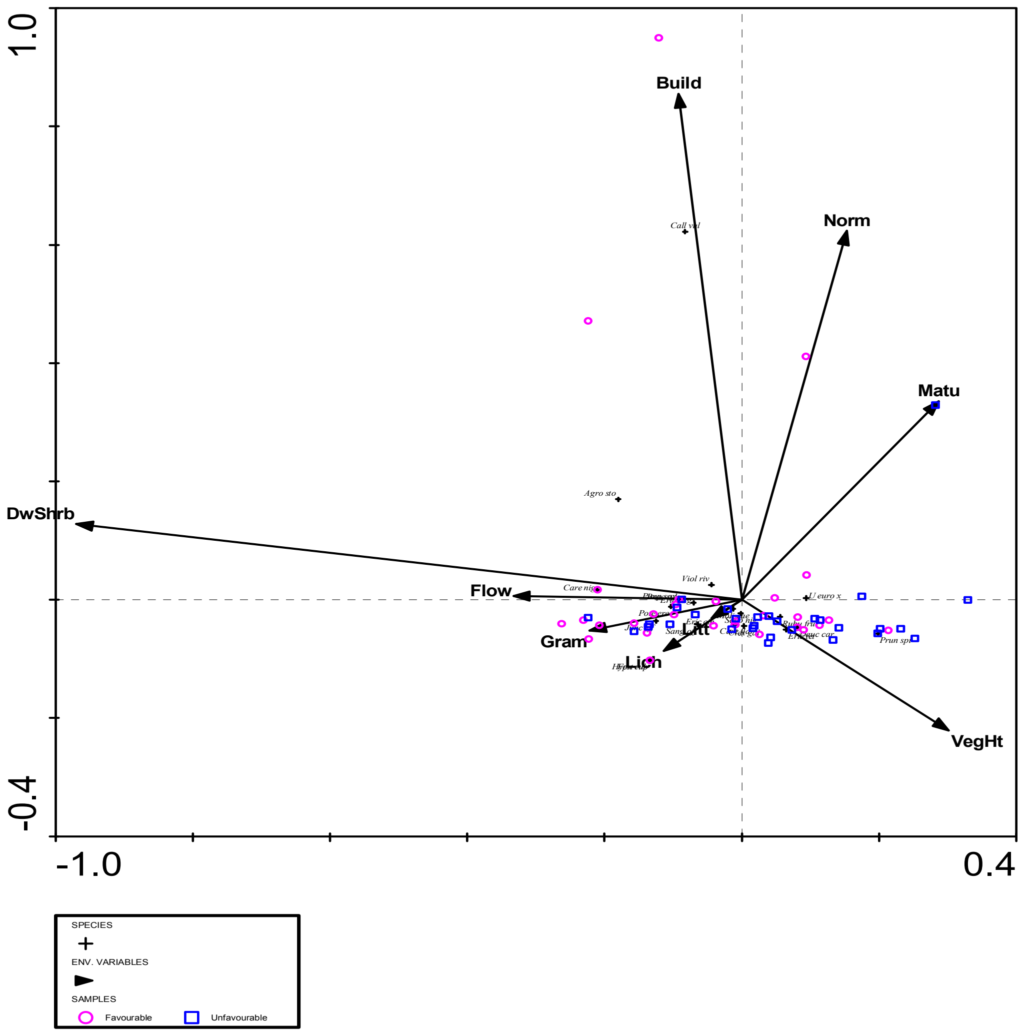



**Figure 27 CCA Ordination diagram for Aylesbeare Heath Dry Heath**

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| Date: January 2005 | Dwg: Figure 28 |
| Author: SRs | Rev: A |
| PAA Ref: N/Clients and Projects/English Nature/ENNA38/Reports/Final Report/Figures | PAA Dwg: |

**Figure 28 CCA Ordination diagram for The Lizard Dry Heath**

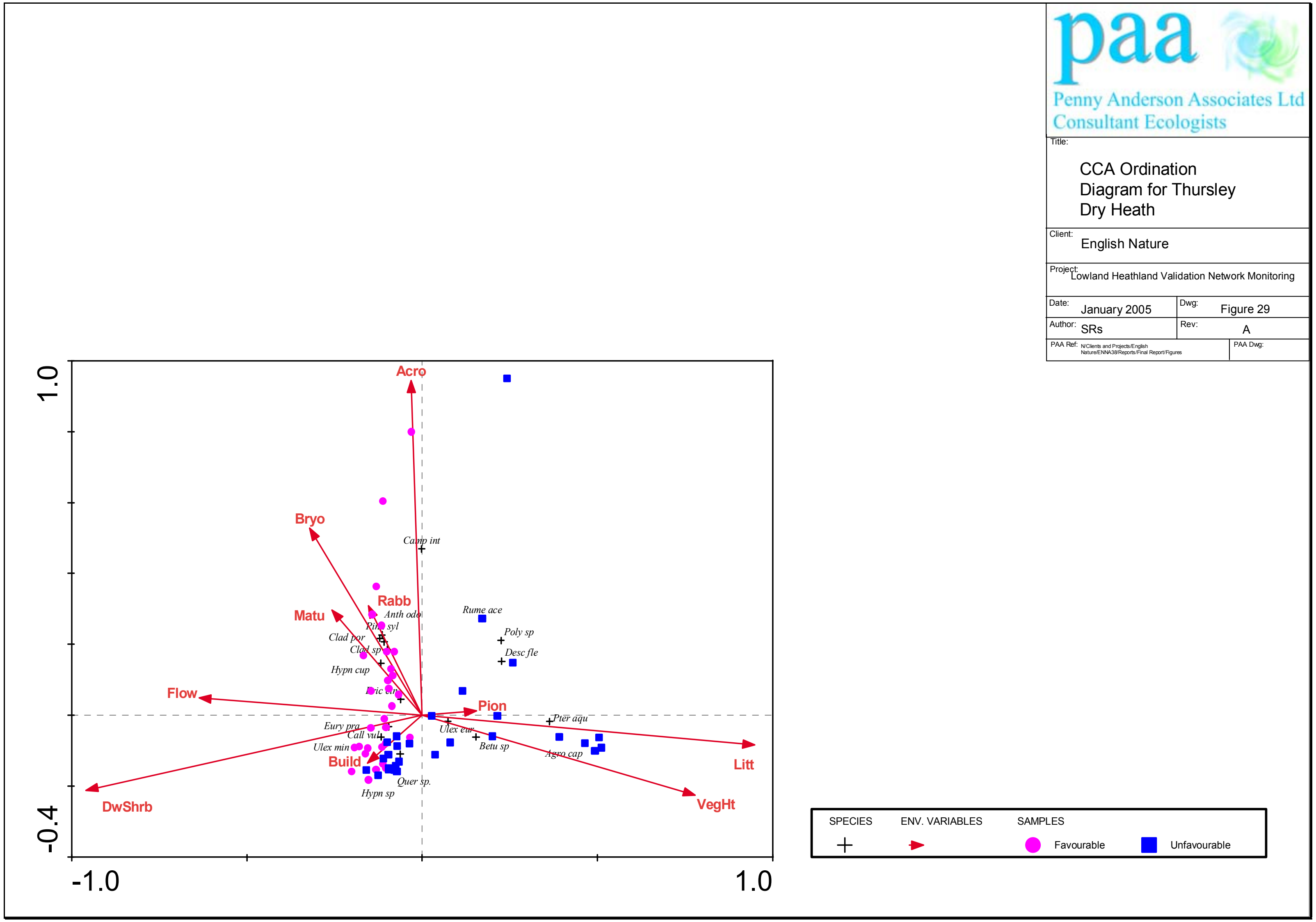
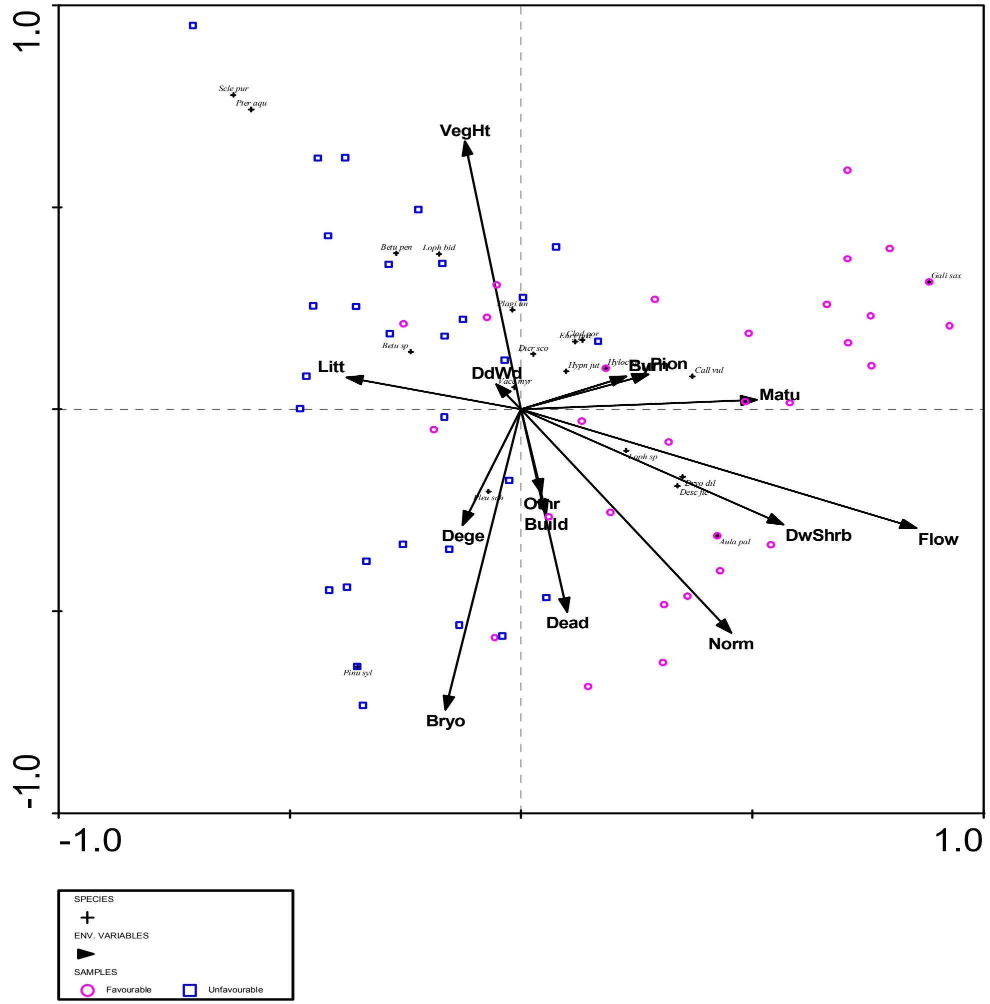



**Figure 29  CCA Ordination diagram for Thursley Dry Heath**

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| Title: CCA Ordination Diagram for Lazonby Fell Dry Heath | |
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| Project: Lowland Heathland Validation Network Monitoring | |
| Date: January 2005 | Dwg: Figure 30 |
| Author: SRs | Rev: A |
| PAA Ref: N/Clients and Projects/English Nature/ENNA38/Reports/Final Report/Figures | PAA Dwg: |

**Figure 30 CCA Ordination diagram for Lazonby Fell Dry Heath**

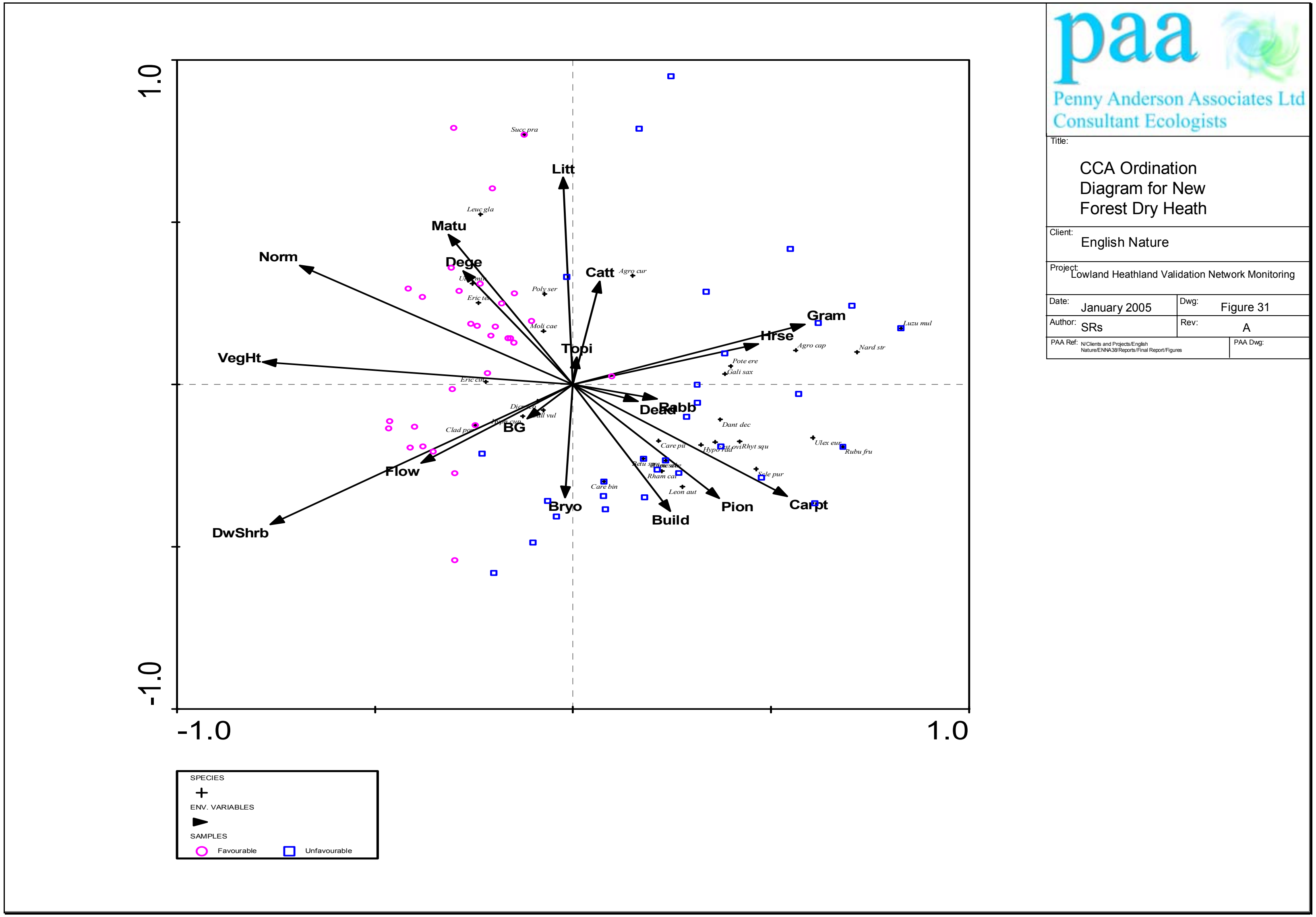



**Figure 31 CCA Ordination diagramfor New Forest Dry Heath**

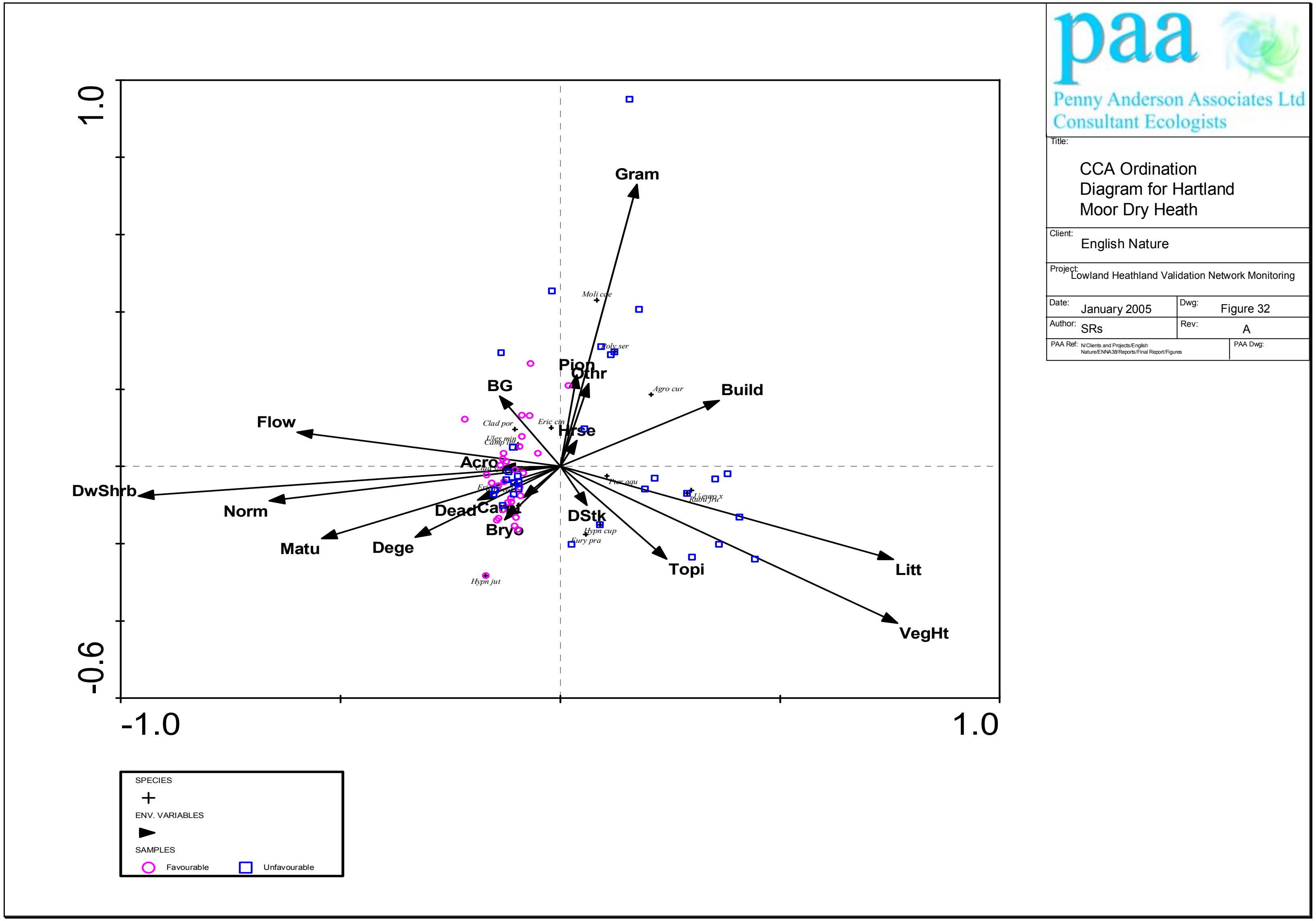
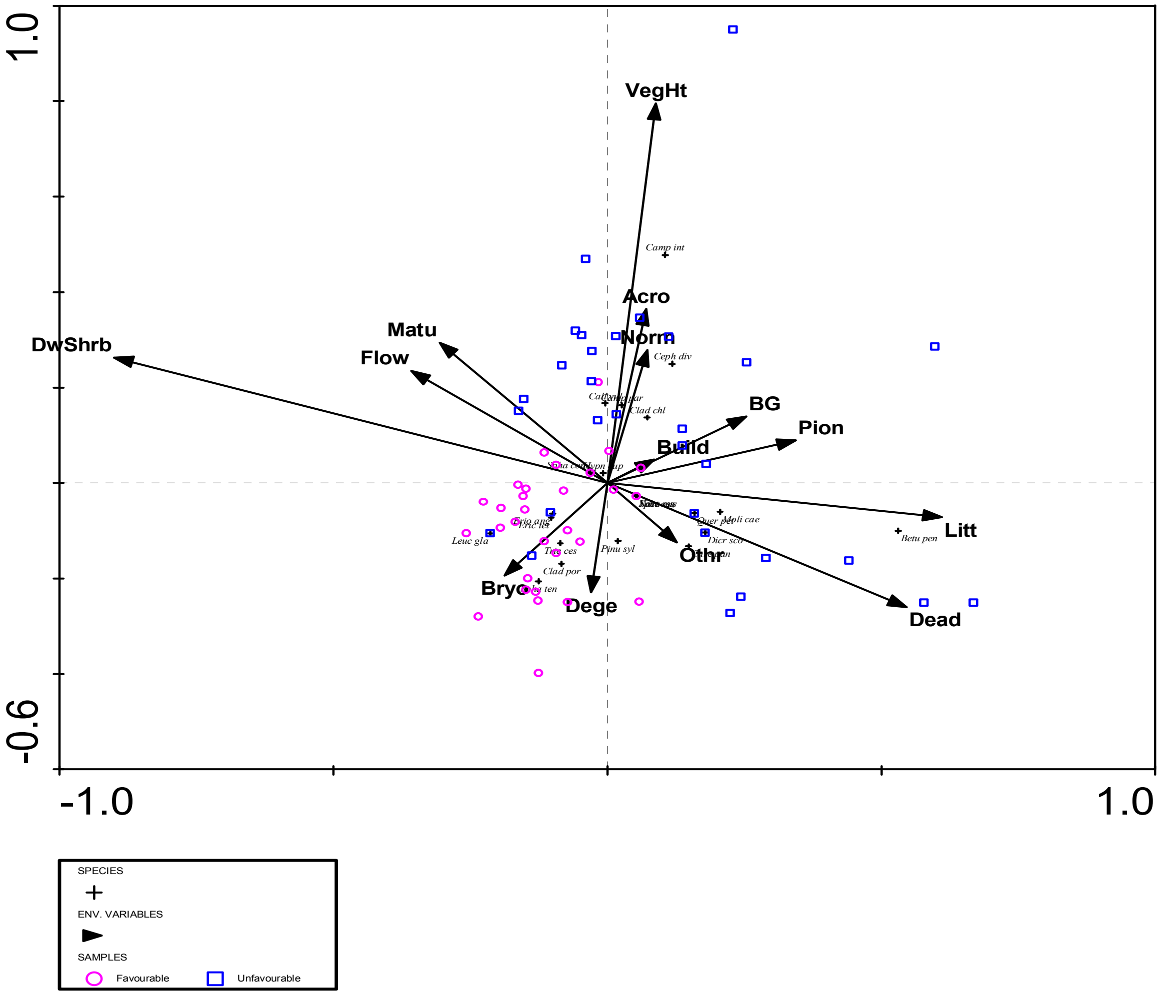



**Figure 32 CCA Ordination diagram for Hartland Moor & Wytch Heath Dry Heath**

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| Author: SRs | Rev: A |
| PAA Ref: N/Clients and Projects/English Nature/ENNA38/Reports/Final Report/Figures | PAA Dwg: |

**Figure 33 CCA Ordination diagram for Roydon Common Wet Heath**

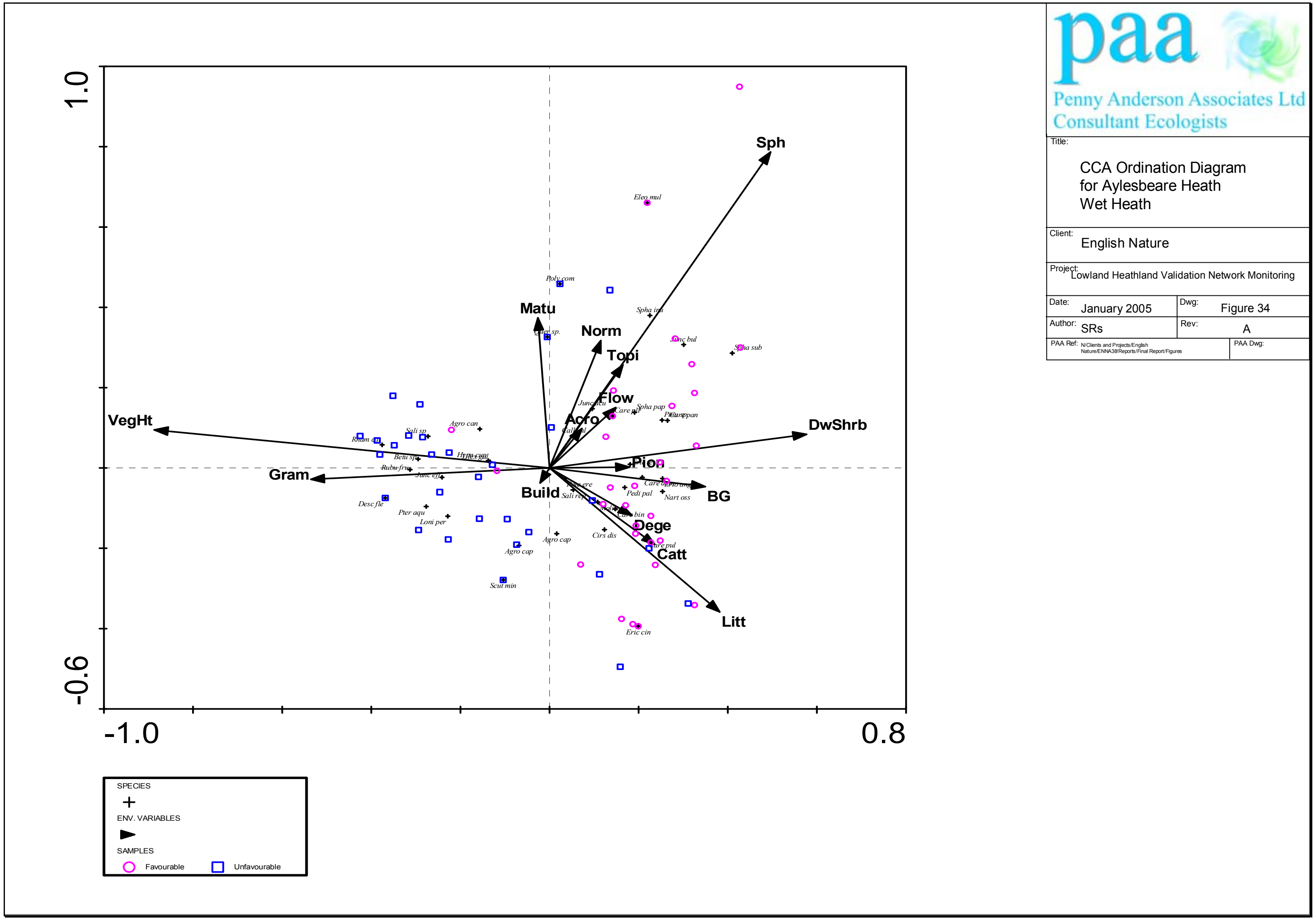


**Figure 34 CCA Ordination diagram for Aylesbeare Heath Wet Heath**

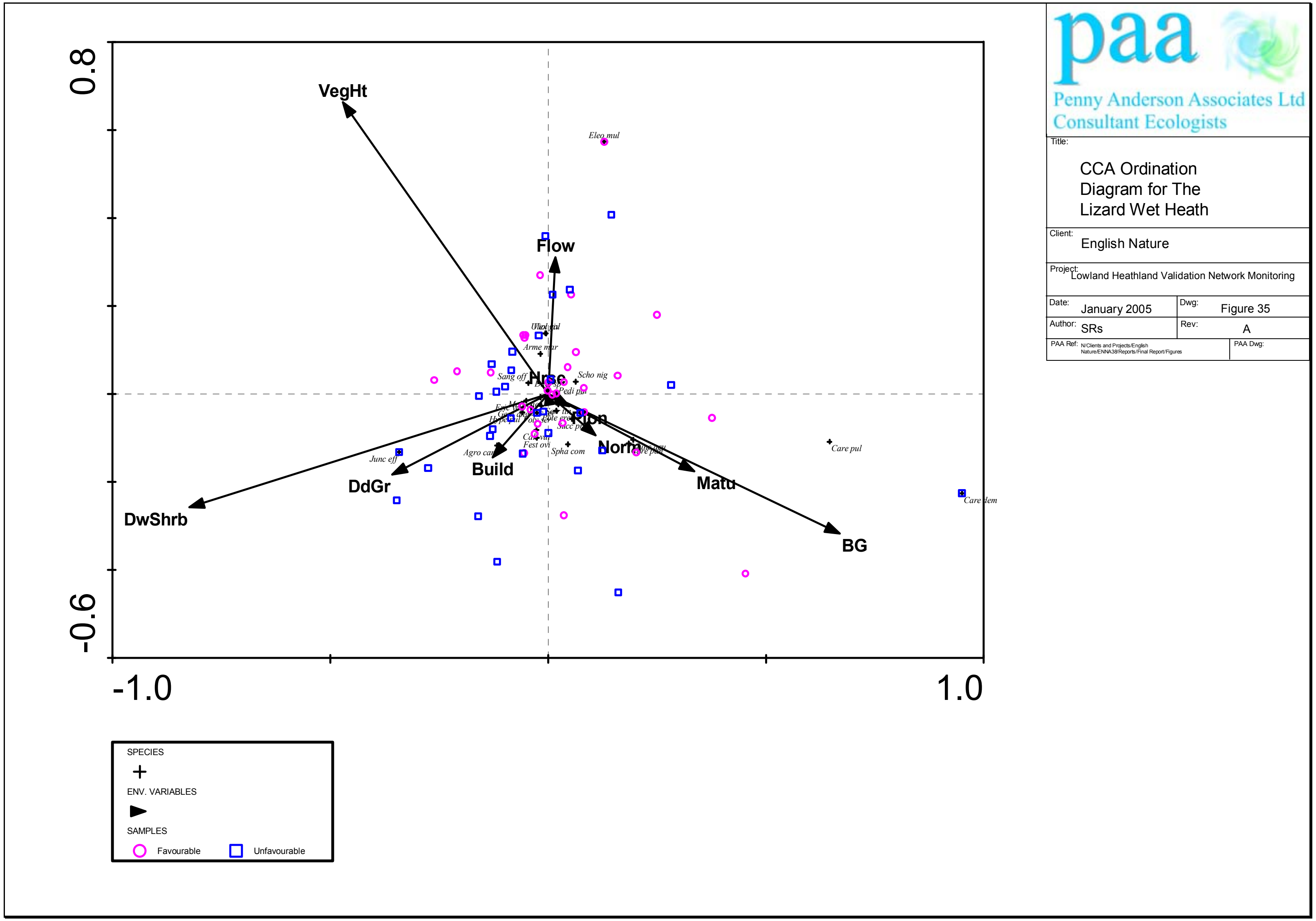


**Figure 35 CCA Ordination diagram for The Lizard Wet Heath**

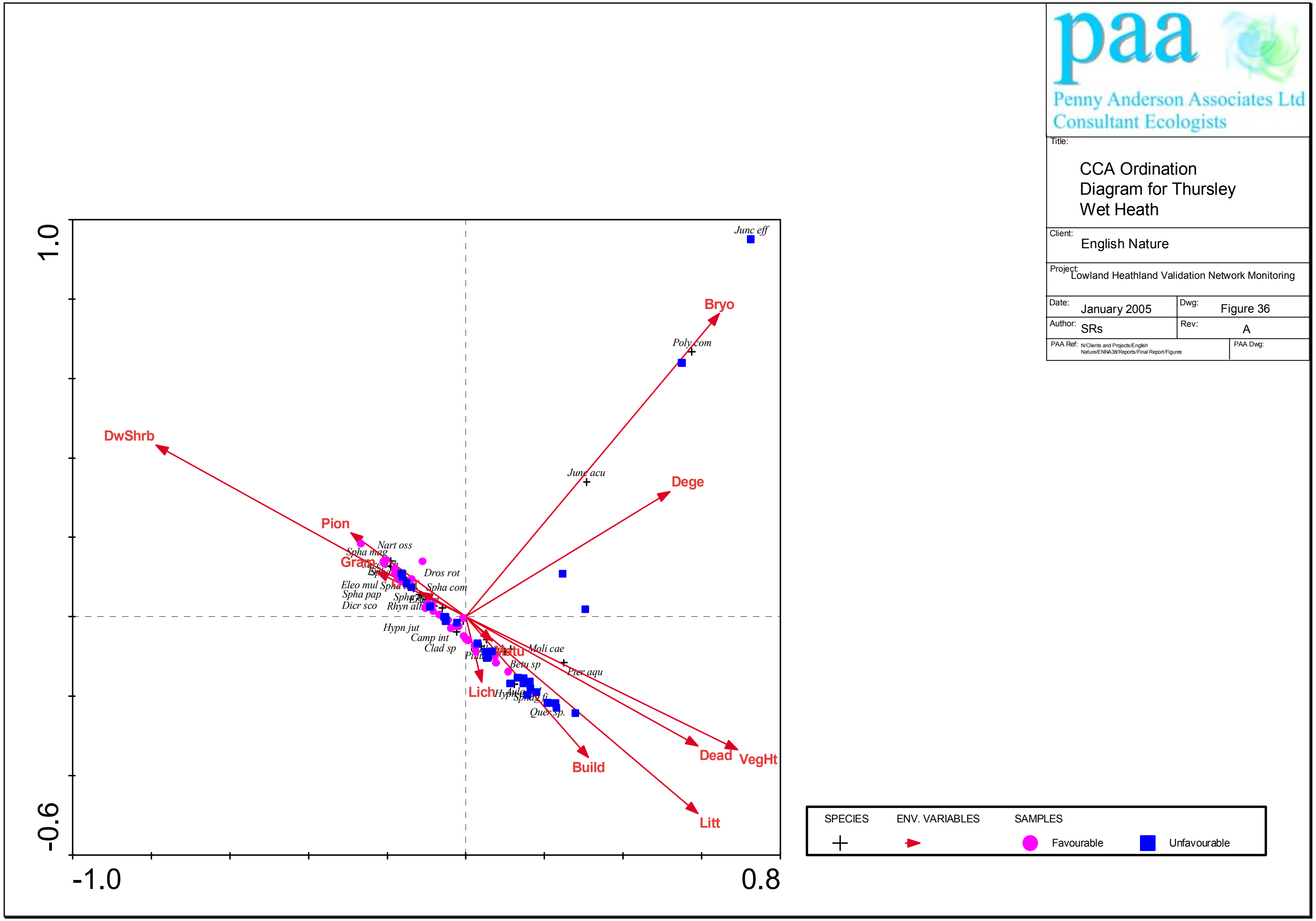


**Figure 36 CCA Ordination diagramfor Thursley Wet Heath**

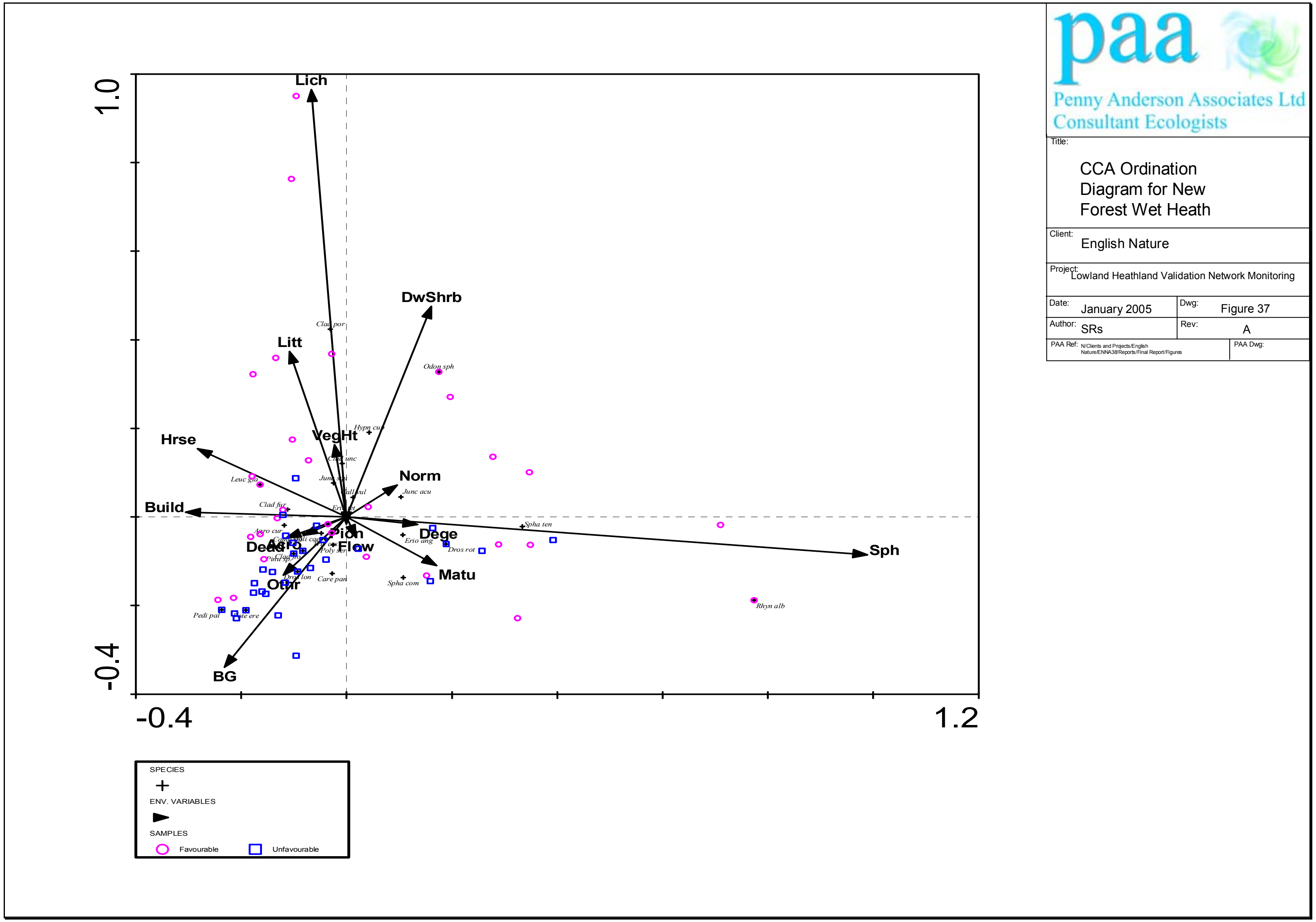


**Figure 37 CCA Ordination diagram for New Forest Wet Heath**

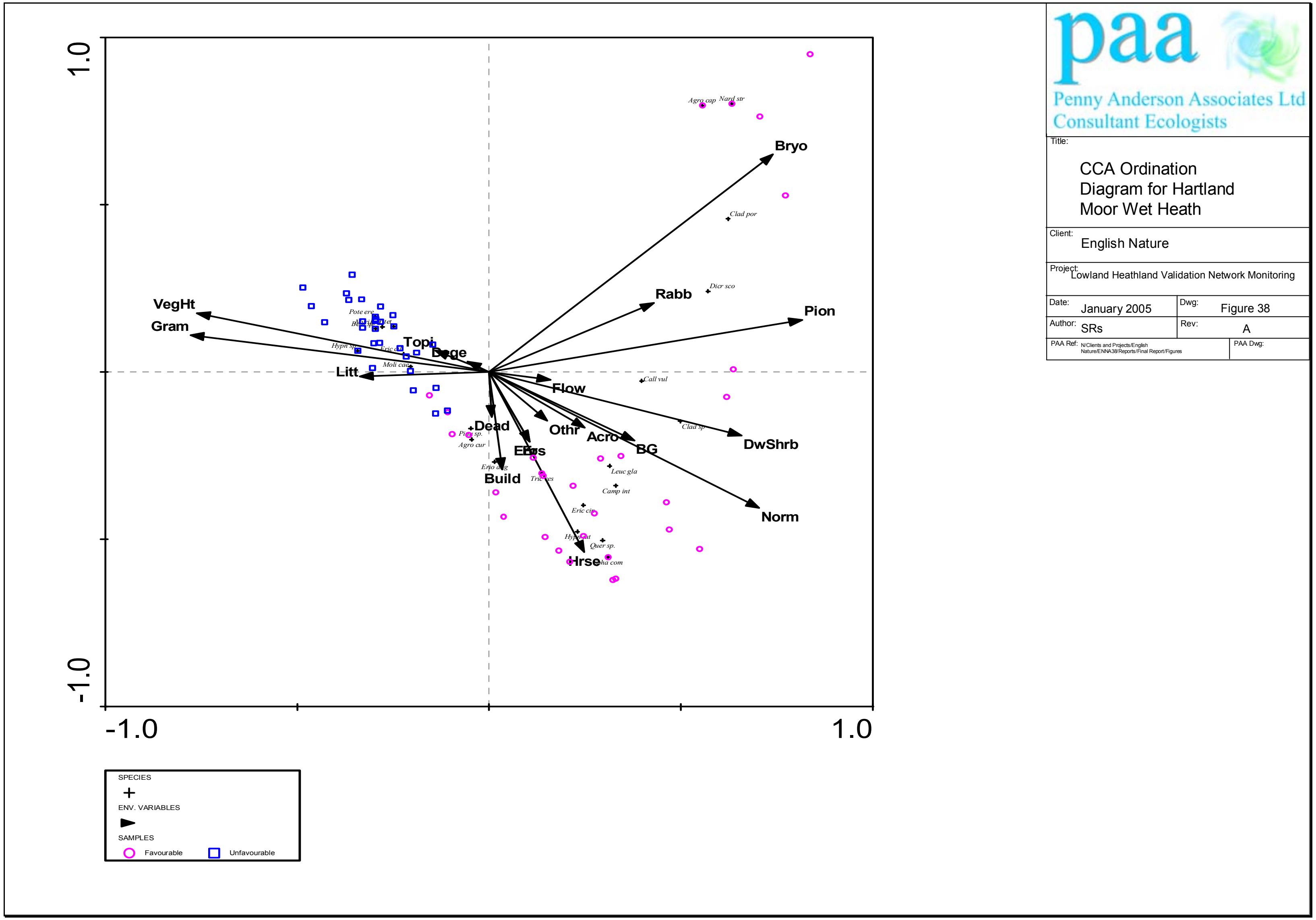


**Figure 38 CCA Ordination diagram for Hartland Moor & Wytch Heath Wet Heath**

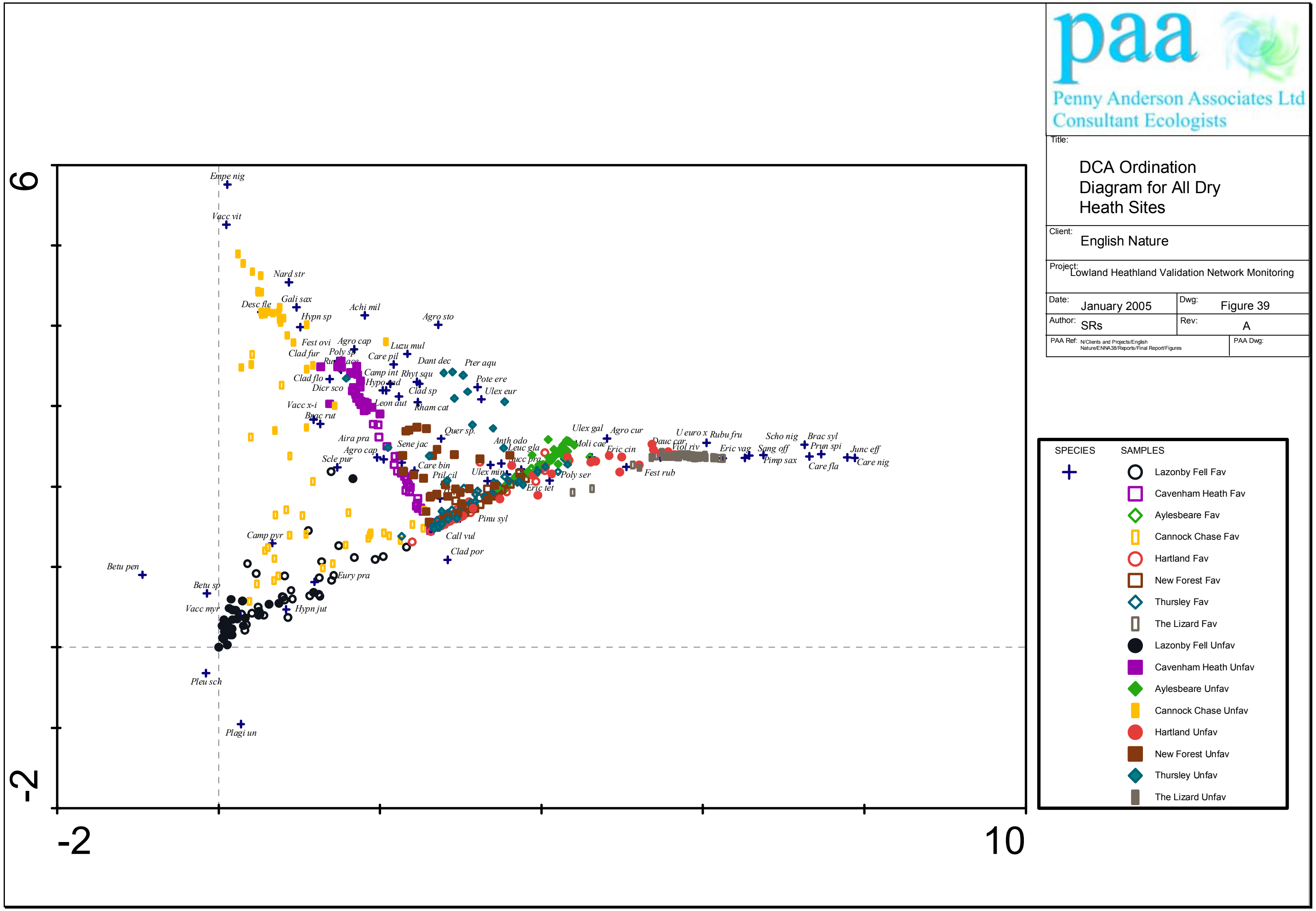


**Figure 39 DCA Ordination diagram for all Dry Heath Sites**

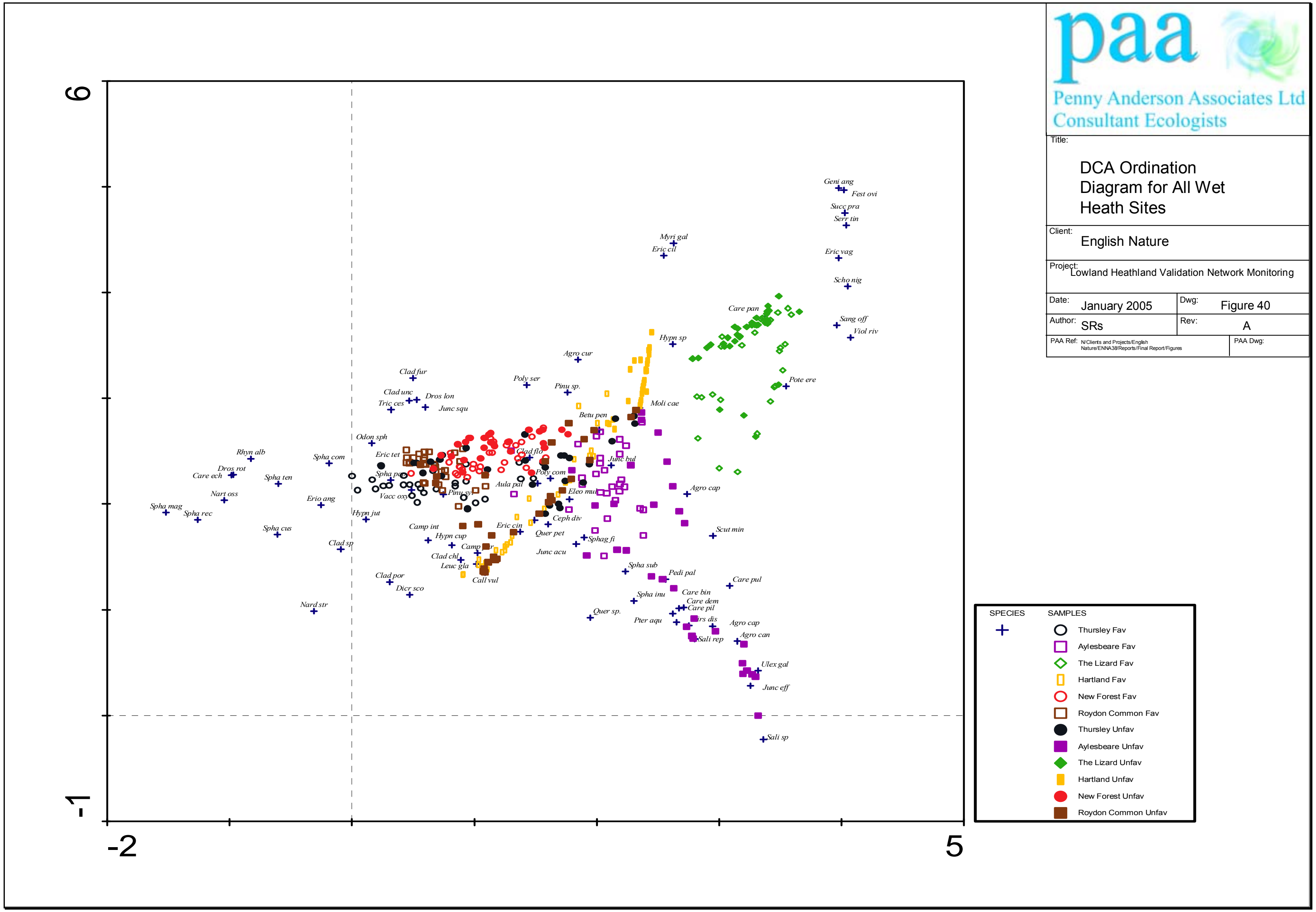


**Figure 40 DCA Ordination diagram for all Wet Heath Sites**

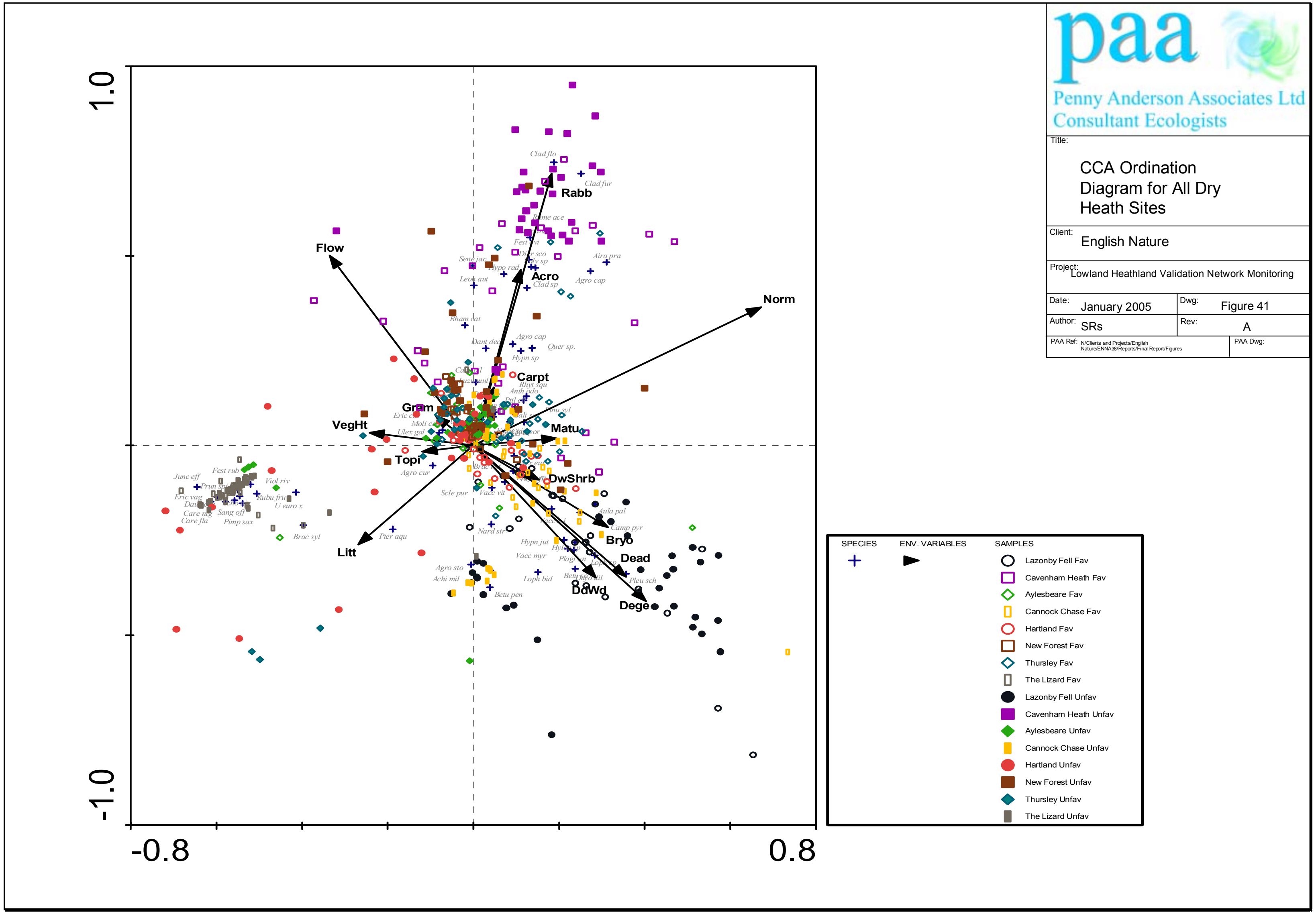


**Figure 41 CCA Ordination diagram for all Dry Heath Sites**

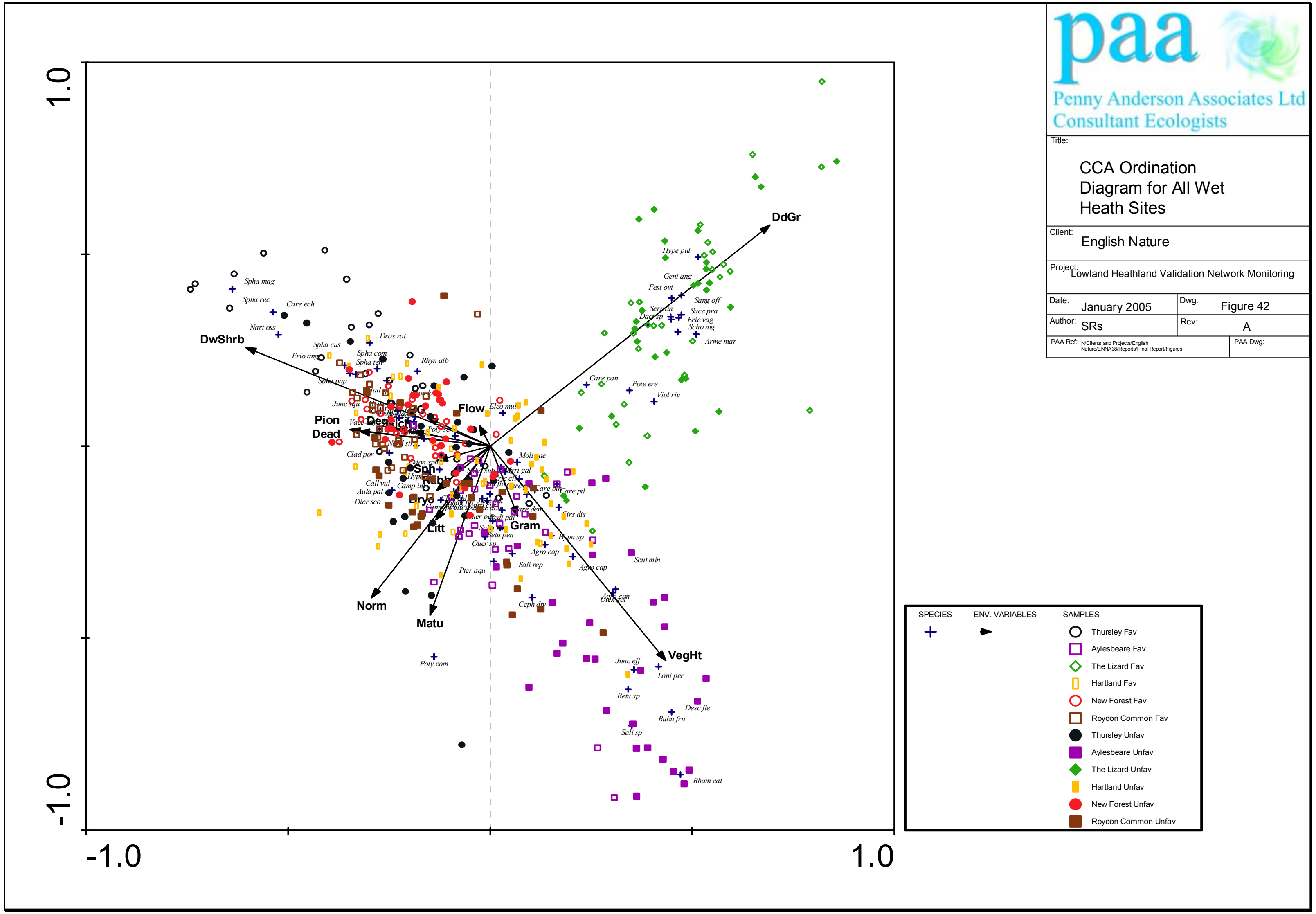


**Figure 42 CCA Ordination diagram for all Wet Heath Sites**

# Appendix 1 Results of the T-Test Analyses

| **Results Of The T-Test Analysis For Aylesbeare, Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 54.10 | -8.828 | **0.000** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 28.00 | -0.996 | 0.328 |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | insufficient data for analysis | | |
| Mature heather (%) | 59.60 | -1.606 | 0.114 |
| Degenerate heather (%) | 40.70 | 0.975 | 0.335 |
| Dead heather (%) | 48.30 | 2.025 | **0.048** |
| Proportion flowering (%) | insufficient data for analysis | | |
| Proportion normal growth (%) | 39.70 | 1.765 | 0.085 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 8.20 | -2.242 | 0.054 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Aylesbeare, Wet Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 57.80 | -4.623 | **0.000** |
| *Sphagnum* (%) | 40.00 | 2.551 | **0.015** |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | insufficient data for analysis | | |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | 57.20 | 0.554 | 0.582 |
| Mature heather (%) | 53.90 | 0.917 | 0.363 |
| Degenerate heather (%) | 31.10 | 1.321 | 0.196 |
| Dead heather (%) | insufficient data for analysis | | |
| Proportion flowering (%) | 30.40 | 3.282 | **0.003** |
| Proportion normal growth (%) | 29.40 | 2.975 | **0.006** |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | 58.00 | 0.000 | 1.000 |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 48.70 | 0.062 | 0.951 |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 6.70 | 0.023 | 0.982 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Cannock Chase, Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 49.9 | 4.885 | 0.000 |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 41.1 | 2.764 | 0.008 |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | 35.7 | -2.148 | 0.039 |
| Mature heather (%) | 53.3 | 2.403 | 0.020 |
| Degenerate heather (%) | 56.3 | 1.550 | 0.127 |
| Dead heather (%) | 45.70 | 1.277 | 0.208 |
| Proportion flowering (%) | 34.70 | 2.781 | 0.009 |
| Proportion normal growth (%) | insufficient data for analysis | | |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | insufficient data for analysis | | |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| Results Of The T-Test Analysis For Cavenham Heath, Dry Heath | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 30.80 | 4.892 | **0.000** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 57.40 | 0.758 | 0.451 |
| Acrocarpous moss (%) | 47.20 | -1.448 | 0.154 |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | 57.60 | 0.175 | 0.862 |
| Building heather (%) | 55.10 | -7.329 | **0.000** |
| Mature heather (%) | insufficient data for analysis | | |
| Degenerate heather (%) | insufficient data for analysis | | |
| Dead heather (%) | 31.60 | 2.583 | **0.015** |
| Proportion flowering (%) | 34.80 | -3.235 | **0.003** |
| Proportion normal growth (%) | 38.10 | 0.009 | 0.993 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 43.50 | -0.507 | 0.615 |
| Erosion (%) | 42.00 | 0.439 | 0.663 |
| Litter (%) | 31.90 | 2.056 | **0.048** |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Hartland Moor, Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 37.60 | -3.171 | 0.003 |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 37.40 | 1.384 | 0.175 |
| Acrocarpous moss (%) | insuffiecient data for analysis | | |
| Graminoid (%) | 31.20 | -1.968 | 0.058 |
| Pioneer heather (%) | 30.40 | -0.550 | 0.586 |
| Building heather (%) | 37.30 | -2.652 | 0.012 |
| Mature heather (%) | 50.30 | 2.884 | 0.006 |
| Degenerate heather (%) | 55.30 | 1.004 | 0.320 |
| Dead heather (%) | 55.90 | 0.422 | 0.675 |
| Proportion flowering (%) | 38.70 | 1.300 | 0.201 |
| Proportion normal growth (%) | 30.80 | 2.967 | 0.006 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | 28.10 | -1.672 | 0.106 |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 56.00 | 0.087 | 0.931 |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | insufficient data for analysis | | |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| Results Of The T-Test Analysis For Hartland Moor, Wet Heath | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 46.20 | -7.618 | **0.000** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | insufficient data for analysis | | |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | 49.50 | -6.310 | **0.000** |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | 56.00 | 2.222 | **0.030** |
| Mature heather (%) | insufficient data for analysis | | |
| Degenerate heather (%) | insufficient data for analysis | | |
| Dead heather (%) | insufficient data for analysis | | |
| Proportion flowering (%) | 51.00 | 1.430 | 0.159 |
| Proportion normal growth (%) | 45.40 | 9.695 | **0.000** |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 17.50 | -2.854 | **0.011** |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Lazonby Fell, Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 54.90 | -1.125 | 0.266 |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 31.80 | -4.298 | **0.000** |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | 25.20 | -0.141 | 0.889 |
| Mature heather (%) | 33.70 | 1.037 | **0.037** |
| Degenerate heather (%) | 25.70 | -2.419 | **0.023** |
| Dead heather (%) | 38.20 | 1.088 | 0.283 |
| Proportion flowering (%) | 44.90 | 11.412 | **0.000** |
| Proportion normal growth (%) | 35.90 | 0.255 | 0.800 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 23.40 | 0.893 | 0.381 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | 11.50 | 1.769 | **0.013** |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For The Lizard, Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 54.40 | -2.587 | **0.012** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | insufficient data for analysis | | |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | insufficient data for analysis | | |
| Mature heather (%) | insufficient data for analysis | | |
| Degenerate heather (%) | insufficient data for analysis | | |
| Dead heather (%) | insufficient data for analysis | | |
| Proportion flowering (%) | 40.10 | 0.601 | 0.551 |
| Proportion normal growth (%) | 52.70 | 0.584 | 0.562 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 11.80 | -0.850 | 0.933 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For The Lizard, Wet Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 57.20 | -0.949 | 0.347 |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | insufficient data for analysis | | |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | 57.80 | -0.457 | 0.649 |
| Mature heather (%) | insufficient data for analysis | | |
| Degenerate heather (%) | insufficient data for analysis | | |
| Dead heather (%) | insufficient data for analysis | | |
| Proportion flowering (%) | 56.40 | 0.506 | 0.615 |
| Proportion normal growth (%) | 52.30 | -1.385 | 0.172 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 56.40 | -0.635 | 0.528 |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | insufficient data for analysis | | |
| Dead grass (%) | 54.20 | -1.613 | 0.113 |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| Results Of The T-Test Analysis For New Forest, Dry Heath | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 50.40 | 12.509 | **0.000** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 47.40 | -0.074 | 0.941 |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | 29.00 | -3.703 | **0.001** |
| Building heather (%) | 47.30 | -3.133 | **0.003** |
| Mature heather (%) | 51.90 | 4.369 | **0.000** |
| Degenerate heather (%) | 41.40 | 1.859 | 0.070 |
| Dead heather (%) | 34.20 | -0.476 | 0.637 |
| Proportion flowering (%) | 31.30 | 3.699 | **0.001** |
| Proportion normal growth (%) | insufficient data for analysis | | |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 27.50 | 0.026 | 0.980 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For New Forest, Wet Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 48.80 | -0.189 | 0.851 |
| *Sphagnum* (%) | 44.00 | 1.945 | 0.058 |
| Lichen (%) | 31.00 | 3.789 | **0.001** |
| Bryophyte (%) | insufficient data for analysis | | |
| Acrocarpous moss (%) | 31.90 | -1.308 | 0.200 |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | 37.70 | -0.882 | 0.383 |
| Building heather (%) | 49.90 | -0.625 | 0.535 |
| Mature heather (%) | 52.50 | -1.219 | 0.228 |
| Degenerate heather (%) | 49.50 | 1.628 | 0.110 |
| Dead heather (%) | insufficient data for analysis | | |
| Proportion flowering (%) | 53.70 | -0.957 | 0.343 |
| Proportion normal growth (%) | insufficient data for analysis | | |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 36.80 | -3.986 | **0.000** |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 48.10 | 4.511 | **0.000** |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Roydon Common** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 39.70 | -2.927 | **0.006** |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | insufficient data for analysis | | |
| Bryophyte (%) | 36.40 | 0.715 | 0.479 |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | insufficient data for analysis | | |
| Pioneer heather (%) | insufficient data for analysis | | |
| Building heather (%) | insufficient data for analysis | | |
| Mature heather (%) | 57.80 | 0.659 | 0.512 |
| Degenerate heather (%) | 55.70 | 1.516 | 0.135 |
| Dead heather (%) | 56.10 | -0.254 | 0.801 |
| Proportion flowering (%) | 57.60 | 0.284 | 0.777 |
| Proportion normal growth (%) | 58.00 | 0.000 | 1.000 |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | 30.10 | -1.533 | 0.136 |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 14.00 | -3.143 | **0.007** |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Thursley Dry Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 43.7 | -5.006 | **0.000** |
| *Sphagnum* (%) | insufficient data | | |
| Lichen (%) | insufficient data | | |
| Bryophyte (%) | 31.8 | 5.584 | **0.000** |
| Acrocarpous moss (%) | 46.2 | 1.038 | 0.305 |
| Graminoid (%) | insufficient data | | |
| Pioneer heather (%) | 31.4 | -0.307 | 0.761 |
| Building heather (%) | 41.4 | -1.808 | 0.078 |
| Mature heather (%) | 44.4 | 0.317 | 0.753 |
| Degenerate heather (%) | insufficient data | | |
| Dead heather (%) | insufficient data | | |
| Proportion flowering (%) | 48.4 | -2.314 | **0.025** |
| Proportion normal growth (%) | insufficient data | | |
| Proportion drumstick form (%) | insufficient data | | |
| Proportion topiary form (%) | insufficient data | | |
| Proportion carpet form (%) | insufficient data | | |
| Grazed (%) | insufficient data | | |
| Uprooted dwarf shrub (%) | insufficient data | | |
| Bare ground (%) | insufficient data | | |
| Erosion (%) | insufficient data | | |
| Litter (%) | 17.1 | -4.534 | **0.000** |
| Dead grass (%) | insufficient data | | |
| Dead wood (%) | insufficient data | | |
| Stones (%) | insufficient data | | |
| * = statistically significant values shown in bold | | | |

| **Results Of The T-Test Analysis For Thursley, Wet Heath** | | | |
|---|---|---|---|
| **Variable** | **DF** | **t-value** | **p-value*** |
| Vegetation height (cm) | 54 | -1.447 | 0.154 |
| *Sphagnum* (%) | insufficient data for analysis | | |
| Lichen (%) | 54.1 | 0.148 | 0.883 |
| Bryophyte (%) | 29.2 | -1.671 | 0.105 |
| Acrocarpous moss (%) | insufficient data for analysis | | |
| Graminoid (%) | 31.4 | -0.857 | 0.398 |
| Pioneer heather (%) | 54.3 | 0.778 | 0.440 |
| Building heather (%) | 52.4 | -1.184 | 0.242 |
| Mature heather (%) | 52.6 | 0.149 | 0.882 |
| Degenerate heather (%) | 38.2 | -1.262 | 0.214 |
| Dead heather (%) | 45.3 | -1.906 | 0.063 |
| Proportion flowering (%) | insufficient data for analysis | | |
| Proportion normal growth (%) | insufficient data for analysis | | |
| Proportion drumstick form (%) | insufficient data for analysis | | |
| Proportion topiary form (%) | insufficient data for analysis | | |
| Proportion carpet form (%) | insufficient data for analysis | | |
| Grazed (%) | insufficient data for analysis | | |
| Uprooted dwarf shrub (%) | insufficient data for analysis | | |
| Bare ground (%) | insufficient data for analysis | | |
| Erosion (%) | insufficient data for analysis | | |
| Litter (%) | 45.7 | -1.632 | 0.110 |
| Dead grass (%) | insufficient data for analysis | | |
| Dead wood (%) | insufficient data for analysis | | |
| Stones (%) | insufficient data for analysis | | |
| * = statistically significant values shown in bold | | | |

# Appendix 2 Results of the Mann-Whitney U-Test Analyses

| Results of the Mann-Whitney U-Test Analyses For Aylesbeare | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Aylesbeare Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 857.50 | **0.000** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| **Aylesbeare Wet Heath** | Dwaf Shrub Cover (%) | 30, 30 | 779.00 | **0.000** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 480.00 | 0.393 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| **Results of the Mann-Whitney U-Test Analyses For Cannock Chase** | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Cannock Chase Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 804.50 | **0.000** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 495.00 | 0.078 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For Cavenham Heath | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Cavenham Heath Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 852.50 | **0.000** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 435.00 | 0.317 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 255.00 | **0.000** |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 28, 29 | 353.50 | 0.298 |
| | Burning (Y/N) | 28, 24 | 348.00 | 0.355 |
| | Burning Rotation (Years) | 27, 24 | 324.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For Hartland Moor | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Hartland Moor Dry Heath** | Dwaf Shrub Cover (%) | 30, 28 | 583.50 | **0.011** |
| | Grazing (Y/N) | 30, 28 | 420.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 28 | 420.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 28 | 420.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 28 | 420.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 28 | 405.00 | 0.301 |
| | Rabbit Dung (Y/N) | 30, 28 | 420.00 | 1.000 |
| | Other Dung (Y/N) | 30, 28 | 405.00 | 0.301 |
| | Erosion (Y/N) | 30, 28 | 405.00 | 1.000 |
| | Burning (Y/N) | 30, 28 | 405.00 | 1.000 |
| | Burning Rotation (Years) | 30, 28 | 405.00 | 1.000 |
| **Hartland Moor Wet Heath** | Dwaf Shrub Cover (%) | 30, 30 | 729.00 | **0.000** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 555.00 | **0.005** |
| | Rabbit Dung (Y/N) | 30, 30 | 510.00 | **0.040** |
| | Other Dung (Y/N) | 30, 30 | 465.00 | 0.317 |
| | Erosion (Y/N) | 30, 30 | 480.00 | 0.154 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| **Results of the Mann-Whitney U-Test Analyses For Lazonby Fell** | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Lazonby Fell Dry Heath** | Dwaf Shrub Cover (%) | 29, 20 | 359.00 | 0.158 |
| | Grazing (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Sheep Dung (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Cattle Dung (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Horse Dung (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Rabbit Dung (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Other Dung (Y/N) | 29, 20 | 300.00 | 0.406 |
| | Erosion (Y/N) | 29, 20 | 290.00 | 1.000 |
| | Burning (Y/N) | 29, 20 | 300.00 | 0.406 |
| | Burning Rotation (Years) | 29, 20 | 300.00 | 0.406 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For The Lizard | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **The Lizard Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 581.50 | 0.051 |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| **The Lizard Wet Heath** | Dwaf Shrub Cover (%) | 30, 30 | 360.50 | 0.184 |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 465.00 | 0.741 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For New Forest | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **New Forset Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 669.00 | **0.001** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 435.00 | 0.317 |
| | Horse Dung (Y/N) | 30, 30 | 270.00 | **0.001** |
| | Rabbit Dung (Y/N) | 30, 30 | 390.00 | **0.040** |
| | Other Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| **New Forest Wet Heath** | Dwaf Shrub Cover (%) | 30, 30 | 513.50 | 0.345 |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 390.00 | 0.200 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 435.00 | 0.317 |
| | Erosion (Y/N) | insufficient data for analysis | | |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For Roydon Common | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Roydon Common Dry Heath** | Dwaf Shrub Cover (%) | 30, 30 | 605.50 | **0.021** |
| | Grazing (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Other Dung (Y/N) | 30, 30 | 435.00 | 0.317 |
| | Erosion (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning (Y/N) | 30, 30 | 450.00 | 1.000 |
| | Burning Rotation (Years) | 30, 30 | 450.00 | 1.000 |
| * = statistically significant values indicated in bold | | | | |

| Results of the Mann-Whitney U-Test Analyses For Thursley Heath | | | | |
|---|---|---|---|---|
| **Site** | **Variable** | **N** | **U-value** | **p-value*** |
| **Thursley Dry Heath** | Dwaf Shrub Cover (%) | 30, 25 | 489.50 | 0.052 |
| | Grazing (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Sheep Dung (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Cattle Dung (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Horse Dung (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Rabbit Dung (Y/N) | 30, 25 | 437.50 | **0.034** |
| | Other Dung (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Erosion (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Burning (Y/N) | 30, 25 | 375.00 | 1.000 |
| | Burning Rotation (Years) | 30, 25 | 375.00 | 1.000 |
| **Thursley Wet Heath** | Dwaf Shrub Cover (%) | 30 | 587.00 | **0.042** |
| | Grazing (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Uprooted Dwarf Shrub (Y/N) | 30 | 450.00 | 1.000 |
| | Sheep Dung (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Cattle Dung (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Horse Dung (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Rabbit Dung (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Other Dung (Y/N) | 29, 30 | 435.00 | 1.000 |
| | Erosion (Y/N) | insufficient data for analysis | | |
| | Burning (Y/N) | insufficient data for analysis | | |
| | Burning Rotation (Years) | insufficient data for analysis | | |
| * = statistically significant values indicated in bold | | | | |

# Research Information Note

*English Nature Research Reports*, No. 669

## Validation Network Project: Lowland heathland monitoring covering: dry and wet heaths

Report Authors: Sarah Ross & Clive Bealey, 2005
Keywords: Validation Network; lowland heathlands; dry and wet heath

## Introduction

The overall objective of the Validation Network project is to ensure that data on the condition of individual features on Sites of Special Scientific Interest (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. 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; establish a set of control sites to ensure that individual site assessments match regional or national changes in feature condition over time; and to contribute to a wider network of monitoring sites that will allow a better understanding of the drivers of change. This document reports on part of Validation Network monitoring on key lowland habitats. These are: lowland wet and dry heaths within the lowland heathland Priority Habitat. The heathland habitats were represented by NVC types H1, H2, H3, H4, H6, H7, H8, M14, M16, M25 and U-type communities.

## What was done

- English Nature carried out a validation exercise at nine lowland heathland sites (Cannock Chase SSSI, Staffordshire; Cavenham Heath NNR, Suffolk; Roydon Common NNR, Norfolk; Aylesbeare Heath SSSI (part of East Devon Pebble Bed Heaths SSSI), Devon; The Lizard NNR, Cornwall; Thursley NNR, Surrey; Lazonby Fell SSSI, Cumbria; New Forest SSSI, Hampshire; Hartland Moor NNR & Wytch Heath SSSI, Dorset).
- Comparisons were made between condition assessments and quantitative data (botanical and environmental), on favourable and unfavourable plots.
- A variety of methods were used to make statistical comparisons between the favourable and unfavourable plots including: C-S-R strategies, Suited Species scores and Multivariate Analysis. This provided the basis for comparing condition using the more qualitative Condition Assessment methodology.

**Continued……**

## Results and conclusions

The comparison of qualitative and quantitative methodologies indicated that in general the rapid (qualitative) assessment approach yielded similar results to the detailed quadrat-based (quantitative) approach. Many of the variables could be relatively accurately assessed using the rapid assessment approach, making this type of assessment a cost-effective and relatively robust way to assess vegetation condition. However, the rapid assessments tended to under-estimate the number and abundance of negative indicator species and over-record the abundance of desirable grass species. The low failure threshold of *Molinia caerulea* appeared to cause failure in the graminoid attribute across all (both 'favourable' and 'unfavourable') wet heath plots.

Further (multivariate), analysis showed that Favourable plots tended to have greater cover of building and mature heather, along with more flowering heather. The bryophyte cover was higher while the acrocarpous moss cover was lower than for unfavourable plots. This suggests that regular monitoring of the dwarf shrub and moss components of a heathland should give a good indication of changes in terms of vegetation condition. Between sites, the dwarf shrub variables gave consistently useful differences between dry heath sites, along with the degree of rabbit grazing. However, the variation between wet heath sites was not great and the majority of sites were clustered together.

## English Nature's viewpoint

This is the latest of a series of reports from the Validation Network. It shows that the condition assessment methodology tested on lowland heathland vegetation generally appears to be robust and applicable in the field, although some adjustments to mandatory targets are needed. Further training of officers undertaking field assessments in both species identification and consistency of recording should result in more accurate assessments of condition on both wet and dry lowland heathland habitats.

## Selected references

ALONSO, I., and others. 2003. Lowland Heathland SSSIs: Guidance on conservation objectives setting and condition monitoring. *English Nature Research Reports*, No. 511. Peterborough: English Nature.

BEALEY, C.E., & COX, J. 2004. 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*, No. 564. Peterborough: English Nature.

JOINT NATURE CONSERVATION COMMITTEE. 2004. *Common Standards for Monitoring Designated Sites.* Peterborough: JNCC.

### Further information

*English Nature Research Reports* and their *Research Information Notes* are available to download from our website: www.english-nature.org.uk

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