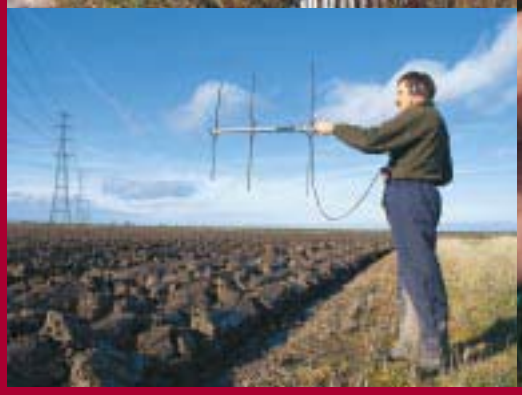
ENGLISH NATURE

Report Number
609

Validation Network Project

Lowland calcareous grasslands: *Bromus erectus* (CG3) grassland

English Nature Research Reports



working today
for nature tomorrow

English Nature Research Reports

Number 609

Validation Network Project

Lowland calcareous grasslands: *Bromus erectus* (CG3) grassland

Sarah Ross,
Clive Bealey
&
Jonathan Cox

ISSN 0967-876X

Acknowledgements

We would like to thank local team and site management staff from English Nature: David Burton and Linda Smith at Martin Down NNR, Graham Steven at Knocking Hoe NNR, Alison Graham-Smith at Lindrick Golf Course. Dave Hutton and Steve Weeks at the Kent Wildlife Trust (Queendown Warren); James Riley at the Wiltshire Wildlife Trust (Salisbury Plain); Paul Toynton and Dominic Ash at the Defence Estates MOD office (Salisbury Plain); Stuart Corbett at Dstl Porton Down; Nigel Critchley and John Fowbert from ADAS Redesdale;

Summary

1. English Nature together with the other UK statutory nature conservation agencies are committed to monitoring condition on designated sites under the Common Standards framework. This sets out the timing and broad structure for monitoring approaches in each agency. English Nature is committed to establish a system for assessing the condition of SSSI features in order to meet the Government's Public Service Agreement target of 95% of SSSI features in favourable condition by 2010. Information on the trends in feature condition is needed to identify obstacles that are preventing favourable condition being achieved for all SSSI features.
2. The Validation Network project has an overall objective to ensure that data on the condition of individual features on SSSIs is accurate, consistent and scientifically robust. The means to achieve this outcome is through a sample of sites on which quantitative monitoring is undertaken on a regular basis in parallel with the cycles of condition assessment for SSSIs.
3. This report presents the results and conclusions of the analyses of data collected for *Bromus erectus* (CG3) grasslands within England, undertaken as part of the Validation Network project. The report outlines the methods used to collect and analyse data, presents the analysis results and discusses these results in relation to aims of the Validation Network project.
4. Six lowland grassland sites within England were selected for monitoring. These sites were Lindrick Golf Course SSSI, South Yorkshire; Knocking Hoe SSSI, Bedfordshire; Queendown Warren SSSI, Kent; Martin Down SSSI, Hampshire; Porton Down SSSI, Wiltshire/Hampshire; and Salisbury Plain Training Area SSSI, Wiltshire/Hampshire.
5. Datasets collected for each sample area included a standard CG3 grassland Vegetation Condition Assessment field survey form, quadrat-based data on botanical composition and cover, a range of measured environmental variables at the quadrat scale (eg. herb to grass ratio, scrub cover, litter cover, aspect and slope), and a range of environmental variables at the plot scale (eg. soil chemistry, disturbance and climate). Analysis took four approaches:

   Firstly, datasets were used to compare qualitative standard English Nature Vegetation Condition Assessment field survey results against detailed quantitative botanical and environmental measurements to assess the effectiveness of each approach in identifying vegetation condition of a site and triggering changes in condition class (ie. changes from favourable to unfavourable condition, and vice versa).

   Secondly, differences in botanical composition of pairs (or groups) of plots on each site were assessed using two vegetation models, the Competitor – Stress tolerator – Ruderal (C-S-R) model and the Suited Species Scores model. Thirdly, univariate statistical analyses of quantitative data were undertaken to identify differences between pairs (or groups) plots of different vegetation condition. Both these analysis approaches were used to identify how different plant communities might relate to differences in vegetation condition scores.

   Finally, multivariate analyses were used to identify the potential drivers of change from favourable to unfavourable condition in order to highlight any possible habitat management that might maintain or improve the condition of the vegetation on each site. The CCA analysis was particularly useful for this.

6. Comparison of qualitative and quantitative vegetation condition data indicated that more than 50% of the plots assessed had different numbers of passes for the mandatory attributes used to identify favourable vegetation condition, depending on the approach used. Although patterns were somewhat difficult to detect, there was a general decrease in the pass rate for mandatory features using the qualitative dataset, suggesting this methodology might yield unfavourable status more frequently in CG3 grasslands than would be gained from a more detailed quadrat-based assessment. However, overall many plots remained in unfavourable condition irrespective of which assessment was implemented, as at least one mandatory attribute failed to meet the required target.
7. The C-S-R model indicated that all plots had a greater affinity with the Stress-tolerator plant strategy and a lesser affinity with the Competitor plant strategy. However, this model provided a relatively poor approach to analysing these data, as score for each community was typically less than 4% fit to any one strategy.
8. Suited Species Scores assessments showed a proportion of the species present within the plant community were tolerant of (ie. 'suited to') grazing and calcicole conditions, and generally less tolerant of high nutrient and moisture levels. Again, as with the C-S-R model, there were some difficulties in applying the model due to limited data. However, both the C-S-R and Suited Species Score models characterised the CG3 grassland communities as dry, calcareous, rather nutrient poor systems that were to some degree maintained by grazing.
9. Assessment of the botanical and environmental differences between pairs (or groups) of plots on a site and the assessment of data using multivariate analysis techniques (CCA and DCA) gave very similar results. The variables identified as being most often significant in the separation of favourable and unfavourable vegetation plots were vegetation height, ratio of herbs to grasses, litter cover, rabbit activity and slope. All these variables therefore, appear to be good indicators of vegetation condition status. In addition, scrub cover and aspect were also useful indicators on some plots. The least useful variables, in terms of separating out favourable and unfavourable vegetation in this dataset, were grazing (of cattle, sheep, etc), and the cover of bare ground
10. Overall, the validation exercise on CG3 grasslands showed that the condition assessment methodology was accurate in assessments relating to most physical attributes, but more inconsistent with those requiring identification of plant species (positive indicators and negative indicators). This can be explained by lower detection rates of some of the less conspicuous species in the positive indicator group and higher detection rates of some of the larger species in the negative indicator group. This is of some concern as identification to species level of constituent grassland species is required for assessment of most of the primary attributes. Grazing and steepness of slope (and therefore depth of soil), appeared to be important drivers of favourable condition. Scrub presence was not necessarily detrimental to the quality of the vegetation community.
11. Further training of officers undertaking field assessments in identification of key species plus further research into the relevance of some elements (eg the relative importance of some of the indicator species) of the primary attributes is recommended.

Contents

List of tables

List of figures

1. Introduction

In June 2003, Penny Anderson Associates Ltd (PAA) was commissioned by English Nature to undertake a project to analyse and report on data collected for *Bromopsis erecta* grassland habitats within six different lowland grassland sites within England. The habitats are classified as *Bromus erectus*[1] CG3 grasslands under the National Vegetation Classification (Rodwell 1992).

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.

The monitoring of key features allows each site to be categorised as favourable maintained, favourable recovered, favourable 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 regional and national targets, including those identified within the UK Biodiversity Action Plan.

1.2 Overall aims

The overall aims of the Validation Network 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 trend 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;

[1] *Bromus erectus* is now classified as *Bromopsis erecta* (Stace 1997).

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 *Bromus erectus* (CG3) grasslands within England, as part of the Validation Network project. The report outlines the methods used to collect and analyse data, presents the analysis results and discusses these results in relation to aims of the Validation Network project (as stated above).

The field data are presented in separate Appendices for future reference, and maps of each site are provided to aid interpretation.

Throughout the report nomenclature follows Stace (1997) for all higher plants, Watson (1981) for bryophytes and Dobson (2000) for lichens. National Vegetation Community (NVC) types and sub-communities are described with reference to Rodwell (1992).

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, Robertson and Jefferson 2000).

2.2 Sites selected

Six lowland grassland sites within England have been selected for monitoring (Table 1). These sites are either Sites of Special Scientific Interest (SSSI) or Local/National Nature Reserves (LNR/NNR). Two sites are selected as candidate Special Areas of Conservation (cSAC). The sites are:

- Lindrick Golf Course SSSI, South Yorkshire;
- Knocking Hoe NNR/SSSI, Bedfordshire;
- Queendown Warren LNR/NNR/SSSI, Kent;
- Martin Down NNR, Hampshire;
- Porton Down SSSI/cSAC, Wiltshire/Hampshire;
- Salisbury Plain Training Area SSSI/cSAC, Wiltshire/Hampshire.

Lindrick Golf Course SSSI (Figure 1) is an area of magnesian limestone (dolomite) with a mixture of unimproved grassland and scrub between the greens and fairways of the golf course. The main species within the grassland are *Bromopsis erecta* and *Brachypodium pinnatum*. Other species include *Carlina vulgaris, Cirsium acaule, Scabiosa columbaria, Centaurea scabiosa, Blackstonia perfoliata* and *Centaurium erythraea*.

Knocking Hoe NNR/SSSI (Figure 2) is an area of unimproved calcareous grassland, dominated by *Festuca ovina* and *Bromopsis erecta* with a diversity of other species including *Asperula cynanchica, Linum catharticum, Lotus corniculatus, Primula veris, Sanguisorba minor* and *Viola hirta*.

Queendown Warren LNR/SSSI (Figure 3) has unimproved calcareous grassland and woodland. The grassland is dominated by *Bromopsis erecta* and *Festuca ovina*, with a diversity of associated species including *Polygala calcarea, Asperula cynanchica, Hippocrepis comosa* and several species of orchid.

Martin Down NNR (Figure 4) also includes Martin and Tidpit Down SSSI. The area includes extensive unimproved calcareous grassland, chalk heath and scrub. The grassland flora is diverse with species such as *Thesium humifusum, Senecio integrifolius, Gentianella anglica, Serratula tinctoria* and *Centaurium pulchellum*, along with several species of orchid.

Porton Down SSSI (Figure 5) is also designated an SPA and falls within Salisbury Plain cSAC. The area is designated for its unimproved calcareous grasslands but also includes scrub and woodland habitats. The grassland communities are diverse and include *Festuca ovina – Avenula pratensis*[2] grassland (CG2), *Avenula pubescens* grassland (CG6) and *Bromus erectus* grassland (CG3).

Salisbury Plain SSSI (Figures 6a and 6b) is also designated a SPA and cSAC and forms the largest known expanse of unimproved chalk downland in north-west Europe. A large proportion of the site supports *Bromus erectus* grassland (CG3) with a range of associated species including *Festuca rubra, Koeleria macrantha, Sanguisorba minor, Galium verum* and *Leontodon hispidus*.

Additional information on each site, including a National Grid Reference, is provided in the SSSI citations presented in Appendix I.

2.3 Plot selection for CG3 grassland monitoring

Within each site between one and five plots within the CG3 grassland habitats were selected for monitoring. Where possible, 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.

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.

Plots were selected 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.

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).

2.4 Data collection

2.4.1 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 (Robertson & Jefferson, 2000).

[2] *Avenula* is now classified as *Helictotrichon* (Stace 1997).

2.4.2 Quantitative vegetation data

Grassland condition assessment methodology is based on the assessment of primary attributes (habitat characteristics that are recommended for the determination of community condition) and secondary attributes (usually structural aspects which provide information on the drivers of condition). Condition is a composite of measurements of these attributes against targets (JNCC 2004). Three attributes were assessed in the field under this general heading. These were botanical composition, the ratio of herbs to grasses and the cover of scrub. Each is briefly described below.

2.4.2.1 Botanical composition

Botanical composition was recorded using 1mx1m quadrats. Quadrats were placed within a plot using randomly selected co-ordinates within five strips, based on the method described in Hodgson and Colasanti (1995). Thirty quadrats, equally divided between the five strips, were recorded in each plot, except for Easton Down (on Porton Down) where 21 quadrats were recorded.

All higher plants, together with bryophytes and lichens able to be identified in the field, were recorded. Nests at 10cmx10cm, 20cmx20cm, 30cmx30cm, 40cmx40cm, 50cmx50cm and 100cmx100cm were used to record the first occurrence of each species in the quadrat.

2.4.2.2 Herb to grass ratio

This attribute was recorded using a pin-frame as employed in previous studies (Robertson, Bingham and Slater 2000). A sub-sample of 30 pin 'hits' within the frame was used, with the first 'hit' only being recorded for each pin, and described as either grass or herb (see also litter and bare ground measurements). Grass records include the Gramineae[3] only, while herb records include dicotyledon plants and monocotyledons that are not Gramineae (eg. the Cyperaceae and Juncaceae).

2.4.2.3 Scrub cover

Scrub cover was assessed as an estimated percent cover in an expanded 5x5m area centred on the 1mx1m quadrat.

2.4.3 Environmental data - quadrat scale

A range of environmental and structural variables was sampled at each quadrat location to aid in the interpretation of variation in the botanical data. The variables measured were sward structure, litter, bare ground, grazing, aspect and slope. The methods used are described briefly.

2.4.3.1 Sward structure

A 200g drop disc and 'sward stick' was used to measure an index of height (based on sward bulk) and maximum 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. Maximum height was recorded before the disc was dropped.

[3] Referred to as the Poaceae in Stace (1997).

2.4.3.2 Litter and bare ground

Litter and bare ground were assessed by recording the number of pin frame 'hits' on litter during the herbs to grass ratio measurements. Estimated percent cover of these two attributes was also assessed within each quadrat.

2.4.3.3 Grazing

An index of rabbit grazing was assessed by counting the number of rabbit faecal pellets per quadrat (Dolman and Sutherland 1992, Bealey 2001). The presence of other dung (eg. cattle, sheep, horse) was also noted. Additional information of stock grazing regimes on the site was collated from Site Managers. This information is variable in its detail for each site and has been used as an aid to interpretation of data rather than being included in the analysis.

2.4.3.4 Aspect and slope

At each quadrat location aspect was measured using a hand-held compass while slope was measured using a hand-held clinometer.

2.4.3.5 Environmental data - plot scale

At the plot scale a number of additional environmental attributes were assessed or collated. These were soil characteristics, additional information of rabbit activity and other disturbance features (such as tracks, fires, etc), along with climate data.

2.4.3.6 Soil characteristics

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. Fresh pH was measured in the field. Organic matter content (loss on ignition), pH, and cation exchange capacity (CEC) were all assessed. 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), total nitrogen (N).

2.4.3.7 Disturbance

Additional information on rabbit activity at the plot scale was collected by measuring the dimensions of any warren within the plot and describing rabbit activity on a wider scale.

A description of additional disturbance factors such as tracks, 'fly' tipping and fires was also noted and its impact described.

2.4.3.8 Climate

Additional information on climate was obtained as monthly long-term averages (1971–2000) from the nearest Meteorological Station for each site. Data cover 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 2.

2.4.4 Data handling

Qualitative data were provided on written field survey forms for each plot. Additional background information was kindly provided by Site Managers and/or locally-based English Nature personnel.

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).

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.

2.4.5 Data analysis

2.4.5.1 Assessment of vegetation condition

The condition of the vegetation on each plot was assessed using the standard Vegetation Condition Monitoring forms for CG3 grassland community types. In each case the mandatory attributes were predominantly used to guide the division into either favourable of unfavourable condition (all mandatory attributes must pass the assessment for a site to be designated as in favourable condition).

Those sites where both plots were identified as unfavourable were scrutinised further to rank the plots in terms of 'relative favourable condition'. If a plot failed a particular attribute but the fail was marginal, or if the plot had a lower overall number of failed attributes, then the plot was identified as being favourable relative to its partner plot. For Salisbury Plain all five plots were ranked using the same system.

This resulted in each site having its plots ranked to identify those plots with favourable or relatively favourable vegetation condition, compared with unfavourable plots. These ranks were then used in further data analysis and discussion.

2.4.6 Comparison of qualitative and quantitative condition data

The qualitative condition assessment information for each plot was collated from the standard assessment forms provided by English Nature, and each target allocated a 'pass' or 'fail' depending on whether it reached the target set by the standard assessment for CG3 grassland communities.

In addition, the equivalent quantitative information collected through quadrat sampling was averaged for each plot and also allocated a 'pass' or 'fail' in relation to the relevant target set by the standard assessment. To compare data some manipulation of quantitative information was required.

Rabbit disturbance was assessed by eye for the whole plot in the qualitative assessment, while the percent cover of disturbance was assessed in each quadrat for the quantitative assessment. In this latter case, an average of no more than 5% disturbance was considered a 'pass' (based on an average plot scale of 1ha, with 5% representing approximately the 0.05ha required by the standard condition assessment).

Percent frequency of each species was calculated for each plot and these data were used to approximate percent cover of key indicator species. Where necessary these data were then converted to an abundance scale (DAFOR) to enable comparison with the abundance scale used in the qualitative assessments. The conversion used, provided by English Nature, is presented in Table 3.

The key indicator species lists used for Salisbury Plain were slightly modified in line with English Nature agreements for this site, with *Senecio jacobaea* being removed from the negative indicator species list. In addition, *Centaurea scabiosa, Genista tinctoria, Onobrychis viciifolia, Serratula tinctoria* and *Viola hirta* were added to the positive indicator species list.

Finally, some of the quantitative datasets were transformed prior to calculation of the average to increase the normality of data distribution. A square-root transformation was undertaken on the height data and an arcsine transformation on scrub cover (Sokal and Rohlf 1995). Averages were back-transformed prior to comparison with qualitative data.

2.4.7 Assessment of botanical composition

Botanical composition was assessed using the Modular Analysis of Vegetation and Interpretation System (MAVIS) developed by the Centre for Ecology and Hydrology (CEH). This package incorporates analysis of datasets against standard classifications including the National Vegetation Classification (NVC) (Rodwell 1992), the Countryside Vegetation System (CVS) (Bunce and others 1999), Competitor – Stress tolerator – Ruderal (C-S-R) characterisation (Grime 1979, Grime and others 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.

CVS data were not assessed as these categories are very broad and all plots were likely to belong to the Calcareous Grassland class. The Ellenberg values were not assessed as these have been largely replaced by Suited Species Scores for British plants (Hill and others 1999). NVC classification was not assessed, as all plots were known to belong to the CG3 calcareous grassland community.

In addition, Suited Species Scores (Critchley 2000) were used to assess differences between plots. The scores used were Calcicole, Grazing, Nutrient and Moisture Suited Species Scores available for each species present within each plot. The Suited Species Scores were obtained from Appendix 9 of Robertson, Bingham and Slater (2000).

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 was 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). For calcicole suited species the total score was calculated for each quadrat. For the other attributes (nutrient, grazing and moisture) 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 quadrat indices. The indices and their interpretation are presented in Table 5.

These data were analysed using the Mann-Whitney *U*-test to compare pairs of plots and the Kruskal-Wallis test to compare data from more than two plots (undertaken on the Salisbury Plain dataset only).

2.4.8 Assessment of vegetation and environmental variables

A range of variables relating to vegetation composition, vegetation structure, environmental conditions and soils were measured within each plot. The majority of variables were measured within each quadrat yielding a set of data for each plot. Soils data were, however, taken at the plot (rather than quadrat) level with no sampling undertaken at Porton Down or Salisbury Plain because of restrictions due to the presence of buried ordnance.

For quadrat-based data, the variables for each pair of plots were analysed using a two sample t-test to assess significant differences between the plots in respect of each variable measured. For Salisbury Plain there were five unpaired plots, and these data were analysed using Analysis of Variance (ANOVA) followed by Tukey pair-wise comparisons to assess significant differences between all five plots. 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).

Soils data were collected at the plot scale with a single measurement of each soil chemical parameter taken from a bulked sample from within the plot. These data are discussed in general terms and also included in a regression analysis with the results from the multivariate analysis (detailed below).

Meteorological data were available at the plot scale only, and are discussed briefly and also included in a regression analysis with the results from the multivariate analysis detailed below.

2.4.9 Multivariate analyses

Differences between species composition between pairs of plots and groups of plots (Salisbury Plain) were explored using Detrended Correspondence Analysis (DCA). Abundance data for each species were calculated from the quadrat data using the transformation presented in Robertson, Bingham and Slater (2000). Data relating to pairs of plots from each site were analysed using a standard run within the DCA programme options.

The Salisbury Plain dataset has five plots and the DCA included all five plots in the analysis. 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 and weather data (available at the plot and site scale, respectively) to identify any linear correlations between these data. The 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 the correlations between different environmental variables can also be assessed by interpreting the angle between two variables on the ordination diagram. An acute angle suggests a positive relationship between the two variables, while an obtuse angle indicates a negative relationship.

In addition, the CCA can be used to identify a subset of environmental variables that are 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 significant amount of variation within the ordination diagram can then be identified.

As for DCA, the CCA was undertaken on pairs of plots at each site, and the group of five plots for Salisbury Plain. Nine environmental variables were included in the analysis, and these were vegetation height, sward structure (drop disc height), litter cover, bare ground cover, proportion of grass, proportion of herb, scrub cover, rabbit grazing and slope. Again, down-weighting of rare species was used to reduce their influence on the ordination. These results are presented as tri-plot ordination diagrams.

3. Results and discussion

3.1 Vegetation condition assessments

The Condition Assessment forms were used to identify the condition of each of the CG3 grassland plots, and the results of this assessment is summarised in Table 6. The number of passes for the mandatory attributes was an important deciding factor in whether a plot was favourable or unfavourable vegetation condition. All five mandatory attributes must pass the relevant criteria for the plot to be considered in favourable condition. Details of specific pass or fails for each criterion are presented in Table 7.

Lindrick Golf Course had two plots, the Old 12th Fairway plot and the 17th Fairway, and both were assessed to be in unfavourable condition. This was generally due to a high cover of grasses and low frequency/diversity of positive indicator species. However, on the 17th Fairway the lower cover of *Brachypodium pinnatum* suggests this plot was in slightly more favourable condition than the Old 12th Fairway.

Two plots were present on Knocking Hoe. The plot on The Hoe passed on all mandatory attributes signifying it was in favourable condition. However, the plot on Compartments 4–5 had slightly greater grass component and had a greater number of negative indicator species, relegating this plot's vegetation to the more unfavourable status of the two plots.

Queendown Warren had a similar set of plots to Knocking Hoe in terms of vegetation condition. The plot on Main Bank passed on all mandatory attributes signifying it was in favourable condition. However, the plot on East Bank failed due to a smaller number of positive indicator species than required, and the condition assessment therefore identified this plot as unfavourable.

Martin Down had four plots covering a range of vegetation conditions. Plot 4A was classed as unfavourable due to the high cover of grasses and in particular *Brachypodium pinnatum*, although the fail on positive indicator species was considered marginal. Plot 4B was identified as being in unfavourable condition due to high cover of grasses, although in this case *Brachypodium pinnatum* was not considered an issue. This plot was therefore considered to be in slightly more favourable condition out of the pair. Plots 2C East and 2C West were both identified as in unfavourable condition. However, because Plot 2C East had only one failed mandatory attribute, this plot was considered to have a higher ranking vegetation condition than Plot 2C West which failed on two mandatory criterion.

Porton Down had two plots, Battery Hill and Easton Down, both being in unfavourable condition in relation to the Vegetation Condition Assessment data. Again, unfavourable condition at Battery Hill was linked to the high number and frequency of negative indicator species while all other mandatory attributes passed. Easton Down failed on both the high number of negative indicator species and the high cover of scrub, indicating this plot had slightly lower vegetation condition than Battery Hill.

Salisbury Plain had a total of five CG3 grassland plots. All plots failed on one or more mandatory attributes resulting in them all being classed as being in unfavourable condition. However, Plot 20.01 failed only on a slightly higher cover of negative indicator species, suggesting this plot might be regarded as the highest ranking plot. Other plots failed on two

mandatory attributes, but there was no general pattern to which attribute this was. In order to rank the remaining four plots, the non-mandatory attributes were assessed.

3.2 Comparison of qualitative and quantitative vegetation condition data

This assessment consisted of comparisons between qualitative and quantitative data for mandatory attributes and then comparisons between the same datasets for additional (ie. non-mandatory) attributes. Data are compared in detail in Table 7 and summarised in Table 8, while raw data are presented in Appendix II (qualitative data), Appendix III (quantitative data for species) and Appendix IV (quantitative data for vegetation and environmental variables).

3.2.1 Mandatory attributes

Five mandatory attributes were compared between the qualitative and quantitative datasets for each site. Nine out of the 17 plots (52.9%) assessed did not have the same number of mandatory passes when comparing qualitative and quantitative assessments (Tables 7 and 8). These were Lindrick Golf Course 17th Fairway (L2), three plots on Martin Down (M1–M3), Porton Down Easton Down (P2), and four plots within Salisbury Plain (S1– S4).

On Lindrick Golf Course 17th Fairway (L2) the cover of *Brachypodium pinnatum* was recorded only once for the qualitative assessment, and therefore assumed to be at a low cover, although it occurred frequently within the quadrat records at some quite high covers (eg. cell size 1). This suggests that *Brachypodium pinnatum* was less readily picked up during the standard vegetation condition survey compared to the more detailed quadrat recording. This might relate to sward height and, therefore, grazing intensity, with a lower canopy height making it more difficult to readily distinguish this species in the grassland sward.

On Martin Down Plot 4A (M1) the quantitative dataset estimated a higher cover of both positive and negative indicator species leading to a pass and a fail for these two categories, respectively. The opposite was indicated by the qualitative data. The other mandatory attribute difference was a marginal difference in grass proportion that tipped the assessment to a pass or fail by a difference of only 4%.

Martin Down Plot 4B (M2) showed a similar range of differences in assessments. Again, positive indicator species were estimated at a higher cover using quantitative data, giving a pass. However, grass proportion was significantly lower using the quantitative assessment data compared to the qualitative assessments. Martin Down Plot 2C East (M3) gave different discrepancies, with quantitative assessments providing greater measures for height and rabbit grazing.

On Porton Down (P2) three mandatory indicators were different between the qualitative and quantitative assessments. The qualitative assessment generally provided larger estimates for two negative indicators (scrub cover and the cover of negative indicators) and one positive indicator (herb proportion).

Salisbury Plain (S1–S4) data indicated that, in general, the greater number of passes was achieved through the quantitative assessment data. In particular, the quantitative assessment appeared to provide larger estimates of positive indicator species cover and smaller estimates of negative indicator species cover, resulting in more passes for these two attributes. Although for S3 the opposite occurred for negative indicator species. On plot S4 the

differences where attributed to a lower estimate of grass proportion and scrub cover using quantitative data, leading to more mandatory attribute passes for this dataset.

In summary, the qualitative English Nature Vegetation Condition Assessment methodology typically led to a lower number of passes for mandatory attributes. Using the qualitative method, 2 of the 17 plots (11 per cent) were determined as being in favourable condition compared to 7 (41 per cent) when the quantitative method was applied. This difference is statistically significant (Chi-square = 6.071, $P < 0.05$). This method was therefore likely to classify more sites as being in less favourable condition. Quantitative data tended to increase the pass rate for the mandatory attributes.

3.2.2 Other attributes

While quantitative data generally increased the pass rate for mandatory attributes, it tended to reduce the pass rate for other non-mandatory attributes. In particular the vegetation height measurements were consistently greater in the quantitative dataset and were more often above the maximum required for a pass. This might be an artifice of using 'first height' data for comparison, as this reflects maximum rather than average heights.

On Salisbury Plain, litter was regularly estimated to be at a higher cover using the qualitative dataset compared to the quantitative data. This attribute therefore achieved a better pass rate using the quantitative dataset.

Rabbit grazing and associated disturbance was more often recorded as affecting smaller areas (<0.05ha) using qualitative data than with quantitative data. In this case, comparison of these data was difficult as data were collected in very different ways and not readily comparable. This difference might be an artifice of data conversion from quadrat to plot scale rather than any difference in the survey method.

3.3 Assessment of botanical composition

The assessment of botanical composition included an analysis of the C-S-R percentage scores and Suited Species Scores for each plot, followed by a comparison of plots at each site. Each is discussed, in turn, below.

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

The percentage score for each of the primary plant strategies (C-S-R values) for each plot are presented in Table 9. The percentage score is low (<4%) in all cases for all primary strategies. This is likely to reflect the relatively high number of species within the dataset that do not have any data attached to them within the C-S-R model (often more than 20 species were excluded from the analysis due to this).

An assessment of the percentage scores indicates that in all cases the species composition related most closely to the Stress tolerator plant strategy, with this score always being the highest for each plot. The score for the Competitor plant strategy was often the lowest score, indicating a very poor fit to this plant strategy.

The CG3 grassland plots were therefore showing a plant community characteristic of the Stress tolerator primary plant strategy. This indicates the community comprises

predominantly of species that are able to withstand a degree of environmental stress. This stress is often in the form of shortages of light, water, mineral nutrients or sub-optimal temperatures (Grime and others 1988) all of which can limit plant productivity.

In the case of these plots, it is likely that low nutrient availability was the main factor attributable to increased stress on plants, with some additional effects of low water availability on south-facing slopes and sites with very shallow or compacted soils (Porton Down and Salisbury Plain).

3.3.2 Analysis using Suited Species Scores

Average values for Calcicole, Grazing, Nutrient and Moisture Suited Species Scores/Indices were calculated for each plot and are presented in Table 8, with the original data presented in Appendix VI. Analysis of the variation between plots was assessed using either Mann-Whitney *U* or Kruskal-Wallis tests, and these results are presented in Tables 9 and 10.

Some general trends on the Suited Species Scores can be drawn from Table 10. The Sum of the Calcicole Score ranged from 2.2 to 14.1. The higher scores occurred at Queendown Warren and Martin Down, although there were no clear divisions between sites. These sites therefore had the greater number of species positively suited to calcicole conditions. However, no score obtained was negative, indicating all plots had some degree of positive association with calcareous characteristics, as would be expected from a CG3 grassland community.

The Suited Species Indices for grazing, nutrient and moisture ranged from 1 to –1, with positive values indicating the presence of species positively associated with that variable, and a negative value indicating the presence of species negatively associated with that attribute.

All sites, except Martin Down 2C East (M3), had a slight positive association with grazing, indicating a proportion of the species present were ‘suited to’ or tolerant of higher grazing levels. However, none of the indices were greater than 0.37 suggesting there was also a proportion of species that were negatively affected by, or were indifferent to, high levels of grazing. Indeed, assessing these data in detail (Appendix VI) indicated there were a large number of species within each plot that have no preference for grazing level, several that were more tolerant of grazing (eg. *Briza media, Linum catharticum* and *Pimpinella saxifraga*), and rather few occurrences of species that were considered less tolerant of grazing (eg. *Clinopodium vulgare* and *Arrhenatherum elatius*).

An assessment of the Nutrient Suited Species Index identifies all plots had a fairly high complement of species that were ‘not suited by high nutrients’, ie. were characteristic of low nutrient availability within their soils. The highest index was –0.30 for Salisbury Plain Plot 35.03 (S5), indicating that this plot had fewer species tolerant of low nutrient conditions, suggesting the site had relatively more nutrients available. The majority of plots had a value of –0.5 or less, with the lowest indices at Knocking Hoe The Hoe (K2) and Queendown Warren Main Bank (Q2) (indices of –0.83 and –0.84 respectively).

The Moisture Suited Species Index also showed a generally high number of species more typical of dry conditions, with indices values ranging from -0.36 (Salisbury Plain, Plot 35.03) to –0.68 (Lindrick Common, Old 12th Fairway (L1)). A botanical composition with such strong associations with dry conditions would be expected on these CG3 grassland habitats

due to their typically shallow soils and free-draining nature of the underlying chalk and limestone deposits.

In terms of pairs of plots in favourable or unfavourable condition, there were some significant differences between Suited Species Scores (Table 11). In the majority of cases those plots with higher scores for Calcicole Suited Species also had a higher score for Grazing Suited Species Index. These sites often also had relatively more species typical of lower nutrient conditions, although this trend was less clear. Moisture Suited Species Index was very variable and showed no clear trend with regard to other Suited Species Scores. This is likely to reflect the generally dry nature of the CG3 grasslands that show very little variation in wetness.

Overall the analysis of all five plots on Salisbury Plain gave highly significant differences for all parameters (sum of the Calcicole Score, Grazing Suited Species Index, Nutrient Suited Species Index and Moisture Suited Species Index). These data are presented in Table 12.

The sum of the Calcicole Score for plot 79.09 (S1) was significantly greater than the scores for all other plots except plot 69.01 (S4). Conversely, plot 35.03 (S5) had a significantly lower calcicole score than all other Salisbury Plain plots. This indicates that plot 79.09 had a greater number of species positively associated with calcicole conditions, while plot 35.03 had a lower number of species associated with calcicole conditions.

The Grazing Suited Species Index was significantly lower for plot 35.03 compared to all other plots, indicating this plot had a lower number of species associated with higher grazing levels. Plot 43.03 (S3) also had significantly fewer species associated with grazing compared to plots 79.09 and 69.01.

In terms of the Nutrient Suited Species Index, plot 35.03 had significantly fewer species associated with high nutrients than plots 20.02 (S2), 43.03 and 69.01, but not with respect to plot 79.09. Plot 69.01 had a significantly lower value than all other plots at this site, indicating it had the greater number of species associated with low nutrient availability.

3.4 Assessment of vegetation and environmental variables

Vegetation and environmental variables were collected at either the quadrat scale or at the plot scale. Quadrat scale data were assessed using standard statistical analyses (two sample t-tests and ANOVA) while plot scale data are discussed briefly and used as parameters within the multivariate analyses (detailed later).

3.4.1 Quadrat scale variables

A total of 15 variables measuring vegetation traits and two variables measuring environmental traits were analysed for each site (collectively known as environmental variables). Many of these variables showed significant differences between the favourable and unfavourable plots.

At Lindrick Golf Course (Table 13) those measurements relating to vegetation height (sward height, drop disc height and sward mass index) showed highly significant differences between the Old 12th Fairway (L1) and the 17th Fairway (L2) plots. In all cases, the Old 12th Fairway had the greater value. Other significantly different variables were scrub cover, litter

cover and proportion of grass and herbs. The Old 12th Fairway had a lower scrub cover but a greater litter cover and a greater proportion of grasses. This plot was also on a shallower slope and had a more easterly aspect compared to the 17th Fairway that was more southerly in aspect. These factors all contributed to the Old 12th Fairway's (L1) less favourable condition.

Knocking Hoe (Table 14) showed fewer significant differences between Compartments 4-5 (K1) and The Hoe (K2). Vegetation heights were greater on Compartment 4-5, suggesting this plot was the least favourable in terms of vegetation condition. Again, the less favourable plot was on a shallower slope, although in this case the two plots had similar aspects of south and south-east (K1 and K2 respectively).

Table 15 provides the results for the two plots at Queendown Warren. The East Bank plot (Q1) had more unfavourable characteristics with taller vegetation, a greater scrub and litter cover and a lower proportion of herbs. This plot also had reduced effects of cattle and rabbit grazing compared to the Main Bank plot (Q2). These two sets of variables are likely to be linked. In terms of aspect and slope, both were similar although the Main Bank plot showed a slightly more southerly aspect.

The first two plots on Martin Down were 4A (M1) and 4B (M2), and their results are presented in Table 16. In general, there were fewer significant differences between these two plots, in terms of the variables measured. Plot 4B had the slightly more favourable condition of the two plots, with a significantly greater proportion of herbs and fewer grasses, along with significantly more rabbit grazing and disturbance compared to plot 4A. Again, the aspects of these two sites were similar at around north (the significant difference is likely to be an artifice of the use of degrees for aspect) however, plot 4A had the greater slope.

The second pair of plots on Martin Down was plots 2C East (M3) and 2C West (M4). Plot 2C West had a significantly greater vegetation height, a significantly lower proportion of herbs and had significantly less rabbit disturbance. These data are presented in Table 17 and suggest plot 2C West had the less favourable vegetation condition.

The two plots assessed on Porton Down were Battery Hill (P1) and Easton Down (P2), and the results of the two-sample t-test analyses are presented in Table 18. Battery Hill showed significantly greater levels of rabbit grazing and rabbit disturbance. Easton Down showed significantly greater vegetation heights and scrub cover indicating that, out of these two plots, it is in less favourable condition. The greater sward heights and scrub cover on Easton Down are likely to reflect the lower rabbit activity here.

Salisbury Plain had a total of five plots, and these were analysed using ANOVA (results presented in Table 19) with significant pair-wise interactions identified using Tukey pair-wise comparison tests (results presented in Table 20). The majority of the variables measured showed an overall significant difference between plots, and the multiple comparison tests are discussed in detail to identify where these differences occur.

A lower sward height was characteristic of more favourable vegetation for CG3 grasslands, and significantly lower sward heights were found in plots 79.09 (S1) and 43.03 (S3). A very similar pattern of significant differences was found for drop disc height.

Scrub cover was very slightly greater in plot 70.09 compared to all other plots. However, the mean values for scrub cover were all very similar and the probability for plot 70.09 was only just within the significance level. Therefore differences between plots appear unlikely to have any great ecological significance.

Rabbit grazing and disturbance was significantly higher on plot 70.09 than on all other plots, and this was especially noticeable for the index of rabbit grazing (based on counts of rabbit faecal pellets). This plot was also the only plot that had a nearby rabbit burrow, with no burrows within the vicinity of other plots (hence distance to burrow measurement is zero).

In terms of the grass to herb ratio, plot 69.01 (S4) had the lowest proportion of grass and the highest proportion of herbs. Plot 35.03 (S5) had the highest proportion of grass and the lowest proportion of herbs. Plots 79.09, 20.01 (S2) and 43.03 all had similar proportions of grass and herb and were not significantly different from one another.

All plots had low measurements of litter cover and bare ground, but some significant differences were identified. Plots 79.09 and 20.01 had significantly less litter cover than most other plots, while plot 79.09 had significantly greater bare ground cover than all other plots including plot 20.01.

In terms of slope, plot 20.01 had the greatest slope angle and this was significantly more than all other plots on Salisbury Plain. Plot 69.01 also had a steeper slope and this is significantly greater than the slopes for all plots except plot 20.01. The remaining plots all had similar slopes and showed no significant differences.

The aspects of the five plots varied considerably, with each plot having a different aspect to the other (and all interactions were found to be highly significant). The more southerly plots were plot 43.03 and plot 35.03, while the most northerly plot was plot 69.01.

3.4.2 Plot scale variables

3.4.2.1 Soil data

Soil data collected for each plot are presented in Table 21. Measurements of cation exchange capacity (CEC) and hydrogen ions (H) were similar across all sites. Measurements of pH, organic matter content, extractable phosphorus phosphate (PO_4-P) and the resulting phosphate index values were all quite variable. The lowest pH values were found at Lindrick Golf Course and the highest at Knocking Hoe and Queendown Warren.

Sodium (Na) concentrations were slightly greater within the soils of the Knocking Hoe and Queendown Warren when compared to other plots, although between pairs of plots concentrations were very similar.

Lindrick Golf Course plots showed a slightly different chemistry to all other plots, with higher concentrations of potassium (K), magnesium (Mg), iron (Fe), aluminium (Al), and respectively higher potassium and magnesium indices. In contrast, calcium (Ca) and total nitrogen (N) concentrations were lower at Lindrick Golf Course than at other sites. This reflects the underlying geology of the site, which is an outcrop of Magnesian Limestone (Dolomite). Other sites sampled occur on Chalk deposits.

3.4.2.2 Meteorological data

The 1971 to 2000 long-term averages for selected meteorological data for the nearest recording station to each site are presented in Appendix V. These data are plotted as monthly long-term averages for each weather station (Figure 7) to identify trends over time and to illustrate any similarities of differences in the datasets.

Sheffield weather station data were used for Lindrick Golf Course, Rothamsted for Knocking Hoe and Wye for Queendown Warren. Data from Boscombe Down weather station were used for Martin Down, Porton Down and Salisbury Plain.

The average maximum and minimum temperatures for all four stations showed very similar trends and values over time, although there were marginally lower minimum temperatures recorded at Rothamsted and Boscombe Down.

The trend for number of days of air frost at each site was similar, with number of days increasing during the November to February winter period. Sheffield typically showed lower numbers of days of air frost compared to the other sites and this might be attributed to its more urban location, and Lindrick Golf Course is likely to have a greater number of days of air frost. Rothamsted and Boscombe Down showed the highest number of air frost days on average.

Boscombe Down showed the greatest number of hours of sunshine, followed closely by Rothamsted and Wye. Sheffield weather station showed the least number of hours of sunshine with perhaps up to 10 hours less than Boscombe Down. The seasonal trends for these four sites were very similar, with greater hours of sunshine recorded during the summer period, as would be expected.

Rainfall and number of days with rainfall greater than 1mm show similar trends, with Sheffield having the highest rainfall and Wye generally the lowest (particularly during the summer months).

3.5 Assessment using multivariate analyses

3.5.1 De-Trended Correspondence Analyses (DCA)

In general, the analysis of pairs of plots, or the group of five plots at Salisbury Plain, indicated that the plots were relatively similar in botanical composition. This is illustrated by the Eigenvalues of the axes of the ordination plots presented in Table 22. The first two axes were generally the more important in separating out species and quadrats, however the sum of the Eigenvalues was generally small. In addition, the ordination graphs themselves showed the close proximity of each pair/group of plots at each site (see Figures 8-14).

Some general trends could be observed across the ordination diagrams for each site. The plot identified as having fewer favourable attributes using the analysis of environmental variables (t-test and ANOVA results) tended to occur toward the centre of the ordination diagram. Those plots with more favourable CG3 grassland attributes tended to occur toward the right of the diagram.

The distribution of species within the ordination diagram reflected this, with species typically considered uncharacteristic of CG3 grassland types (eg. *Cirsium vulgare, Cirsium arvense, Urtica dioica, Arrhenatherum elatius* and *Senecio jacobaea*) were all found toward the origin or to the left of many plots. Species more characteristic of these communities such as *Lotus corniculatus, Carex flacca, Plantago lanceolata* and *Festuca,* were clustered together often toward the centre right. Other species more rarely occurring in the community were found toward the edges of the ordination diagram. These species vary according to the plot, but typically include *Polygala calcarea, Viola* and *Thymus.*

In the majority of cases the quadrats within a single plot were clustered closely together. There were, however, some exceptions to this. Quadrats were more spread across the ordination for Queendown Warren East Bank (unfavourable) (Figure 10). This suggests this plot had a more variable species composition. In contrast, Martin Down Plots 2C East and 2C West overlap considerably in the ordination diagram, indicating these two plots have very similar botanical compositions (Figure 12).

Senecio jacobaea, although nationally a notifiable weed, is actually a natural component of CG3 grasslands and is a preferential species (i.e. typical of the community). It occurs in NVC constancy tables (Rodwell, 1992) at a frequency of 1-2 and Domin values of 1-4 depending on the sub-community. Clearly, this species becomes a problem to stock in grasslands under poor management and is therefore still a potential negative indicator.

An analysis with all sites pooled (Figure 15), reflects the observations at individual sites. The ordination plot shows favourable sites generally lying at the left end of DCA axis 1 and generally at the bottom end of DCA axis 2. Examination of the species plots show a clear trend from the more mesotrophic and higher successional phase species at the right hand side to the more calcicolous stress-tolerators at the left hand side. The differences between site scores in favourable versus unfavourable plots is significant for both axes (Mann-Whitney *U*-tests: $U = 21327.0$, $P < 0.001$ for axis 1; $U = 20562.0$, $P < 0.001$ for axis 2). This is despite some plots being 'split' on the ordination with some quadrats lying amongst the wholly favourable plots and some amongst wholly unfavourable (as in Martin Down 2c East above). There are also plots which, although relatively unfavourable within their pairing, actually lie towards the favourable end of the axes. Of particular note here is Martin Down 2c West, which, despite having a high proportion of scrub, has most of the quadrats at the favourable end of axis 1 demonstrating that scrubby sites can still have high quality botanical communities.

3.5.2 Canonical Correspondence Analysis

3.5.2.1 General observations

In general, the CCA of each pair or group of plots separated out the species and quadrats more effectively than the DCA. An assessment of the Eigenvalues (Table 23) indicated that the first and second axes had the highest values and so were more important in terms of separating out the species and quadrats within the dataset than the third and fourth axes.

The cumulative percent variance of the species-environment relations (Table 23) gives an indication of the variance explained by each successive axis in the ordination diagram. The percent variance of the species-environment relations for the first two axes of the tri-plots generally accounts for a relatively large proportion of the variance of the species in relation to

the environmental variables, between 55 and 70%. Axes 3 and 4 together typically account for a smaller proportion of additional variance in all CCA ordinations (approximately 20% additional variance). Approximately 10 to 20% of the variation in the species and samples is not explained by the ordination results.

3.5.2.2 Lindrick Golf Course

Lindrick Golf Course CCA (Figure 16) separated the two plots fairly successfully, with the Old 12th Fairway occurring towards the left of the ordination diagram and the 17th Fairway to the right of the diagram. This indicates the plots have fairly distinct botanical compositions, although the short length of axis 1 and 2 identify them as not too dissimilar.

In terms of the ordination diagram (Figure 16) axis 1 was positively associated with vegetation height and litter cover, and negatively associated with scrub and herb cover and, to a lesser degree, slope (due to the short length of the arrow for this variable). Axis 2 was weakly positively associated with rabbit activity and negatively associated with the proportion of grass in the sward.

In general, those quadrats within the more unfavourable condition vegetation of the Old 12th Fairway were associated with higher vegetation heights, litter cover and proportions of grass in the sward. This confirms the less favourable conditions for a CG3 grassland community, as the species found in this area of the ordination diagram were less typical of this community (including *Cirsium vulgare, Senecio jacobaea, Cirsium arvense* and *Poa humilis* and a number of tree species that were presumably seedlings).

Those quadrats within the more favourable 17th Fairway plot were more scattered across the ordination, indicating they have a greater diversity of species and environmental variables. A large number of the quadrats were associated with increasing herb proportions in the sward, and associated with species such as *Viola hirta, Primula veris, Carex flacca* and *Lotus corniculatus* that were all typical herbs of these CG3 communities. A second smaller group of quadrats cluster around species such as *Agrostis capillaris, Trisetum flavescens, Phleum bertolonii, Trifolium repens* and *Ranunculus bulbosus*. These quadrats were negatively associated with vegetation height and litter cover. This suggests that these species persist in grassland that were kept at lower heights with less litter build-up and, possibly also with a reduced scrub cover. Rabbit grazing was not associated with the quadrats but there is a mowing regime in place and this might act in a similar way.

3.5.2.3 Knocking Hoe

The quadrats at Knocking Hoe also showed a fairly well defined split into two plots on the ordination diagram (Figure 17), despite both plots being classed as unfavourable within the condition assessment. Quadrats from Compartment 4 and 5 occur to the right of the ordination while quadrats from The Hoe occur on the left. Again, the short axes indicated the botanical distinction is not great but can still be identified. Only vegetation height and slope were significant variables in the ordination (Table 25).

The quadrats within Compartment 4-5 (unfavourable) were positively associated with vegetation height. There was also some indication that the proportion of grass litter and scrub cover in these quadrats was also greater. The species associated with this part of the ordination were *Senecio jacobaea, Trifolium repens, Agrostis capillaris, Cirsium arvense,*

Holcus lanatus, Medicago lupulina, Phleum bertolonii and *Prunella vulgaris*. Many of these species were found within CG3 Grasslands but were not necessarily characteristic of them. Indeed, some such as *Senecio jacobaea* can be problematic. The suite of species and environmental variables suggests an under-managed calcareous grassland vegetation type.

Quadrats within The Hoe (favourable condition) were associated with greater proportions of herbs within the sward, slightly increased rabbit grazing and increased slope. Species typical of calcareous grasslands were found here, such as *Leontodon hispidus, Pilosella officinalis, Gentianella amarella, Carex caryophyllea, Sanguisorba minor* and *Leucanthemum vulgare*. There were also some of the more rare or locally occurring calcareous grassland species within this group, including *Seseli libanotis, Tephroseris integrifolia* and *Asperula cynanchica*.

3.5.2.4 Queendown Warren

The separation of quadrats within the Queendown Warren plots was not well defined in terms of the ordination (Figure 18). Many of the quadrats were located toward the origin of the ordination axes indicating the quadrats were not readily separated on species and/or environmental variables. This reflects the assessment of these plots as both being unfavourable in terms of English Nature's condition assessment. However, the quadrats relating to the relatively more unfavourable East Bank plot occur more towards the right of the ordination diagram. This part of the diagram was associated with increasing litter cover, scrub cover, vegetation height and, to some extent, increasing proportion of grass, all of which are less favourable attributes in terms of the CG3 grassland community. Many of these variables were significant, explaining up to 65% of the variation in the dataset (Table 26).

The species associated with the East Bank plot also reflected the less favourable status, with a greater abundance of species less typical of calcareous grasslands, such as *Cirsium arvense, Arrhenatherum elatius, Agrostis capillaris* and *Poa trivialis*.

3.5.2.5 Martin Down Plot 4

As found for Queendown Warren, Plot 4 at Martin Down showed minimal differences in the species composition and measured environmental variables between Plots 4A and 4B (Figure 19). This was indicated by the clustering of the quadrats around the origin of the ordination, and the low cumulative percent variance of the species-environment relation for axes 1 and 2 (38.8%). However, as for Queendown Warren, some differences between the two plots could be identified.

Plot 4A (relatively unfavourable) was typically associated with increasing scrub cover, vegetation height, proportion of grass within the sward and slope. All these were typical of a CG3 grassland plot that is of less favourable condition.

Plot 4B quadrats (more favourable vegetation) tended to be negatively associated with the above variables, but positively associated with herb proportion and rabbit grazing. Interestingly, this group of quadrats also appeared to be associated with increasing litter cover (an attribute usually limited to unfavourable status). However, an assessment of the conditional effects for this environmental variable (Table 27) indicated it does not have a significant effect in explaining any additional variation along axis 1 or 2.

3.5.2.6 Martin Down Plot 2C

Figure 20 presents the ordination diagram for Plot 2C East and West for Martin Down. This CCA ordination was more successful at explaining the variation between the quadrats than the DCA ordination, and the cumulative percent variance of the species-environment relation for axes 1 and 2 was slightly higher at 55.5%. As for many other CCA ordinations, one vegetation plot tended to occur toward the right of the ordination diagram while the other occurred to the left.

Plot 2C East (favourable condition) was found to the right of the ordination, with positive association with slope and increasing grass proportions in the sward. These quadrats were typically associated with grasses such as *Dactylis glomerata, Holcus lanatus, Brachypodium sylvaticum*, along with herbs such as *Achillea millefolium, Galium mollugo, Sonchus asper* and *Ranunculus repens*. These quadrats were also associated with greater abundances of shrubs such as *Lonicera periclymenum, Clematis vitalba, Cornus sanguinea, Prunus spinosa* and *Euonymus europaeus*.

Plot 2C West (unfavourable) showed the opposite associations to the above environmental variables. The species present within the quadrats appear quite varied and included species typical of calcareous grassland (eg. *Polygala calcarea, Carlina vulgaris*) along with those less typical (eg. *Senecio jacobaea, Ranunculus bulbosus, Trifolium pratense*). These quadrats and species were generally clustered together indicating the species composition is similar, although there were a small number of quadrats that show greater similarities to the 2C Plot and occur in the left of the ordination diagram. Forward selection analysis of variables suggests slope was the only significant measured variable in the ordination (Table 28).

3.5.2.7 Porton Down

The quadrats within the two plots at Porton Down are presented in Figure 21. The plots again occurred in two main areas of the ordination diagram, with Battery Hill (favourable vegetation) present on the left of the ordination and Easton Down (unfavourable) on the right. However, the interpretation of the environmental variables was less straightforward than at other sites. The majority of quadrats within the Battery Hill plot were associated with greater herb proportions while some were associated with increasing herb height. Within Easton Down plot the quadrats appeared to be divided between those associated with increase rabbit activity and bare ground, and those associated with an increased proportion of grass.

This can be partly explained by the significance of these environmental variables on the variation explained within the ordination. Only drop disc height had a significant effect on explaining the variation along the axes (Table 29). As such, the Battery Hill plot was associated with lower drop disc height relating to the favourable condition. Easton Down was associated with greater drop disc height and, therefore, was less favourable.

3.5.2.8 Salisbury Plain

The five plots on Salisbury Plain (Figure 22) overlapped considerably, indicating their range from favourable (Rank 1) to unfavourable (Rank 5) vegetation and various condition scores in between. However, some general observations could be made. Plot 35.03 appeared to be least favourable as it was more strongly associated with an increasing proportion of grass. Plot 20.01 was associated with a taller vegetation height and, to some extent, an increasing

herb proportion, illustrating a slightly more favourable vegetation condition for CG3 grasslands.

Plot 69.01 had a positive association with increased herb proportion but was generally negatively associated with other variables.

The species composition reflects this distribution to some extent. Plots 20.01, 69.01 and 79.09 had a greater abundance of species such as *Gentianella, Thymus, Briza media, Scabiosa columbaria, Anthyllis vulneraria* and *Primula veris* that are characteristic of chalk grassland communities, which occurred on the left side of the ordination.

The ordination was, however, not readily interpreted as the quadrats were clustered toward the origin (0, 0), despite five environmental variables showing significant effects on the axes (Table 30).

3.5.2.9 All sites pooled

An analysis of all plots together revealed a similar trend for 'unfavourable' and 'favourable' plots along the first axis as in the Decorana analysis (Figure 23). This difference is highly significant (Mann-Whitney U = 24726.0, P<<0.001). The interpretation of the main axis is fairly clear in that the 'unfavourable' end is associated with a high grass ratio, tall and dense vegetation and high litter, while the 'favourable' end is associated with rabbit-grazing, being herb-rich and steeper slopes. All of the environmental variables showed significant effects on the axes (Table 31). The separation of sites along axis 2 at the 'favourable' end of axis 1 reflects that seen in the Decorana analysis. The CCA analysis aids interpretation of this as the environmental vectors clearly show the herb-rich sites on steeper slopes (Queendown Warren and Knocking Hoe favourable plots) at the lower left part and the rabbit-grazed site (Porton), at the upper left part. The sites on steeper slopes are also associated with thinner soils and therefore lower nutrient status which, together with stock grazing, limits the growth of *Bromopsis erecta*. Interestingly, the plots with a high cover of scrub are placed near the most neutral part of the ordination, indicating that unfavourable status is usually associated with lack of grazing management on CG3 grasslands.

3.5.3 Regression analyses of soil and weather data

Very few strong significant linear correlations were found between the soil chemical parameters and the median DCA plot scores (Table 32). Axis 1 was found to have a weakly significantly positive correlation with iron (Fe), while axis 2 was found to have a weakly significant positive correlation with Fe, aluminium (Al) and manganese (Mn).

No strong significant correlations were found between the median DCA axis scores and nutrient analyses. Although axis 1 was weakly negatively correlated to total nitrogen (N).

No significant linear relationships were found between DCA axis 1 scores for sites and the long-term yearly averages for nearby meteorological stations (Table 31). For axis 2, there were strong significant positive relationships with hours of sunshine, rainfall (mm) and number of days rainfall greater than 1mm.

4. Conclusions

Six lowland grassland sites within England were selected for the monitoring of CG3 grassland communities. These were Lindrick Golf Course SSSI, South Yorkshire; Knocking Hoe SSSI, Bedfordshire; Queendown Warren SSSI, Kent; Martin Down SSSI, Hampshire; Porton Down SSSI, Wiltshire/Hampshire; and Salisbury Plain Training Area SSSI, Wiltshire/Hampshire.

On these six sites a series of permanent plots were established within vegetation types representative of a range of favourable to unfavourable CG3 grassland types. Plots within one site were paired to provide a relatively favourable and a relatively unfavourable CG3 grassland type, based on the standard English Nature Vegetation Condition Assessment methodology (although in strict assessment terms both plots might in some cases be considered unfavourable). Where more than two plots occurred, these were ranked in order of relative vegetation condition.

Datasets collected for each sample area included a standard CG3 grassland Vegetation Condition Assessment field survey form, quadrat-based data on botanical composition and cover, a range of measured environmental variables at the quadrat scale (eg herb to grass ratio, scrub cover, litter cover, aspect and slope), and a range of environmental variables at the plot scale (eg soil chemistry, disturbance and climate). Analysis took four approaches including a comparison of qualitative and quantitative data results, and an assessment of the significance of environmental variables in separating favourable and unfavourable plots.

Comparison of qualitative and quantitative vegetation condition data indicated that the same plot could be assessed as being in different condition, in terms of its vegetation, as a result of differences in the two assessment approaches. Overall, more than 50% of the plots assessed had different numbers of passes for the mandatory attributes used to identify favourable vegetation condition when comparing the results of the two assessment approaches.

Although patterns were somewhat difficult to detect, there was a general reduction in the pass rate for mandatory features using the qualitative dataset, suggesting this methodology might yield unfavourable status more frequently in CG3 grasslands. However, in many cases the plot still remained classified as in unfavourable condition under both assessments, as at least one mandatory attribute still failed to meet the required target.

These different results are difficult to attribute to any specific factors using this dataset, but they might be related to the intensity of observations on the ground and the size of the plot used for assessment. The detailed quantitative assessments were completed in a smaller area (ie. the quadrat) rather than the typically larger unit used for the qualitative approach. In addition, the data collection for quantitative data is much more intensive and it is quite likely that more species (both positive and negative indicators) would be recorded compared to the qualitative data collection. Both these factors are also likely to result in differences in estimates of percent cover.

The discrepancy can also be explained by lower detection rates of less conspicuous positive indicator species (such as *Asperula cynanchica* and *Linum catharticum*) using the more qualitative method. Other species such as *Thymus* spp., *Campanula rotundifolia* and *Anthyllis vulneraria* are more conspicuous but would easily be overlooked in the thicker swards associated with CG3 grasslands. This CG community is also inherently ‘poorer’ in terms of

positive indicators which are NVC community constants (only three) and this would imply relative rarity compared to positive indicators for, eg CG2 communities. Also, the generally more conspicuous negative indicators tended to be over-recorded using the qualitative method and this would compound the under-recording of the positive indicators.

There was some inconsistency between the grass:herb ratio under qualitative and quantitative assessments. Seven of the fifteen plots showed non-agreement but only in only four plots was the disagreement serious. Interestingly, these plots were on two sites, Porton Down and Salisbury Plain. The Porton Down assessments over-estimated the herb proportion in the qualitative assessment, particularly where the sward was extremely short and heavily rabbit-grazed. Conversely, the Salisbury Plain assessments under-estimated the herb proportion in the qualitative assessment, particularly where sward height was around 20cm. This appears to relate to the conspicuousness of herbs in the sward, with obvious rosettes of *Pilosella officinarum* and *Leontodon hispidus* in the short sward at Porton Down skewing the herb cover estimate while the tall, dense sward on the Salisbury Plain plots would tend to make any herbs relatively inconspicuous when observed from above.

The C-S-R model provided a relatively poor approach to analysing these data, as within each plot there were often more than 20 species without a C-S-R strategy attached to them, therefore removing them from the vegetation community analysis. The score for each community was typically a less than 4% fit to any one strategy. Generally, however, all plots had the greatest affinity with the Stress-tolerator plant strategy and least affinity with the Competitor plant strategy.

Suited Species Scores assessments showed a proportion of the species present within the plant community were tolerant of (ie ‘suited to’) grazing and calcicole conditions, and generally less tolerant of high nutrient and moisture levels. Again, as with the C-S-R model, there were some difficulties in applying the model due to over half the plant species having no Suited Species Score assigned to them, therefore excluding them from the analysis.

However, both the C-S-R and Suited Species Score models characterised the CG3 grassland communities in broad terms as dry, calcareous, rather nutrient poor systems that were maintained by some degree of grazing. In this case grazing was typically from rabbits with very little measurable effects of stock grazing. These are all characteristics of calcareous grasslands, with limited grazing often also associated with the development of CG3 grasslands (Rodwell 1992) due to the ability of *Bromopsis erecta* to expand rapidly under low grazing or ungrazed management regimes. The C-S-R model identifies a large number of Stress-tolerator species within the grassland, which indicates these communities are less resilient to disturbance (Grime and others 1988). The combination of the requirement for some grazing to maintain the sward along with the vulnerability of many species to disturbance suggests that these communities require sensitive management to balance the level of grazing or mowing to maintain a diverse sward.

Assessment of the differences in the botanical and environmental variables between plots on each site identified which variables were significantly different between pairs (or groups) of plots on each site. Across the dataset, a large number of variables were found to be relatively consistently different. These were vegetation height, drop disc height, scrub cover, slope and aspect. In addition, measurements of rabbit disturbance, distance from a rabbit burrow, litter cover and the proportion of herbs in the sward were also often found to be significantly different between plots.

In general, the favourable vegetation condition plot at each site tended to have significantly lower vegetation heights and a lower scrub cover than those with less favourable vegetation condition. In addition, they occurred on slightly steeper slopes (or on slopes as opposed to flat ground) that were typically south facing. Rodwell (1992) indicates that the CG3 grassland community is often prevalent on warmer south-facing slope in Britain, although such locations can also encourage an increased dominance in *Bromopsis erecta* (a Continental species at its north-western limit in Britain) that would, in turn, reduce the favourable status of the sward.

The importance of grazing in maintaining these swards is reflected in the significance of rabbit disturbance and proximity to rabbit burrows on some of the more favourable plots. This can be particularly important where there grazing by domestic animals is relatively reduced (as appears to be the case on many of these plots) or where there is minimal or no management through cutting. The impact of grazing is also likely to be related to the litter cover (another significant variable) that occurs on any one plot, with higher grazing levels reducing litter development.

Measured variables that showed few or no significant differences between plots were grazing (by cattle, sheep, etc), proportion of grass in the sward, cover of bare ground and sward mass index. Grazing and bare ground showed no significant effect because these variables did not occur on the majority of sites (ie the measure was zero in the majority of cases). The proportion of grass and the sward mass index were measurable on the plots, but the measures were very similar and did not appear to be related to condition status. For example, the proportion of grass was often very similar in both relatively favourable and unfavourable plots, and even where this attribute met the required target for favourable condition the value was often close to the maximum allowed.

The assessment of data using multivariate analysis techniques (in particular DCA) aimed to identify possible drivers for change in vegetation condition on these CG3 grassland sites. In general the CCA ordination provided a better division of plots along the ordination axes, and up to 70% of the variation in the plant species distribution was related to the measured environmental variables. However, as with the results of the univariate analysis (above), only a selection of measured variables were actually significant in the separation of quadrats and species.

Those variables that had the greatest influence on the separation of favourable and unfavourable plots were vegetation height, drop disc height, the proportion of herbs and the proportion of grass in the sward. In addition, litter cover, rabbit activity, and slope were also found to be significant factors influencing the ordination results. Generally the plots with more favourable vegetation were positively associated with the proportion of herb species, rabbit activity and slope, and negatively associated with the proportion of grass species, vegetation height and scrub cover.

Both the univariate and multivariate analyses therefore highlight a similar set of variables as being significant in the separation of favourable and unfavourable vegetation plots. The vegetation height, ratio of herbs to grasses, litter cover, rabbit activity and slope all appeared to be good indicators of condition status. In addition, scrub cover and aspect were also useful on some plots. The least useful variables, in terms of separating out favourable and unfavourable vegetation in this dataset, were grazing (of cattle, sheep, etc), and the cover of bare ground.

5. Recommendations

5.1 Field recording

There are clearly areas of discrepancy between the qualitative and quantitative assessments with this habitat. The primary attributes where there was most disagreement between the two assessments were grass:herb ratio and positive and negative indicator species. Accurate assessment of all of these attributes appears to depend on accessibility of visual cues, and these can result in over-estimation when sward structure is short and open and under-estimation when sward structure is long and closed. As sward structure is only a secondary attribute and CG3 swards tend to be long, this would bias units with longer swards towards an unfavourable status. This is especially critical in CG3 grasslands where many of the herbs (chamaephytes and hemicryptophytes) are at a reduced frequency (Rodwell, 1992).

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

- ∉ training all officers who will be undertaking condition assessments in identification of key species, possibly with additional aids to identification of difficult species key to this habitat;
- ∉ reinforcing the need for careful searching for positive indicator species (and the negative indicator *Brachypodium pinnatum*), particularly in long swards.

5.2 Further research

It is recommended that further research into the relevance of some elements of the Primary Attributes should be undertaken. For example, the inclusion of *Galium verum, Cirsium acaule* and *Primula veris* as positive indicators may not be useful. Also, including *Senecio jacobaea* as a negative indicator in CG3 grasslands may not be adding value unless a higher critical threshold of abundance is used.

6. References

BEALEY, C.E. 2001. *The Relative Importance of Local and Landscape Factors to Chalk Grassland Butterflies.* Unpublished PhD thesis, Open University.

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.

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

DOLMAN, P.M., & SUTHERLAND, W.J. 1992. The ecological change of Breckland grass heaths and the consequences of management. *Journal of Applied Ecology*, 29, 402-413.

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

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.

HEATH. D.. 1995. *An Introduction to Experimental Design and Statistics for Biology*. UCL Press Ltd.

HILL, M.O., and others. 1999. Ellenberg's indicator values for British plants. *ECOFACT Volume 2, Technical Annex.* Huntingdon: Institute of Terrestrial Ecology.

HODGSON, J.G., & COLSANTI, R. 1995. Monitoring Grasslands. *English Nature Research Reports,* No. 156.

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

JOINT NATURE CONSERVATION COMMITTEE. 2004. *Common Standards Monitoring Guidance for lowland grassland habitats*. Peterborough: JNCC.

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., 1992. *British Plant Communities. Volume 3. Grasslands and Montane Communities.* Cambridge: CUP.

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.

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

Tables

Table 1 Summary of the management for each site within the CG3 Grassland Validation Network

Site Name	Plot Name	Plot ID	Management
Lindrick Golf Course	Old 12th Fairway	L1	Mowing and cutting
	17th Fairway	L2	
Knocking Hoe	Compartments 4 - 5	K1	Sheep grazing and rabbit control
	The Hoe	K2	
Queendown Warren	East Bank	Q1	Cattle grazing
	Main Bank	Q2	
Martin Down	4A	M1	Sheep and cattle grazing, herbicide application
	4B	M2	
	2C East	M3	
	2C West	M4	
Porton Down	Battery Hill	P1	Rabbit grazing
	Easton Down	P2	
Salisbury Plain	79.09	S1	A mixture of cattle grazed and ungrazed areas
	20.01	S2	
	43.03	S3	
	69.01	S4	
	35.03	S5	

Table 2 Meteorological station used for each site within the CG3 Grassland Validation Network

Site Name	Meteorological Station	
	Name	Altitude (m AMSL)
Lindrick Golf Course	Sheffield	131m
Knocking Hoe	Rothamsted	128m
Queendown Warren	Wye	56m
Martin Down	Boscombe Down	126m
Porton Down	Boscombe Down	126m
Salisbury Plain	Boscombe Down	126m

Table 3 Conversion of percent frequency to abundance, CG3 grassland analysis

Percent frequency	Abundance (DAFOR)
81-100%	Dominant
61-80%	Abundant
41-60%	Frequent
21-40%	Occasional
1-20%	Rare

Provided by English Nature

Table 4 Suited Species Scores for all Species within CG3 grasslands dataset

(from Robertson, Bingham and Taylor 2000)

NB: 1 = positively suited; -1 = negatively suited; 0 = neither positively nor negatively suited; none = no data available

Species	Calcicole	Grazing	Nutrient	Moisture
Acer pseudoplatanus	none	none	none	none
Achillea millefolium	0	0	0	-1
Agrimonia eupatoria	1	0	0	-1
Agrostis capillaris	0	0	-1	0
Agrostis stolonifera	0	0	1	0
Anacamptis pyramidalis	1	0	-1	-1
Anisantha sterilis	none	none	none	none
Anthoxanthum odoratum	0	0	0	0
Anthyllis vulneraria	1	0	-1	-1
Aphanes arvensis	none	none	none	none
Arabis hirsuta	none	none	none	none
Arenaria serpyllifolia	1	1	0	-1
Arrhenatherum elatius	0	-1	0	0
Artemisia vulgaris	none	none	none	none
Asperula cynanchica cynanchica	1	0	-1	0
Avenula pratense	1	0	-1	0
Avenula pubescens	1	0	-1	0
Bacidia bagliettoana	none	none	none	none
Barbula sp.	none	none	none	none
Bellis perennis	0	1	0	0
Betula pubescens	0	1	0	0
Blackstonia perfoliata	1	0	0	0
Brachypodium pinnatum	1	0	0	-1
Brachypodium sylvaticum	none	none	none	none
Brachythecium rutabulum	none	none	none	none
Briza media	0	1	-1	0
Bromopsis erecta	1	0	-1	-1
Bromus commutatus	none	none	none	none
Bromus hordeaceus hordeaceus	0	0	0	-1
Bryonia dioica	none	none	none	none
Calliergon cuspidatum	none	none	none	none
Campanula glomerata	0	0	0	0
Campanula rotundifolia	0	0	-1	-1
Campylium chrysophyllum	none	none	none	none
Carduus nutans	1	0	1	0
Carex caryophyllea	0	1	-1	-1
Carex flacca	1	0	-1	0
Carex flava	none	none	none	none
Carex humilis	1	0	-1	0
Carlina vulgaris	1	0	-1	-1
Carpinus betulus	none	none	none	none
Catapodium rigidum	none	none	none	none
Centaurea nigra	0	0	-1	0
Centaurea scabiosa	1	0	-1	-1

Species	Calcicole	Grazing	Nutrient	Moisture
Cerastium arcticum	none	none	none	none
Cerastium fontanum	0	1	0	0
Cerastium fontanum scoticum	0	1	0	0
Chamerion angustifolium	none	none	none	none
Cirsium acaule	1	0	-1	0
Cirsium arvense	0	-1	1	0
Cirsium sp	none	none	none	none
Cirsium vulgare	0	-1	1	0
Cladonia rangiformis	none	none	none	none
Clematis vitalba	0	0	0	0
Clinopodium vulgare	1	-1	-1	-1
Cornus sanguinea	none	none	none	none
Crataegus monogyna	1	-1	-1	0
Crepis capillaris	0	1	-1	-1
Ctenidium molluscum	none	none	none	none
Cynoglossum officinale	none	none	none	none
Cynosurus cristatus	0	1	0	0
Dactylis glomerata	1	0	0	0
Danthonia decumbens	0	0	-1	0
Daucus carota carota	1	0	0	-1
Echium vulgare	none	none	none	none
Elytrigia repens	none	none	none	none
Euonymus europaeus	none	none	none	none
Euphrasia agg.	0	1	0	0
Eurhynchium praelongum	none	none	none	none
Eurhynchium swartzii	none	none	none	none
Fallopia sachalinensis	none	none	none	none
Festuca arundinacea	none	none	none	none
Festuca ovina ovina	0	0	-1	-1
Festuca pratensis	0	0	0	0
Festuca rubra rubra	0	0	0	0
Filipendula vulgaris	1	0	-1	0
Fissidens	none	none	none	none
Fissidens cristatus	none	none	none	none
Fissidens curvatus	none	none	none	none
Fragaria vesca	none	none	none	none
Fraxinus excelsior	0	-1	1	0
Galium aparine	0	0	1	-1
Galium mollugo	1	-1	0	0
Galium verum	0	0	-1	-1
Gastridium ventricosum	none	none	none	none
Genista tinctoria	none	none	none	none
Gentianella amarella	1	0	0	0
Gentianella amarella x anglica	1	0	0	0
Geranium robertianum	none	none	none	none
Geranium sp.	none	none	none	none
Geum urbanum	none	none	none	none
Glechoma hederacea	none	none	none	none
Gymnadenia conopsea	none	none	none	none
Helianthemum nummularium	1	0	-1	-1
Helictotrichon pratense	none	none	none	none

Species	Calcicole	Grazing	Nutrient	Moisture
Helictotrichon pubescens	none	none	none	none
Heracleum sphondylium	1	0	1	0
Hippocrepis comosa	1	0	-1	0
Holcus lanatus	0	0	0	0
Homalothecium lutescens	none	none	none	none
Hypericum hirsutum	none	none	none	none
Hypericum perforatum	0	0	0	-1
Hypericum pulchrum	none	none	none	none
Hypnum cupressiforme	none	none	none	none
Hypnum lacunosum	none	none	none	none
Hypochaeris maculata	none	none	none	none
Hypochaeris radicata	0	1	-1	0
Inula conyzae	1	0	-1	-1
Knautia arvensis	0	0	-1	-1
Koeleria macrantha	1	1	-1	-1
Lathyrus pratensis	1	-1	0	0
Leontodon autumnalis	0	1	0	0
Leontodon hispidus	1	1	-1	-1
Leucanthemum vulgare	1	0	-1	-1
Ligustrum vulgare	none	none	none	none
Linaria vulgaris	none	none	none	none
Linum catharticum	1	1	-1	0
Lithospermum officinale	none	none	none	none
Lolium perenne	0	0	0	0
Lonicera periclymenum	0	0	0	0
Lotus corniculatus	0	0	-1	-1
Luzula campestris	0	1	-1	-1
Mahonia aquifolium	none	none	none	none
Medicago lupulina	1	0	0	-1
Melilotus altissimus	none	none	none	none
Myosotis arvensis	none	none	none	none
Odontites vernus	0	0	0	0
Onobrychis viciifolia	1	0	-1	0
Ononis repens	0	0	-1	-1
Origanum vulgare	1	-1	-1	-1
Pastinaca sativa	none	none	none	none
Phleum bertolonii	0	0	0	0
Picris hieracioides	1	0	0	0
Pilosella officinarum	0	1	-1	-1
Pimpinella saxifraga	0	1	-1	-1
Plantago lanceolata	0	1	0	0
Plantago major	0	1	0	0
Plantago media	1	0	-1	0
Poa humilis	none	none	none	none
Poa pratensis	0	0	0	0
Poa trivialis	0	1	0	1
Polygala calcarea	1	0	-1	0
Polygala vulgaris	0	1	-1	0
Polygonum aviculare	0	0	1	0
Potentilla anserina	0	0	0	1
Potentilla erecta	0	0	-1	0

Species	Calcicole	Grazing	Nutrient	Moisture
Potentilla reptans	0	0	0	0
Potentilla sterilis	none	none	none	none
Primula veris	1	1	-1	-1
Prunella vulgaris	0	1	0	0
Prunus domestica	none	none	none	none
Prunus spinosa	0	-1	0	0
Pulsatilla vulgaris	none	none	none	none
Quercus robur	0	-1	0	0
Quercus sp.	0	-1	0	0
Ranunculus acris	1	0	0	0
Ranunculus bulbosus	1	1	-1	-1
Ranunculus repens	0	0	1	1
Reseda lutea	none	none	none	none
Rhamnus cathartica	none	none	none	none
Rhinanthus minor	0	0	-1	0
Rhizomnium	none	none	none	none
Rhytidiadelphus squarrosus	none	none	none	none
Rhytidiadelphus triquetrus	none	none	none	none
Rosa sp.	none	none	none	none
Rubus fruticosus agg.	0	-1	0	0
Rumex acetosa	0	0	0	0
Rumex acetosella	none	none	none	none
Sambucus nigra	none	none	none	none
Sanguisorba minor minor	1	0	-1	-1
Sanguisorba minor muricata	1	0	-1	-1
Sanguisorba officinalis	0	0	-1	0
Scabiosa columbaria	1	1	-1	-1
Scleropodium	none	none	none	none
Senecio erucifolius	none	none	none	none
Senecio jacobaea	1	0	1	-1
Serratula tinctoria	1	0	-1	0
Seseli libanotis	none	none	none	none
Solanum dulcamara	none	none	none	none
Sonchus arvensis	0	0	0	0
Sonchus asper	0	0	0	0
Sonchus oleraceus	0	0	0	0
Stachys officinalis	0	1	-1	-1
Succisa pratensis	0	1	-1	1
Tamus communis	none	none	none	none
Taraxacum agg.	0	1	0	0
Taraxacum pseudonordstedtii	0	1	0	0
Taraxacum sp.	0	1	0	0
Tephroseris integrifolia integrifolia	none	none	none	none
Thymus polytrichus	1	1	-1	-1
Thymus pulegioides	none	none	none	none
Torilis japonica	none	none	none	none
Tragopogon pratensis	0	0	0	-1
Trifolium campestre	none	none	none	none
Trifolium dubium	0	1	0	-1
Trifolium medium	none	none	none	none
Trifolium pratense	0	0	0	0

Species	Calcicole	Grazing	Nutrient	Moisture
Trifolium repens	0	1	0	0
Trisetum flavescens	1	0	0	0
Ulex europaeus	none	none	none	none
Urtica dioica	0	-1	1	0
Veronica arvensis	0	1	0	-1
Veronica chamaedrys	0	1	-1	-1
Veronica officinalis	none	none	none	none
Viburnum lantana	none	none	none	none
Vicia cracca	0	-1	0	0
Vicia sativa sativa	0	0	0	-1
Viola hirta	1	1	-1	-1
Viola riviniana	0	0	-1	0
Weissia microstoma	none	none	none	none
Weissia microstoma brachycarpa	none	none	none	none

Table 5 Interpretaion 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 6 Summary of the vegetation condition of each site within the CG3 Grassland Validation Network

Site name	Plot name	Plot ID	Vegetation condition	Rank condition* within pairs or group
Lindrick Golf Course	Old 12th Fairway	L1	Unfavourable	2
	17th Fairway	L2	Unfavourable	1
Knocking Hoe	Compartments 4 - 5	K1	Unfavourable	2
	The Hoe	K2	Favourable	1
Queendown Warren	East Bank	Q1	Unfavourable	2
	Main Bank	Q2	Favourable	1
Martin Down	4A	M1	Unfavourable	2
	4B	M2	Unfavourable	1
	2C East	M3	Unfavourable	1
	2C West	M4	Unfavourable	2
Porton Down	Battery Hill	P1	Unfavourable	1
	Easton Down	P2	Unfavourable	2
Salisbury Plain	79.09	S1	Unfavourable	2
	20.01	S2	Unfavourable	1
	43.03	S3	Unfavourable	4
	69.01	S4	Unfavourable	3
	35.03	S5	Unfavourable	5

***Rank Condition:** 1 = higher condition (ie more favourable), 2 = lower condition (ie less favourable)

Table 7 Comparison of qualitative and quantitative vegetation condition data, CG3 Grasslands

***** = mandatory attribute
(F) = attribute fails assessment; (P) = attribute passes assessment

Lindrick Golf Course - Old 12th Fairway (L1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	99:1 (F)	98:2 (F)	Y
*Positive indicators at least (F)	No (F)	No (F)	Y
*Cover of *Brachypodium pinnatum*	<20% (F)	23% (F)	Y
*Cover of scrub	<1% (P)	<1% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	23cm (F)	33cm (F)	Y
Cover of litter	12% (P)	26% (F)	N
Cover of bare ground	0% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	0% (P)	Y
Total passes for mandatory attributes	**2**	**2**	**Y**

Lindrick Golf Course - 17th Fairway (L2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	93:7 (F)	86:14 (F)	Y
*Positive indicators at least (F)	No (F)	No (F)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	43% (F)	N
*Cover of scrub	2.5% (P)	2% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	11cm (P)	20cm (F)	N
Cover of litter	11% (P)	16% (P)	Y
Cover of bare ground	<1% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	2% (P)	Y
Total passes for mandatory attributes	**3**	**2**	**N**

Knocking Hoe - Compartments 4 - 5 (K1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	52:48 (P)	54:46 (P)	Y
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	0% (P)	2% (P)	Y
*Negative indicators no more than (O)	No (F)	No (F)	Y
Average height	13cm (P)	21cm (F)	N
Cover of litter	<1% (P)	1% (P)	Y
Cover of bare ground	<1% (P)	1% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	12% (F)	N
Total passes for mandatory attributes	**4**	**4**	**Y**

Knocking Hoe - The Hoe (K2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	38:62 (P)	51:49 (P)	N
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<1% (P)	0% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	10cm (P)	13cm (P)	Y
Cover of litter	<1% (P)	0% (P)	Y
Cover of bare ground	4% (P)	2% (P)	N
Rabbit grazing and disturbance	<0.05 (P)	22% (F)	N
Total passes for mandatory attributes	**5**	**5**	**Y**

Queendown Warren - East Bank (Q1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	50:50 (P)	29:55 (P)	Y
*Positive indicators at least (F)	No (F)	Yes (P)	N
*Cover of *Brachypodium pinnatum*	<1% (P)	0% (P)	Y
*Cover of scrub	5% (P)	16% (F)	N
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	15cm (P)	23cm (F)	N
Cover of litter	<5% (P)	1% (P)	Y
Cover of bare ground	9% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	2% (P)	Y
Total passes for mandatory attributes	**4**	**4**	**Y**

Queendown Warren - Main bank (Q2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	29:71 (P)	32:68 (P)	Y
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	1% (P)	0% (P)	Y
*Cover of scrub	5% (P)	<1% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	9cm (P)	12cm (P)	Y
Cover of litter	<5% (P)	0% (P)	Y
Cover of bare ground	2% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	7% (P)	Y
Total passes for mandatory attributes	**5**	**5**	**Y**

Martin Down - 4A (M1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	64:36 (F)	60:40 (P)	N
*Positive indicators at least (F)	No (F)	Yes (P)	N
*Cover of *Brachypodium pinnatum*	16% (F)	37% (F)	Y
*Cover of scrub	<5% (P)	1% (P)	Y
*Negative indicators no more than (O)	Yes (P)	No (F)	N
Average height	4cm (P)	11cm (P)	Y
Cover of litter	10% (P)	5% (P)	Y
Cover of bare ground	3% (P)	2% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	3% (P)	Y
Total passes for mandatory attributes	**2**	**3**	**N**

Martin Down - 4B (M2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	68:32 (F)	39:61 (P)	N
*Positive indicators at least (F)	No (F)	Yes (P)	N
*Cover of *Brachypodium pinnatum*	<10% (P)	3% (P)	Y
*Cover of scrub	<5% (P)	1% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	4cm (P)	10cm (P)	Y
Cover of litter	32% (F)	6% (P)	N
Cover of bare ground	11% (F)	2% (P)	N
Rabbit grazing and disturbance	<0.05ha (P)	13% (F)	N
Total passes for mandatory attributes	**3**	**5**	**N**

Martin Down - 2C East (M3)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	41:59 (P)	45:50 (P)	Y
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	7% (P)	Y
*Cover of scrub	5% (P)	3% (P)	Y
*Negative indicators no more than (O)	No (F)	Yes (P)	N
Average height	7cm (P)	17cm (F)	N
Cover of litter	0% (P)	2% (P)	Y
Cover of bare ground	<1% (P)	1% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	22% (F)	N
Total passes for mandatory attributes	**4**	**5**	**N**

Martin Down - 2C West (M4)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	63:37 (F)	47:25 (F)	Y
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	3% (P)	Y
*Cover of scrub	38% (F)	27% (F)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	2cm (P)	26cm (F)	N
Cover of litter	15% (P)	3% (P)	Y
Cover of bare ground	<5% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	7% (P)	Y
Total passes for mandatory attributes	**3**	**3**	**Y**

Porton Down - Battery Hill (P1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	39:61 (P)	82:18 (F)	N
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<5% (P)	<1% (P)	Y
*Negative indicators no more than (O)	No (F)	Yes (P)	N
Average height	2cm (P)	2cm (P)	Y
Cover of litter	<5% (P)	0% (P)	Y
Cover of bare ground	9% (P)	9% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	10% (P)	Y
Total passes for mandatory attributes	**4**	**4**	**Y**

Porton Down - Easton Down (P2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	48:52 (P)	77:23 (F)	N
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	14% (F)	1% (P)	N
*Negative indicators no more than (O)	No (F)	Yes (P)	N
Average height	2cm (P)	8cm (P)	Y
Cover of litter	0% (P)	0% (P)	Y
Cover of bare ground	13% (F)	0% (P)	N
Rabbit grazing and disturbance	<0.05ha (P)	<1% (P)	Y
Total passes for mandatory attributes	**3**	**4**	**N**

Salisbury Plain - 79.09 (S1)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	54:46 (P)	56:44 (P)	Y
*Positive indicators at least (F)	No (F)	Yes (P)	N
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<5% (P)	<1% (P)	Y
*Negative indicators no more than (O)	No (F)	Yes (P)	N
Average height	26cm (F)	20cm (F)	Y
Cover of litter	27% (F)	3% (P)	N
Cover of bare ground	5% (P)	6% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	9% (P)	Y
Total passes for mandatory attributes	**3**	**5**	**N**

Salisbury Plain - 20.01 (S2)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	55:45 (P)	54:46 (P)	Y
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<1% (P)	<1% (P)	Y
*Negative indicators no more than (O)	No (F)	Yes (P)	N
Average height	22cm (F)	30cm (F)	Y
Cover of litter	33% (F)	2% (P)	N
Cover of bare ground	2% (P)	1% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	0% (P)	Y
Total passes for mandatory attributes	**4**	**5**	**N**

Salisbury Plain - 43.03 (S3)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	93:7 (F)	52:48 (P)	N
*Positive indicators at least (F)	No (F)	Yes (P)	N
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<5% (P)	0% (P)	Y
*Negative indicators no more than (O)	Yes (P)	No (F)	N
Average height	16cm (F)	23cm (F)	Y
Cover of litter	>25% (F)	8% (P)	N
Cover of bare ground	<10% (F)	1% (P)	N
Rabbit grazing and disturbance	<0.05ha (P)	0% (P)	Y
Total passes for mandatory attributes	**3**	**4**	**N**

Salisbury Plain - 69.01 (S4)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	62:38 (F)	41:59 (P)	N
*Positive indicators at least (F)	Yes (P)	Yes (P)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	>10% (F)	<1% (P)	N
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	16cm (F)	26cm (F)	Y
Cover of litter	>25% (F)	6% (P)	N
Cover of bare ground	<10% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	0% (P)	Y
Total passes for mandatory attributes	**3**	**5**	**N**

Salisbury Plain - 35.03 (S5)			
Site attribute	**Condition assessment**		**Comparable?**
	Qualitative	**Quantitative**	
*Ratio grass:herb	91:9 (F)	82:18 (F)	Y
*Positive indicators at least (F)	No (F)	No (F)	Y
*Cover of *Brachypodium pinnatum*	0% (P)	0% (P)	Y
*Cover of scrub	<5% (P)	0% (P)	Y
*Negative indicators no more than (O)	Yes (P)	Yes (P)	Y
Average height	15cm (P)	31cm (F)	N
Cover of litter	>25% (F)	6% (P)	N
Cover of bare ground	10% (P)	0% (P)	Y
Rabbit grazing and disturbance	<0.05ha (P)	0% (P)	Y
Total passes for mandatory attributes	**3**	**3**	**Y**

Table 8 Summary of the comparison of quantitative and qualitative vegetation condition of each site within the CG3 Grassland Validation Network

Site name	Plot name	Plot ID	Qualitative assessment	Quantitative assessment
Lindrick Golf Course	Old 12th Fairway	L1	Unfavourable	Unfavourable
	17th Fairway	L2	Unfavourable	Unfavourable
Knocking Hoe	Compartments 4 - 5	K1	Unfavourable	Unfavourable
	The Hoe	K2	Favourable	Favourable
Queendown Warren	East Bank	Q1	Unfavourable	Unfavourable
	Main Bank	Q2	Favourable	Favourable
Martin Down	4A	M1	Unfavourable	Unfavourable
	4B	M2	Unfavourable	Favourable
	2C East	M3	Unfavourable	Favourable
	2C West	M4	Unfavourable	Unfavourable
Porton Down	Battery Hill	P1	Unfavourable	Unfavourable
	Easton Down	P2	Unfavourable	Unfavourable
Salisbury Plain	79.09	S1	Unfavourable	Favourable
	20.01	S2	Unfavourable	Favourable
	43.03	S3	Unfavourable	Unfavourable
	69.01	S4	Unfavourable	Favourable
	35.03	S5	Unfavourable	Unfavourable

Rank Condition: 1 = relatively more favourable vegetation condition, 5 = least favourable condition

Table 9 C-S-R values for each site within the CG3 Grassland Validation Network

Site name	Plot name	Plot ID	Plant strategy value		
			Competitor	Stress-tolerator	Ruderal
Lindrick Golf Course	Old 12th Fairway	L1	2.73	3.05	1.86
	17th Fairway	L2	2.31	3.25	2.00
Knocking Hoe	Compartments 4 - 5	K1	2.36	2.96	2.53
	The Hoe	K2	1.93	3.49	2.20
Queendown Warren	East Bank	Q1	2.35	2.97	2.29
	Main Bank	Q2	2.00	3.51	2.07
Martin Down	4A	M1	2.15	3.13	2.38
	4B	M2	2.19	3.30	2.24
	2C East	M3	2.14	3.10	2.28
	2C West	M4	2.31	2.95	2.26
Porton Down	Battery Hill	P1	2.13	3.13	2.37
	Easton Down	P2	2.13	3.34	2.18
Salisbury Plain	79.09	S1	2.37	2.89	2.53
	20.01	S2	2.32	3.05	2.40
	43.03	S3	2.28	2.96	2.54
	69.01	S4	2.08	3.58	2.00
	35.03	S5	2.48	2.87	2.67

Table 10 Average Suited Species Scores/Indices for each of the plots within the CG3 Grassland Analysis

Plot code	No. of Quadrats	Average Suited Species Score/index							
		Sum calcicole score		Grazing suited species index		Nutrient suited species index		Moisture suited species index	
		Average	StDev	Average	StDev	Average	StDev	Average	StDev
L1	30	2.2	0.94	0.00	0.182	-0.54	0.310	-0.68	0.235
L2	30	4.4	1.19	0.20	0.208	-0.54	0.173	-0.40	0.148
K1	30	6.6	2.43	0.13	0.116	-0.38	0.121	-0.45	0.078
K2	30	12.1	2.62	0.32	0.083	-0.83	0.092	-0.45	0.075
Q1	30	10.2	4.23	0.13	0.242	-0.50	0.258	-0.42	0.117
Q2	30	14.1	1.66	0.37	0.056	-0.84	0.070	-0.58	0.042
M1	30	11.4	2.33	0.29	0.115	-0.51	0.137	-0.52	0.084
M2	30	10.2	1.74	0.34	0.093	-0.63	0.108	-0.53	0.053
M3	30	6.8	4.49	-0.03	0.335	-0.41	0.321	-0.37	0.167
M4	30	10.3	4.49	0.31	0.287	-0.62	0.275	-0.40	0.131
P1	30	8.3	1.70	0.39	0.096	-0.65	0.138	-0.58	0.088
P2	21	5.7	1.56	0.24	0.142	-0.67	0.087	-0.56	0.076
S1	30	8.8	1.87	0.20	0.113	-0.36	0.132	-0.42	0.068
S2	30	6.9	2.16	0.16	0.142	-0.49	0.181	-0.43	0.114
S3	30	7.5	2.21	0.10	0.143	-0.50	0.129	-0.39	0.097
S4	30	11.1	2.57	0.19	0.094	-0.74	0.079	-0.46	0.088
S5	30	3.7	1.37	0.10	0.178	-0.30	0.137	-0.36	0.096

Table 11 Results of the Mann-Whitney U-Test analyses for average Suited Species Scores

Site	Variable	N	U-value	p-value
Lindrick Golf Course	Sum Calcicole Score	30	65.50	**0.000**
	Grazing Suited Species Index	30	213.50	**0.000**
	Nutrient Suited Species Index	30	441.50	0.900
	Moisture Suited Species Index	30	143.50	**0.000**
Knocking Hoe	Sum Calcicole Score	30	50.50	**0.000**
	Grazing Suited Species Index	30	86.50	**0.000**
	Nutrient Suited Species Index	30	896.50	**0.000**
	Moisture Suited Species Index	30	442.00	0.906
Queendown Warren	Sum Calcicole Score	30	160.00	**0.000**
	Grazing Suited Species Index	30	128.50	**0.000**
	Nutrient Suited Species Index	30	829.00	**0.000**
	Moisture Suited Species Index	30	826.00	**0.000**
Martin Down Plot 4	Sum Calcicole Score	30	615.50	**0.013**
	Grazing Suited Species Index	30	330.00	0.076
	Nutrient Suited Species Index	30	694.00	**0.000**
	Moisture Suited Species Index	30	475.00	0.711
Martin Down Plot 2C	Sum Calcicole Score	30	278.50	**0.011**
	Grazing Suited Species Index	30	151.50	**0.000**
	Nutrient Suited Species Index	30	642.50	**0.004**
	Moisture Suited Species Index	30	469.50	0.773
Porton Down	Sum Calcicole Score	30, 21	542.00	**0.000**
	Grazing Suited Species Index	30, 21	521.00	**0.000**
	Nutrient Suited Species Index	30, 21	327.50	0.811
	Moisture Suited Species Index	30, 21	283.00	0.539

Table 12 Results of the Kruskal-Wallis analysis of variance for Salisbury Plain plots

Variable	N	KW Test	p-value
Sum Calcicole Score	150	89.089	**0.000**
Grazing Suited Species Index	150	15.348	**0.004**
Nutrient Suited Species Index	150	83.250	**0.000**
Moisture Suited Species Index	150	20.559	**0.000**

Table 13 Results of the T-Test analysis for Lindrick Golf Course

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	57	6.506	**0.000**
Drop disc height	57	8.385	**0.000**
Scrub cover	57	4.076	**0.000**
Index of rabbit grazing	Insufficient Data		
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	Insufficient Data		
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	Insufficient Data		
Distance from rabbit burrow	Insufficient Data		
Proportion of herbs	58	-5.237	**0.000**
Proportion of grass	58	0.348	**0.000**
Litter cover	58	3.577	**0.001**
Bare ground cover	Insufficient Data		
Sward mass index	57	-3.172	**0.002**
Environmental measurements			
Slope	57	-2.514	**0.015**
Aspect	57	-11.95	**0.000**

Table 14 Results of the T-Test analysis for Knocking Hoe

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	58	5.578	**0.000**
Drop disc height	58	4.238	**0.000**
Scrub cover	Insufficient Data		
Index of rabbit grazing	58	-1.115	0.27
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	58	0.851	0.398
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	58	-1.235	0.222
Distance from rabbit burrow	58	2.458	**0.017**
Proportion of herbs	58	-1.109	0.272
Proportion of grass	58	0.675	0.502
Litter cover	58	1.401	0.167
Bare ground cover	58	-0.59	0.557
Sward mass index	58	1.630	0.109
Environmental measurements			
Slope	58	-5.337	**0.000**
Aspect	58	3.898	**0.000**

Table 15 Results of the T-Test analysis for Queendown Warren

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	58	3.854	**0.000**
Drop disc height	58	4.542	**0.000**
Scrub cover	58	3.656	**0.001**
Index of rabbit grazing	58	-0.526	0.601
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	58	-2.633	**0.011**
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	58	-1.166	0.248
Distance from rabbit burrow	58	7.688	**0.000**
Proportion of herbs	58	-2.736	**0.008**
Proportion of grass	58	-0.846	0.401
Litter cover	58	2.315	**0.024**
Bare ground cover	Insufficient Data		
Sward mass index	58	-1.314	0.194
Environmental Measurements			
Slope	55	-0.774	0.442
Aspect	55	-3.058	**0.003**

Table 16 Results of the T-Tests analysis for Martin Down Plot 4

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	78	1.260	0.211
Drop disc height	78	-0.110	0.912
Scrub cover	78	1.057	0.294
Index of rabbit grazing	78	-3.881	**0.000**
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	Insufficient Data		
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	78	-2.241	**0.028**
Distance from rabbit burrow	Insufficient Data		
Proportion of herbs	78	-8.248	**0.000**
Proportion of grass	78	7.560	**0.000**
Litter cover	78	-1.83	0.071
Bare ground cover	78	-0.486	0.629
Sward mass index	78	1.700	0.093
Environmental measurements			
Slope	75	15.152	**0.000**
Aspect	73	111.929	**0.000**

Table 17 Results of the T-Tests analysis for Martin Down Plot 2C

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	58	-2.337	**0.023**
Drop disc height	58	-2.357	**0.022**
Scrub cover	58	-5.841	**0.000**
Index of rabbit grazing	58	-0.709	0.481
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	Insufficient Data		
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	58	2.088	**0.041**
Distance from rabbit burrow	58	6.289	**0.000**
Proportion of herbs	58	5.185	**0.000**
Proportion of grass	58	-1.408	0.685
Litter cover	58	-1.151	0.255
Bare ground cover	58	1.489	0.142
Sward mass index	58	-0.465	0.644
Environmental measurements			
Slope	56	5.884	**0.000**
Aspect	56	-0.248	0.805

Table 18 Results of the T-Test analysis for Porton Down

Variable	DF	t-value	p-value
Vegetation Traits			
Sward height	49	-9.027	**0.000**
Drop disc height	49	-9.497	**0.000**
Scrub cover	49	-2.717	**0.009**
Index of rabbit grazing	49	4.436	**0.000**
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	Insufficient Data		
Index of horse grazing	Insufficient Data		
Index of other grazing animals	Insufficient Data		
Rabbit disturbance	49	3.310	**0.002**
Distance from rabbit burrow	49	11.512	**0.000**
Proportion of herbs	49	-1.034	0.306
Proportion of grass	49	1.252	0.216
Litter cover	Insufficient Data		
Bare ground cover	Insufficient Data		
Sward mass index	49	0.122	0.903
Environmental measurements			
Slope	Insufficient Data		
Aspect	Insufficient Data		

Table 19 Results of the analysis of variance for Salisbury Plain

Variable	DF	f-ratio	p-value
Vegetation traits			
Sward height	4	10.341	**0.000**
Drop disc height	4	11.065	**0.000**
Scrub cover	4	2.712	**0.032**
Index of rabbit grazing	4	4.984	**0.001**
Index of sheep grazing	Insufficient Data		
Index of cattle grazing	4	2.054	0.090
Index of horse grazing	Insufficient Data		
Index of other grazing animals	4	2.148	0.078
Rabbit disturbance	4	4.019	**0.004**
Distance from rabbit burrow	4	53.445	**0.000**
Proportion of herbs	4	0.851	**0.000**
Proportion of grass	4	41.404	**0.000**
Litter cover	4	8.08	**0.000**
Bare ground cover	4	5.028	**0.001**
Sward mass index	4	1.408	0.234
Environmental measurements			
Slope	4	16.246	**0.000**
Aspect	4	342.176	**0.000**

Table 20 Results of the Tukey Pairwise Comparison Analysis for Salisbury Plain ANOVA results for all five CG3 grassland plots

Sward height					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.000**	1.000			
43.03	0.858	**0.002**	1.000		
69.01	**0.021**	0.487	0.250	1.000	
35.03	**0.000**	0.970	**0.000**	0.163	1.000

Drop disc height					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.000**	1.000			
43.03	1.000	**0.000**	1.000		
69.01	**0.016**	0.852	**0.009**	1.000	
35.03	**0.000**	0.932	**0.000**	0.372	1.000

Scrub cover					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	0.135	1.000			
43.03	0.064	0.998	1.000		
69.01	0.076	0.999	1.000	1.000	
35.03	**0.043**	0.992	1.000	1.000	1.000

Index of rabbit grazing					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.004**	1.000			
43.03	**0.004**	1.000	1.000		
69.01	**0.004**	1.000	1.000	1.000	
35.03	**0.004**	1.000	1.000	1.000	1.000

Index of cattle grazing					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	1.000	1.000			
43.03	1.000	1.000	1.000		
69.01	0.155	0.155	0.162	1.000	
35.03	1.000	1.000	1.000	0.155	1.000

Index of other grazing animals					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	1.000	1.000			
43.03	0.136	0.136	1.000		
69.01	1.000	1.000	0.136	1.000	
35.03	1.000	1.000	0.136	1.000	1.000

Rabbit disturbance					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.013**	1.000			
43.03	**0.013**	1.000	1.000		
69.01	**0.013**	1.000	1.000	1.000	
35.03	**0.013**	1.000	1.000	1.000	1.000

Distance from rabbit burrow					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.000**	1.000			
43.03	**0.000**	1.000	1.000		
69.01	**0.000**	**0.000**	**0.000**	1.000	
35.03	**0.000**	1.000	1.000	**0.000**	1.000

Proportion of herbs					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	0.969	1.000			
43.03	0.751	0.980	1.000		
69.01	**0.000**	**0.003**	**0.018**	1.000	
35.03	**0.000**	**0.000**	**0.000**	**0.000**	1.000

Proportion of grass					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	0.993	1.000			
43.03	0.805	0.960	1.000		
69.01	**0.002**	**0.008**	0.062	1.000	
35.03	**0.000**	**0.000**	**0.000**	**0.000**	1.000

Litter cover					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	0.991	1.000			
43.03	**0.000**	**0.000**	1.000		
69.01	0.072	**0.020**	0.437	1.000	
35.03	**0.039**	**0.010**	0.581	0.999	1.000

Bare ground cover					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.008**	1.000			
43.03	**0.008**	1.000	1.000		
69.01	**0.001**	0.987	0.987	1.000	
35.03	**0.003**	0.997	0.997	1.000	1.000

Sward mass index					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	0.996	1.000			
43.03	0.529	0.754	1.000		
69.01	0.973	0.867	0.195	1.000	
35.03	0.997	0.958	0.325	0.999	1.000

Slope					
Plot	79.09	20.01	43.03	69.01	35.03
79.09	1.000				
20.01	**0.000**	1.000			
43.03	0.685	**0.000**	1.000		
69.01	**0.000**	1.000	**0.005**	1.000	
35.03	0.209	**0.000**	1.000	**0.024**	1.000

Table 21 Soil data collected from bulk samples for each CG3 grassland plot

All expressed as mg/kg except pH, CEC, H ions and P/K/Mg Indexes

Site	Plot	pH	Organic matter	CEC	H	Total N	Extractable PO_4-P	K	Na	Ca	Mg	Fe	Al	Mn	P Index	K Index	Mg Index
Lindrick Golf Course	Old 12th Fairway	6.9	13.9	21.8	-1.0	6820	7.0	162	23	2572	718	118	20	676	0.7	2.3	7.2
	17th Fairway	6.8	15.5	24.7	-1.0	6590	6.0	144	24	2792	845	118	14	666	0.6	2.1	7.6
Knocking Hoe	Compartments 4 - 5	7.9	9.8	16.4	-1.0	5170	7.0	88	12	3144	85	9	1	150	0.7	1.4	2.6
	The Hoe	7.9	13.6	21.1	-1.0	7650	5.0	90	14	4064	107	7	2	200	0.5	1.4	3.0
Queendown Warren	East	7.9	15.9	22.0	-1.0	9470	8.0	103	16	4224	122	16	2	295	0.8	1.7	3.2
	Main	7.9	14.2	22.9	-1.0	7860	5.0	68	16	4452	102	23	3	421	0.5	1.1	3.0
Martin Down	4A	7.9	15.1	22.9	-1.0	8800	6.0	62	22	4428	116	26	4	517	0.6	1.0	3.2
	4B	7.5	22.0	24.8	-1.0	10400	7.0	64	24	4779	155	32	5	578	0.7	1.0	3.7
	2C East	7.7	15.9	23.2	-1.0	9150	7.0	82	21	4480	129	7	2	500	0.7	1.3	3.3
	2C West	7.8	16.6	23.7	-1.0	9570	9.0	86	22	4555	142	18	4	486	0.9	1.4	3.5

Table 22 Summary of the DCA ordination results for the CG3 grassland plots

Lindrick Golf Course				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.380	0.231	0.142	0.112
Lengths of gradient	2.562	2.188	1.884	1.826
Cumulative percent variance of species data	12.2	19.7	24.3	27.9
Knocking Hoe				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.494	0.088	0.072	0.055
Lengths of gradient	3.374	2.018	1.564	1.286
Cumulative percent variance of species data	24.3	28.7	32.2	34.9
Queendown Warren				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.460	0.135	0.088	0.066
Lengths of gradient	3.260	2.131	1.576	1.618
Cumulative percent variance of species data	19.5	25.3	29	31.8
Martin Down Plot 4				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.288	0.095	0.069	0.003
Lengths of gradient	2.357	1.724	1.276	1.233
Cumulative percent variance of species data	13.8	19.6	23.8	27.2
Martin Down Plot 2C				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.564	0.116	0.094	0.075
Lengths of gradient	3.497	2.446	1.598	1.598
Cumulative percent variance of species data	21.9	26.4	30.1	33.0
Porton Down				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.275	0.117	0.093	0.068
Lengths of gradient	1.890	1.569	1.634	1.537
Cumulative percent variance of species data	15.5	22.1	27.3	31.2
Salisbury Plain				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.337	0.237	0.168	0.095
Lengths of gradient	2.676	2.239	2.260	1.799
Cumulative percent variance of species data	10.7	18.3	23.6	26.7

Table 23 Summary of the CCA ordination results for the CG3 grassland plots

Lindrick Golf Course				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.245	0.188	0.094	0.069
Speces-environment correlations	0.839	0.773	0.693	0.680
Cumulative percent variance of species data	7.9	14.0	17.0	19.2
Cumulative percent variance of species-environment relation	34.1	60.3	73.4	82.9
Knocking Hoe				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.324	0.049	0.034	0.028
Speces-environment correlations	0.826	0.746	0.796	0.699
Cumulative percent variance of species data	15.9	18.3	20.0	21.4
Cumulative percent variance of species-environment relation	61.6	70.8	77.2	82.6
Queendown Warren				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.417	0.090	0.079	0.053
Speces-environment correlations	0.961	0.795	0.890	0.644
Cumulative percent variance of species data	17.7	21.5	24.9	27.1
Cumulative percent variance of species-environment relation	54.3	66.0	76.4	83.2
Martin Down Plot 4				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.173	0.059	0.040	0.035
Speces-environment correlations	0.889	0.838	0.792	0.746
Cumulative percent variance of species data	10.5	14	16.5	18.6
Cumulative percent variance of species-environment relation	44.3	59.3	69.5	78.4
Martin Down Plot 2C				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.202	0.065	0.053	0.039
Speces-environment correlations	0.618	0.829	0.846	0.761
Cumulative percent variance of species data	7.9	10.4	12.4	14.0
Cumulative percent variance of species-environment relation	42.0	55.5	64.4	74.6
Porton Down				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.185	0.050	0.042	0.037
Speces-environment correlations	0.851	0.764	0.738	0.833
Cumulative percent variance of species data	10.4	13.3	15.6	17.7
Cumulative percent variance of species-environment relation	49.2	62.5	73.6	83.4
Salisbury Plain				
Axes	**1**	**2**	**3**	**4**
Eigenvalues	0.289	0.139	0.110	0.056
Speces-environment correlations	0.933	0.181	0.715	0.754
Cumulative percent variance of species data	9.2	13.6	17.1	18.9
Cumulative percent variance of species-environment relation	36.6	54.2	68.1	75.1

Table 24 Environmental variables for Lindrick Golf Course plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Drop disc	2	0.19
Veg Ht	1	0.18
Herb	7	0.18
Grass	8	0.18
Scrub	3	0.16
Litter	9	0.11
Slope	5	0.07
Rabbit	4	0.05
Bare	10	0.03

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Dropdisc	2	0.19	**0.005**	3.82	0.19
Scrub	3	0.16	**0.005**	3.18	0.35
Herb	7	0.10	**0.005**	2.16	0.45
Litter	9	0.08	**0.030**	1.66	0.53
Veg Ht	1	0.06	0.085	1.39	0.59
Slope	5	0.05	0.300	1.15	0.64
Rabbit	4	0.06	0.345	1.14	0.70
Bare	10	0.02	0.945	0.46	0.72

Table 25 Environmental variables for Knocking Hoe plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Veg Ht	1	0.24
Drop disc	2	0.22
Slope	5	0.22
Scrub	3	0.10
Herb	7	0.08
Grass	8	0.07
Rabbit	4	0.04
Litter	9	0.03
Bare	10	0.03

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Veg Ht	1	0.24	**0.005**	7.93	0.24
Slope	5	0.08	**0.010**	2.50	0.32
Scrub	3	0.04	0.150	1.28	0.36
Dropdisc	2	0.03	0.275	1.14	0.39
Herb	7	0.03	0.255	1.10	0.42
Bare	10	0.03	0.435	0.95	0.45
Litter	9	0.03	0.595	0.89	0.48
Grass	8	0.02	0.870	0.77	0.50
Rabbit	4	0.03	0.760	0.78	0.53

Table 26 Environmental variables for Queendown Warren Plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Dropdisc	2	0.37
Scrub	3	0.33
Veg Ht	1	0.31
Herb	7	0.23
Litter	9	0.07
Slope	5	0.05
Grass	8	0.04
Rabbit	4	0.04
Bare	10	0.02

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Drop disc	2	0.37	**0.005**	10.89	0.37
Scrub	3	0.11	**0.005**	3.32	0.48
Veg Ht	1	0.05	**0.045**	1.51	0.53
Grass	8	0.05	**0.050**	1.49	0.58
Herb	7	0.07	**0.010**	2.35	0.65
Litter	9	0.05	0.120	1.44	0.70
Slope	5	0.03	0.445	0.92	0.73
Rabbit	4	0.02	0.815	0.74	0.75
Bare	10	0.02	0.855	0.53	0.77

Table 27 Environmental variables for Martin Down Plot 4 ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Slope	5	0.14
Herb	7	0.13
Grass	8	0.12
Drop disc	2	0.06
Veg Ht	1	0.05
Rabbit	4	0.05
Litter	9	0.05
Scrub	3	0.05
Bare	10	0.02

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Slope	5	0.14	**0.005**	5.26	0.14
Dropdisc	2	0.06	**0.005**	2.42	0.20
Herb	7	0.05	**0.005**	1.99	0.25
Veg Ht	1	0.03	0.215	1.19	0.28
Grass	8	0.02	0.545	0.95	0.30
Rabbit	4	0.03	0.520	0.96	0.33
Scrub	3	0.02	0.550	0.94	0.35
Bare	10	0.02	0.635	0.93	0.37
Litter	9	0.02	0.895	0.75	0.39

Table 28 Environmental variables for Martin Down Plot 2C ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Slope	5	0.15
Grass	8	0.06
Scrub	3	0.05
Drop disc	2	0.05
Bare	10	0.05
Veg Ht	1	0.04
Herb	7	0.04
Litter	9	0.03
Rabbit	4	0.02

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Slope	5	0.15	**0.005**	3.70	0.15
Dropdisc	2	0.05	0.360	1.10	0.20
Grass	8	0.05	0.215	1.18	0.25
Scrub	3	0.04	0.310	1.10	0.29
Herb	7	0.06	0.150	1.24	0.35
Veg Ht	1	0.04	0.410	1.01	0.39
Bare	10	0.04	0.415	0.99	0.43
Litter	9	0.03	0.875	0.74	0.46
Rabbit	4	0.02	0.950	0.56	0.48

Table 29 Environmental variables for Porton Down Plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Drop disc	2	0.15
Veg Ht	1	0.15
Rabbit	4	0.08
Bare	10	0.08
Scrub	3	0.06
Herb	7	0.05
Grass	8	0.05

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Dropdisc	2	0.15	**0.005**	4.67	0.15
Herb	7	0.06	0.010	1.74	0.21
Scrub	3	0.04	0.075	1.34	0.25
Bare	10	0.04	0.110	1.24	0.29
Rabbit	4	0.04	0.490	0.99	0.33
Grass	8	0.02	0.700	0.84	0.35
Veg Ht	1	0.03	0.870	0.73	0.38

Table 30 Environmental variables for Salisbury Plain plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Grass	8	0.14
Herb	7	0.14
Slope	5	0.11
Drop disc	2	0.06
Veg Ht	1	0.06
Litter	9	0.05
Bare	10	0.05
Rabbit	4	0.04
Scrub	3	0.02

	Conditional effects				
Variable	**Var.N**	**LambdaA**	**P**	**F**	**Cum L_A**
Grass	8	0.14	**0.005**	6.98	0.14
Slope	5	0.10	**0.005**	4.95	0.24
Litter	9	0.05	**0.005**	2.70	0.29
Bare	10	0.04	**0.010**	2.12	0.33
Drop disc	2	0.03	**0.040**	1.49	0.36
Scrub	3	0.02	0.505	1.00	0.38
Rabbit	4	0.02	0.590	0.98	0.40
Herb	7	0.02	0.540	0.95	0.42
Veg Ht	1	0.01	0.875	0.81	0.43

Table 31 Environmental variables for all plots ranked by their marginal and conditional effects as obtained through forward selection

	Marginal effects	
Variable	**Var.N**	**Lambda1**
Grass	7	0.1
Veg Ht	1	0.1
Rabbit	4	0.1
Herb	6	0.09
Dropdisc	2	0.09
Slope	5	0.09
Litter	8	0.07
Scrub	3	**0.05**
Bare	9	**0.03**

	Conditional effects			
Variable	**Var.N**	**LambdaA**	**P**	**F**
Grass	7	0.1	**0.005**	12.57
Veg Ht	1	0.1	**0.005**	12.74
Scrub	3	0.07	**0.005**	8.62
Slope	5	0.05	**0.005**	7.23
Rabbit	4	0.06	**0.005**	6.82
Litter	8	0.04	**0.005**	5.6
Herb	6	0.02	**0.005**	2.82
Bare	9	0.01	**0.01**	2.04
Dropdisc	2	0.02	**0.005**	1.88

Table 32 Spearman's rank correlation coefficient for the Median DCA scores and soil chemical parameters and long-term yearly average for weather data for each CG3 grassland site

	pH	Organic Matter	CEC	P Index	K Index	Mg Index
Axis 1	-0.304	-0.322	-0.061	-0.195	-0.074	0.104
Axis 2	-0.265	0.188	0.292	0.113	-0.240	0.238

	Total N	Extractable PO_4-P	K	Na	Ca	Mg	Fe	Al	Mn
Axis 1	***-0.467***	-0.195	-0.030	0.239	-0.321	0.067	***0.457***	0.246	0.309
Axis 2	0.224	0.113	-0.309	0.330	0.345	0.164	***0.402***	***0.443***	***0.406***

	Max Temp	Minimum Temp	Air Frost	Sunshine	Rainfall	Rainfall >1mm
Axis 1	0.034	-0.334	0.334	0.395	0.030	0.152
Axis 2	-0.101	0.152	-0.152	**0.516**	**0.759**	**0.820**

Bold figures indicate strong linear correlations (ie >0.5)

Bold Italic figures indicate weak linear correlations (ie 0.4 to 0.5)

Figures

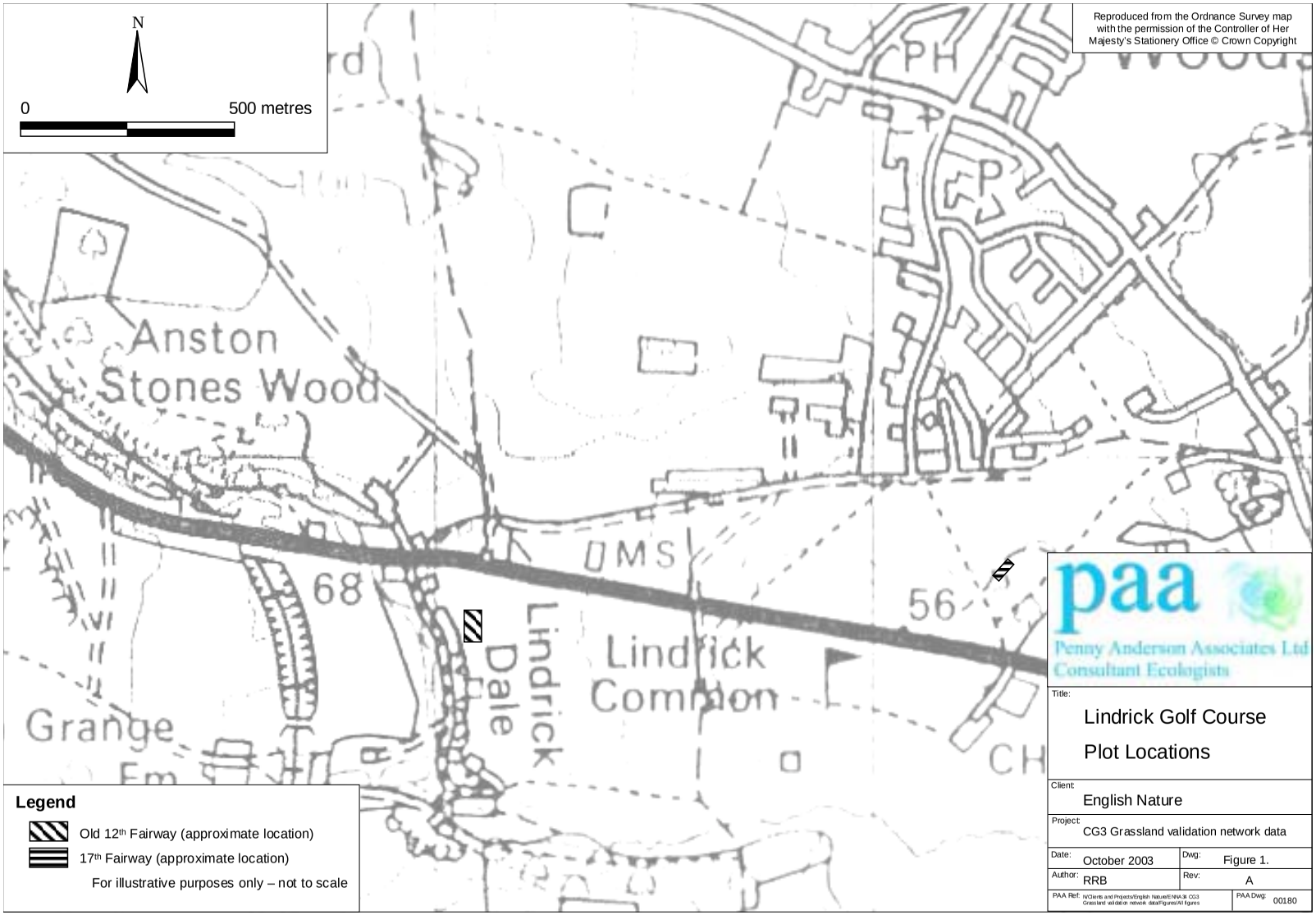


Figure 1 Lindrick Golf Course plot locations

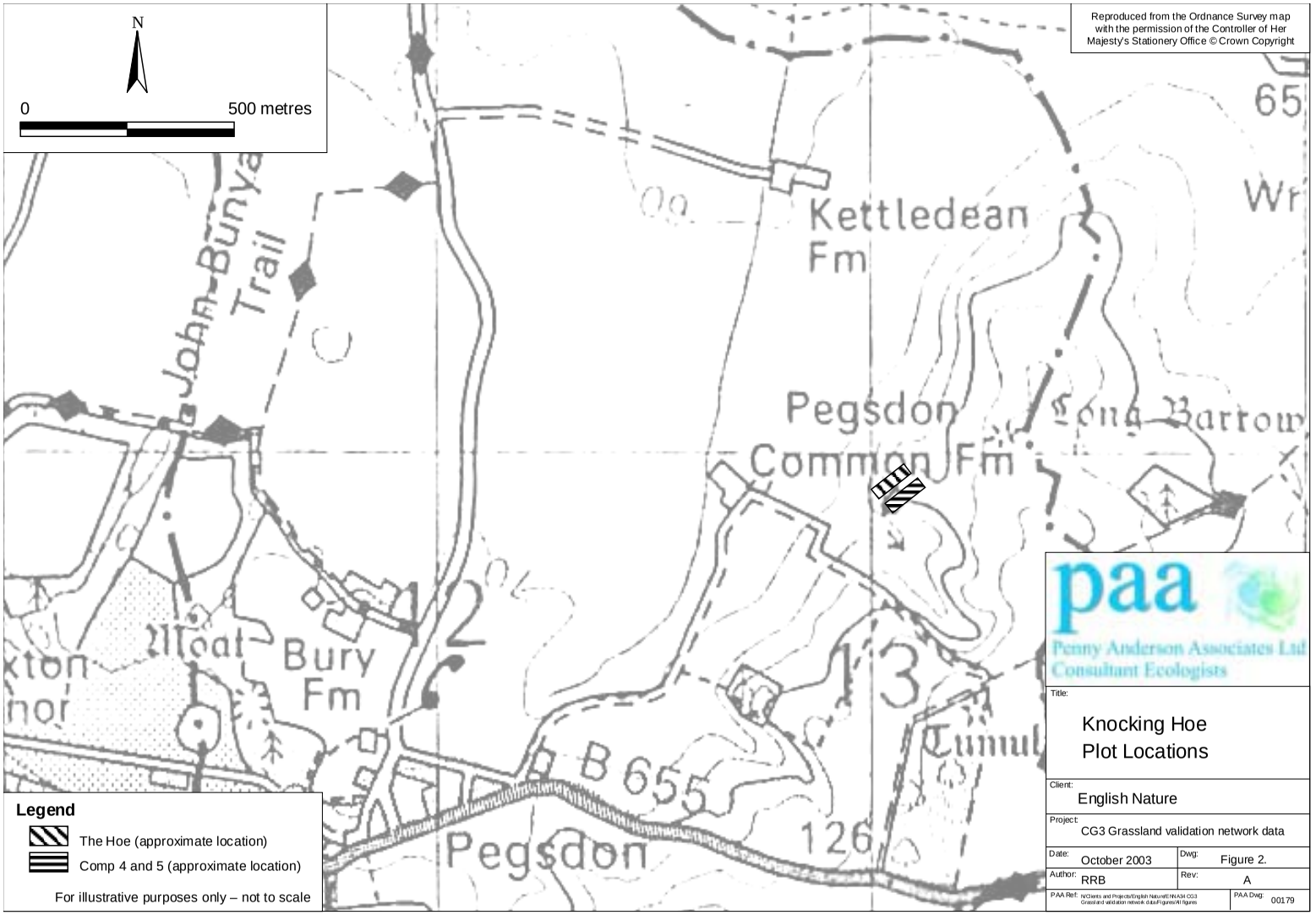


Figure 2 Knocking Hoe plot locations

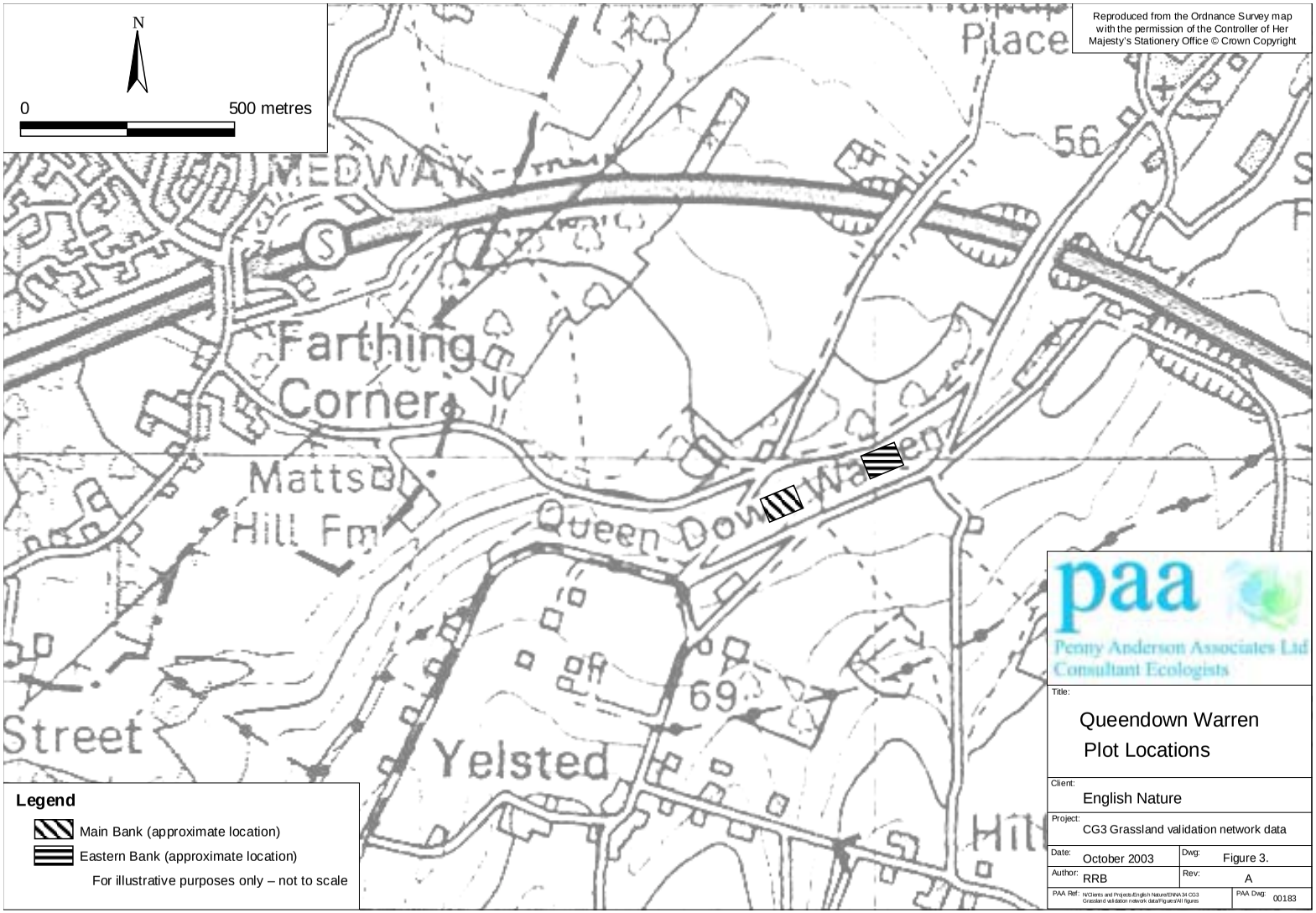


Figure 3 Queendown Warren plot locations

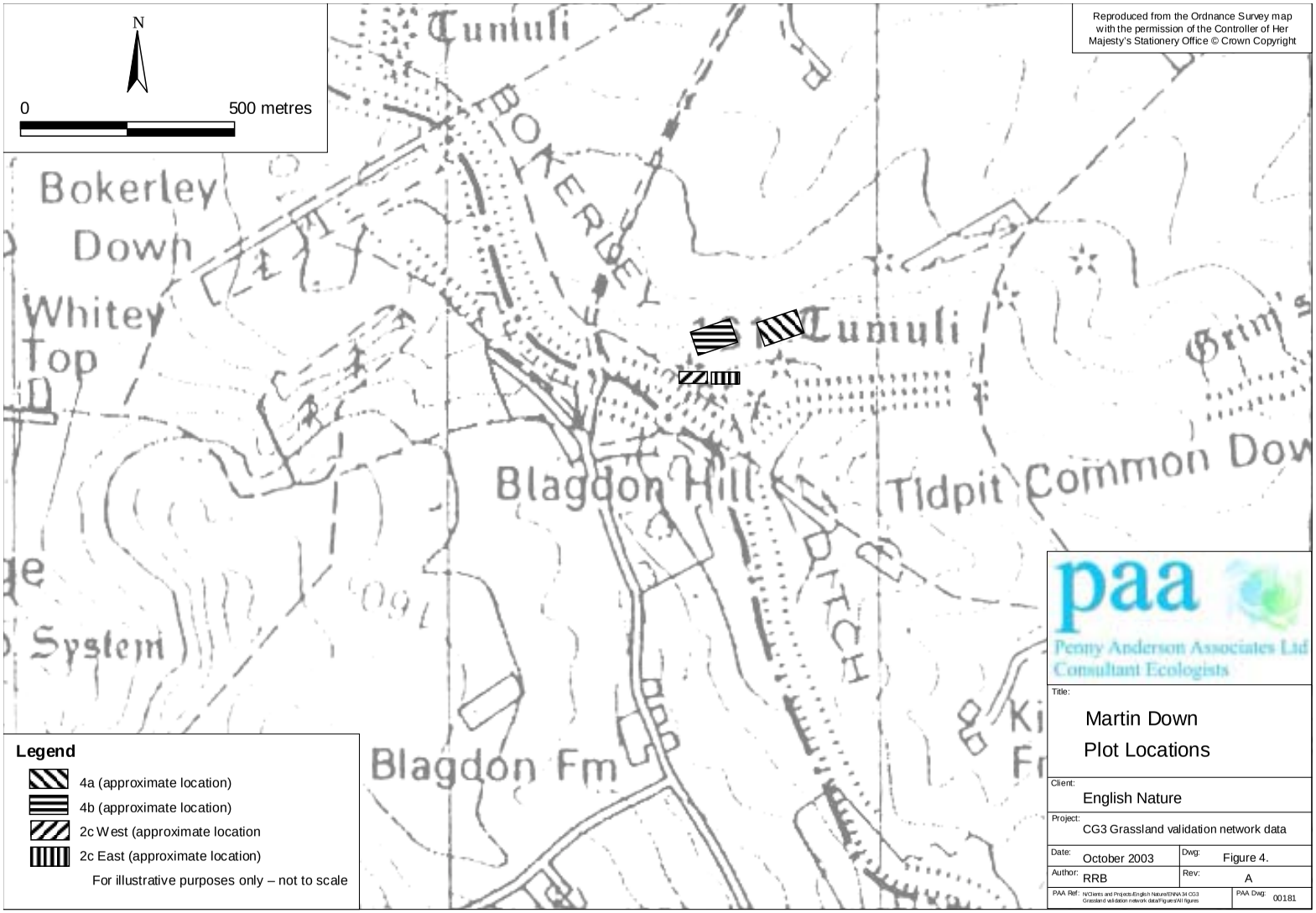


Figure 4 Martin Down plot locations

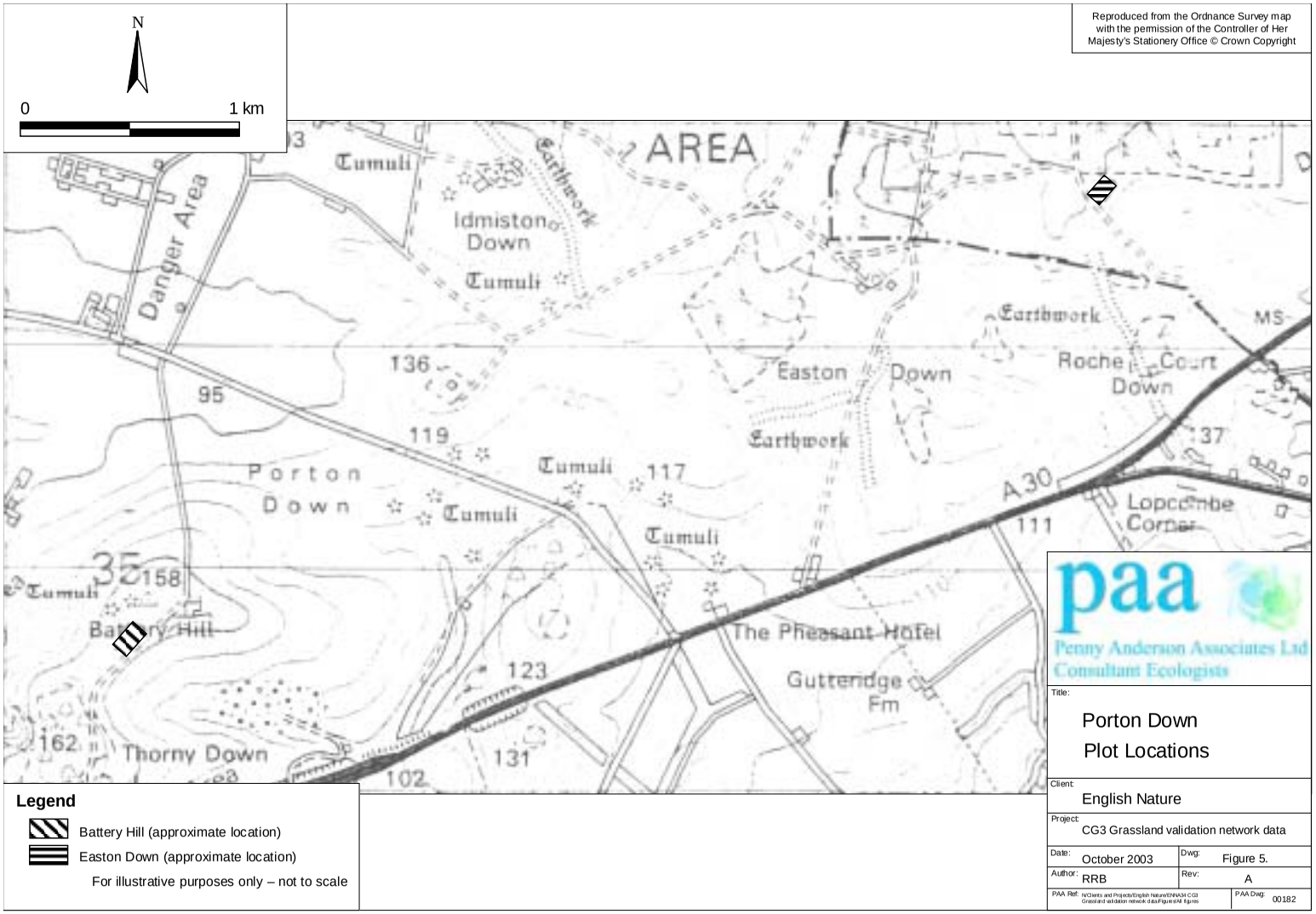


Figure 5 Porton Down plot locations

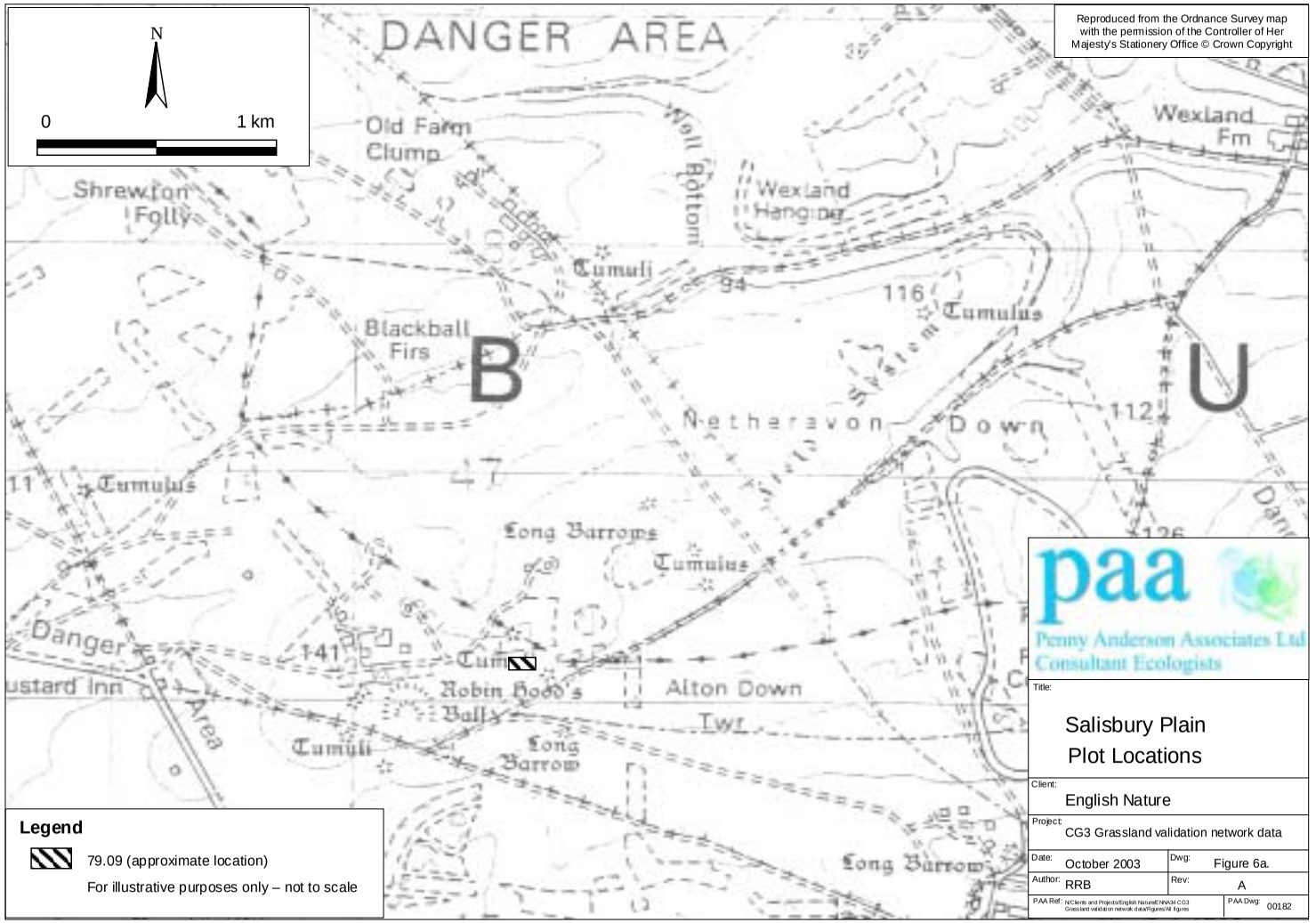


Figure 6a Salisbury Plain plot locations

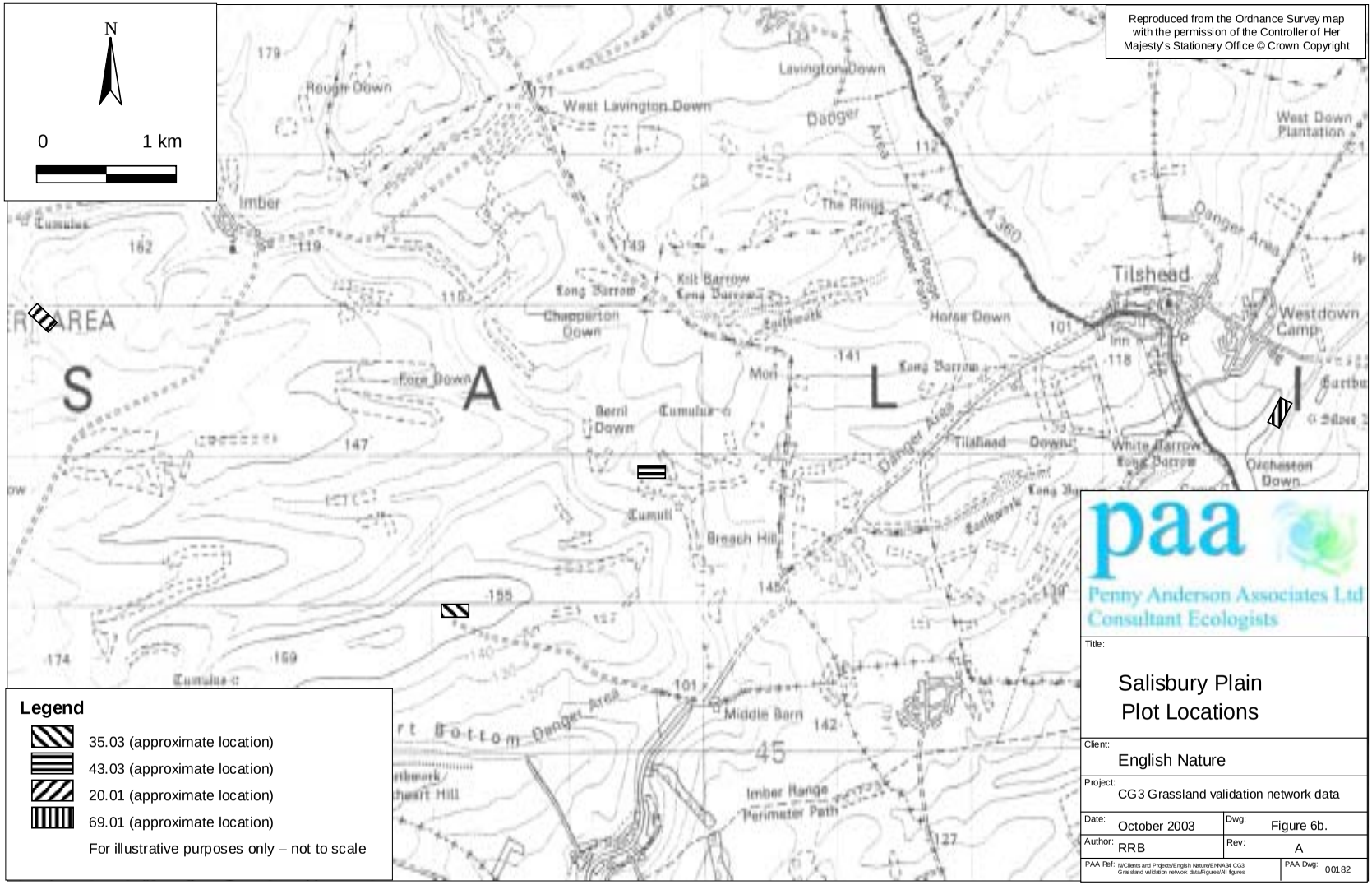
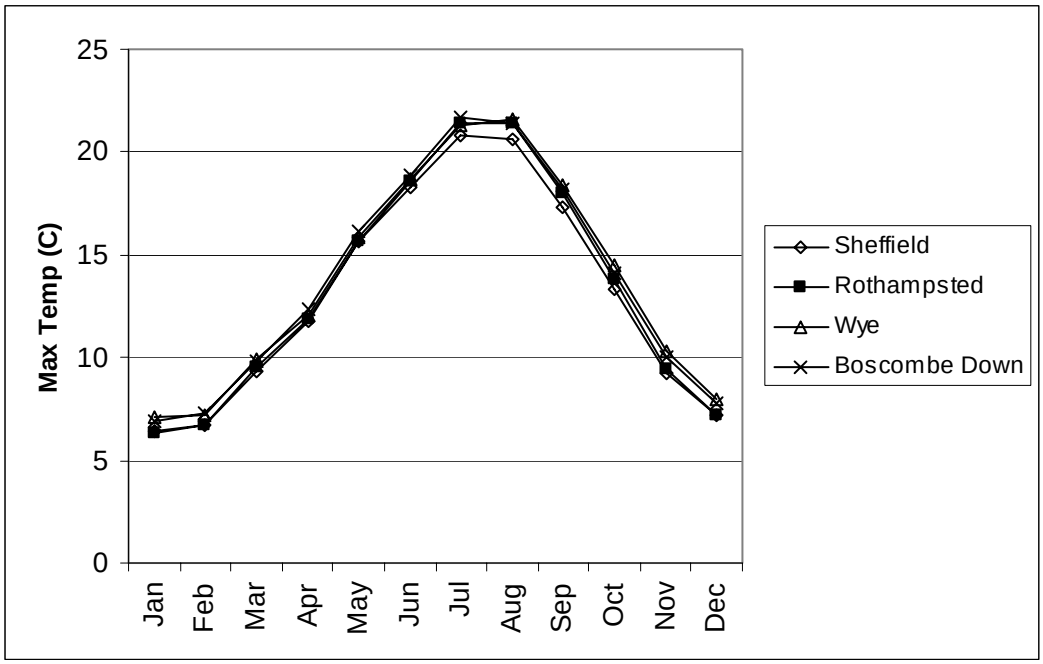
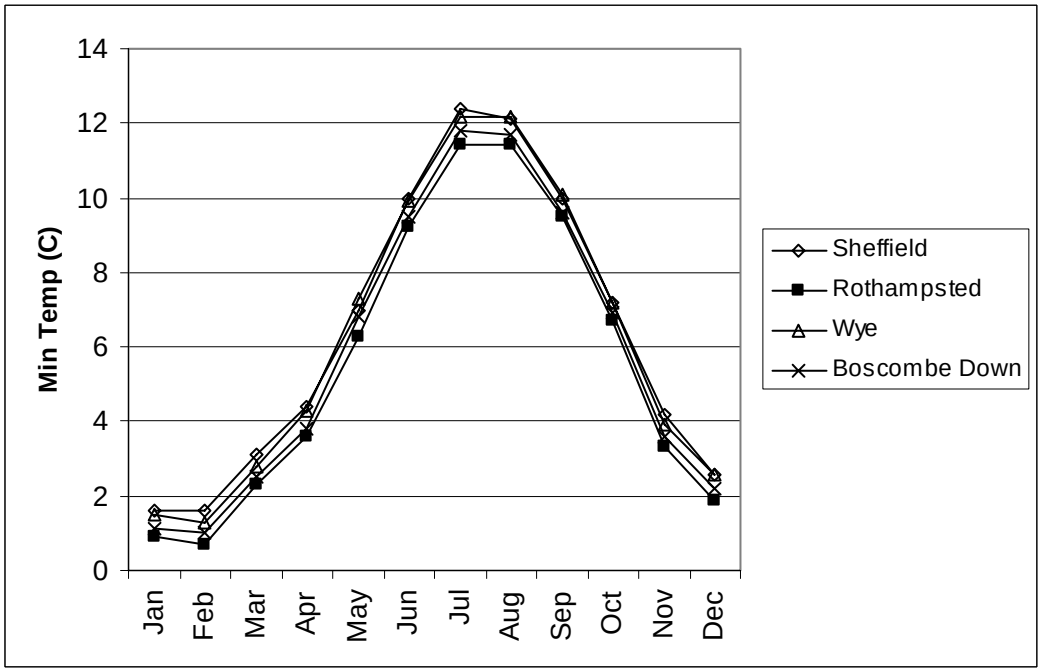


Figure 6b Salisbury Plain plot locations

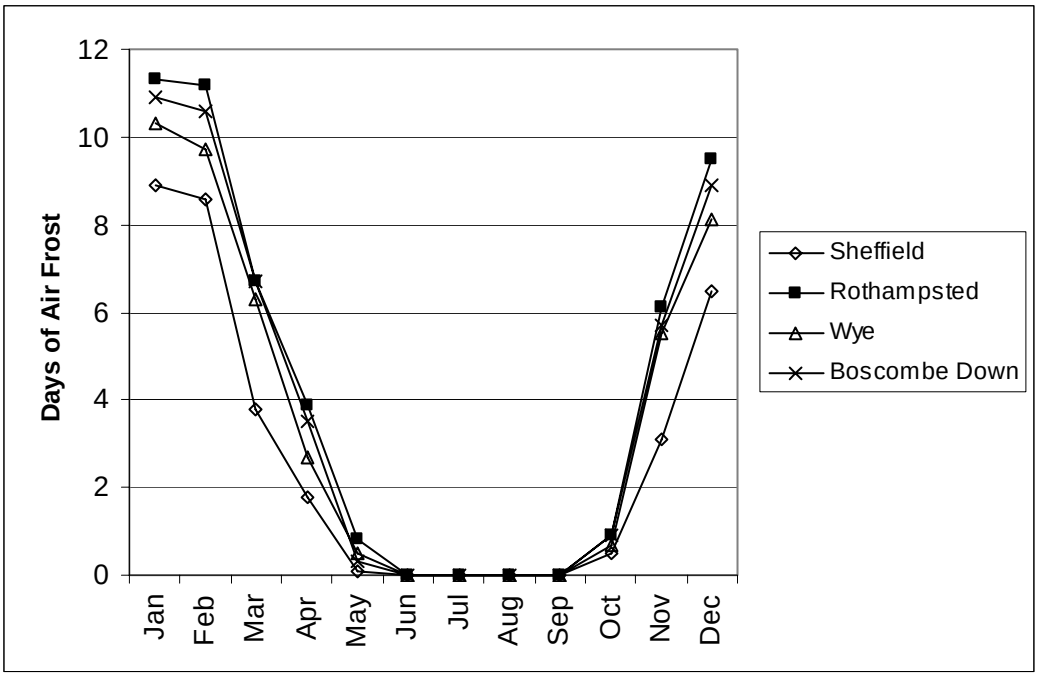
A) Maximum Temperature



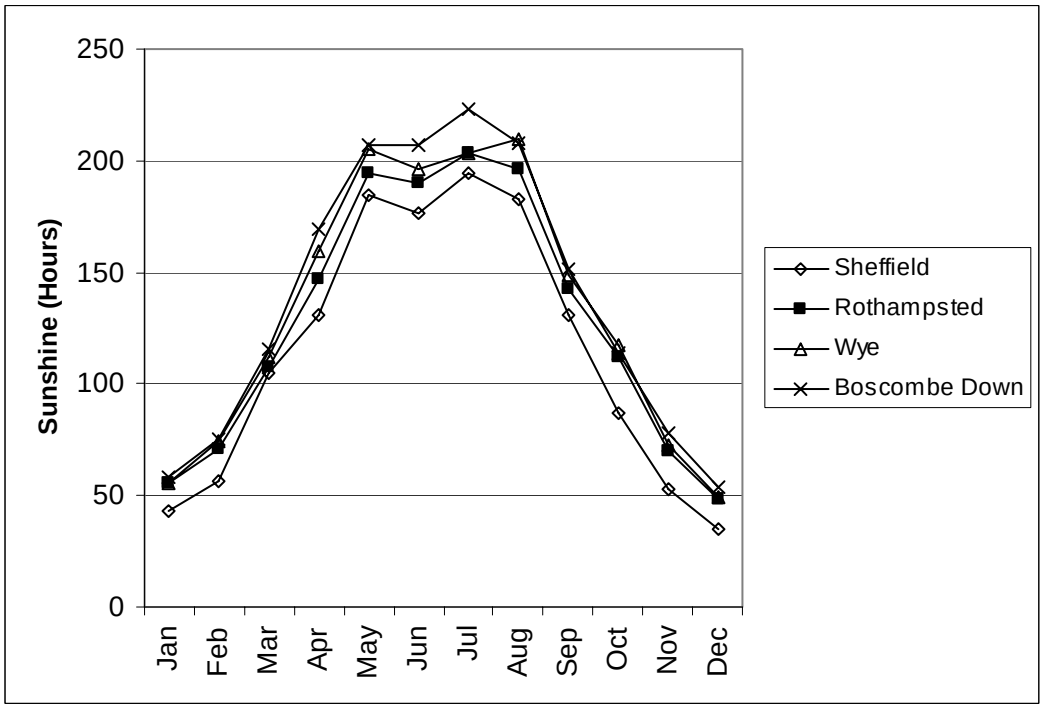
B) Minimum Temperature



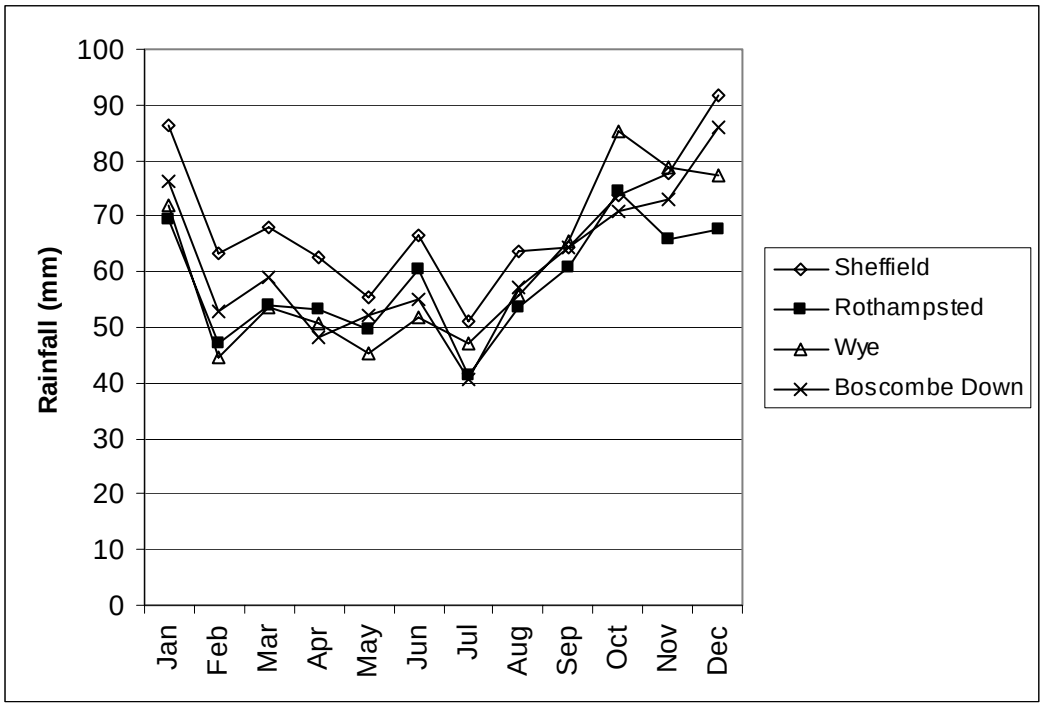
C) Days of Air Frost



D) Hours of Sunshine



E) Rainfall



F) Days of Rainfall >1mm

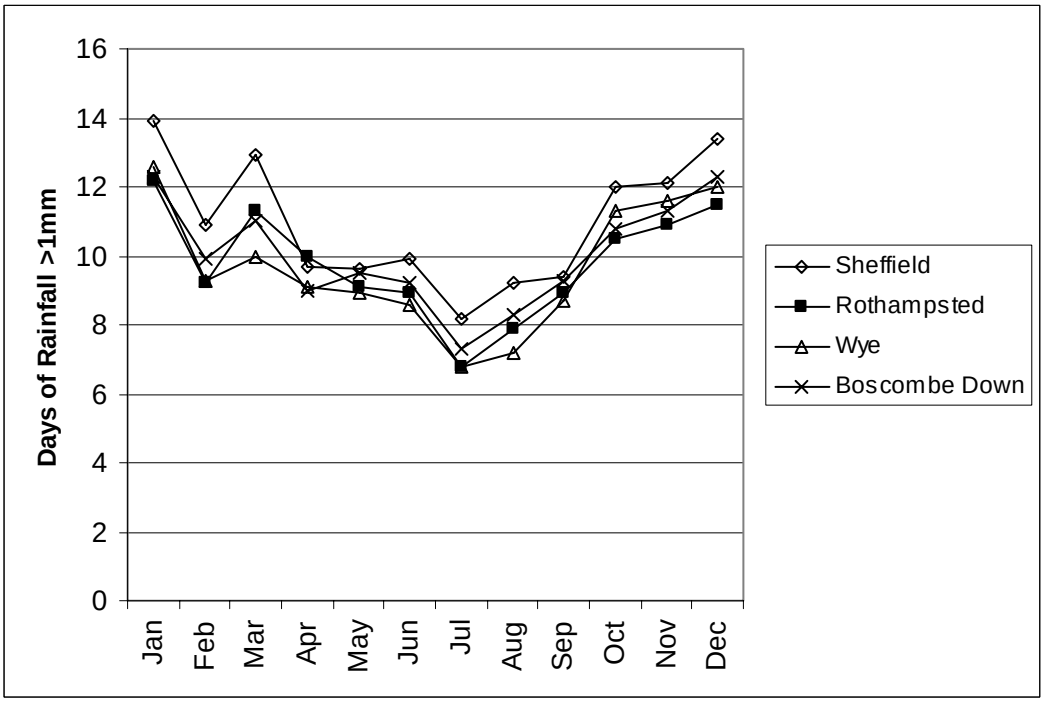


Figure 7 Long Term Averages (1971 - 2000) for selected meteorological data for each weather station

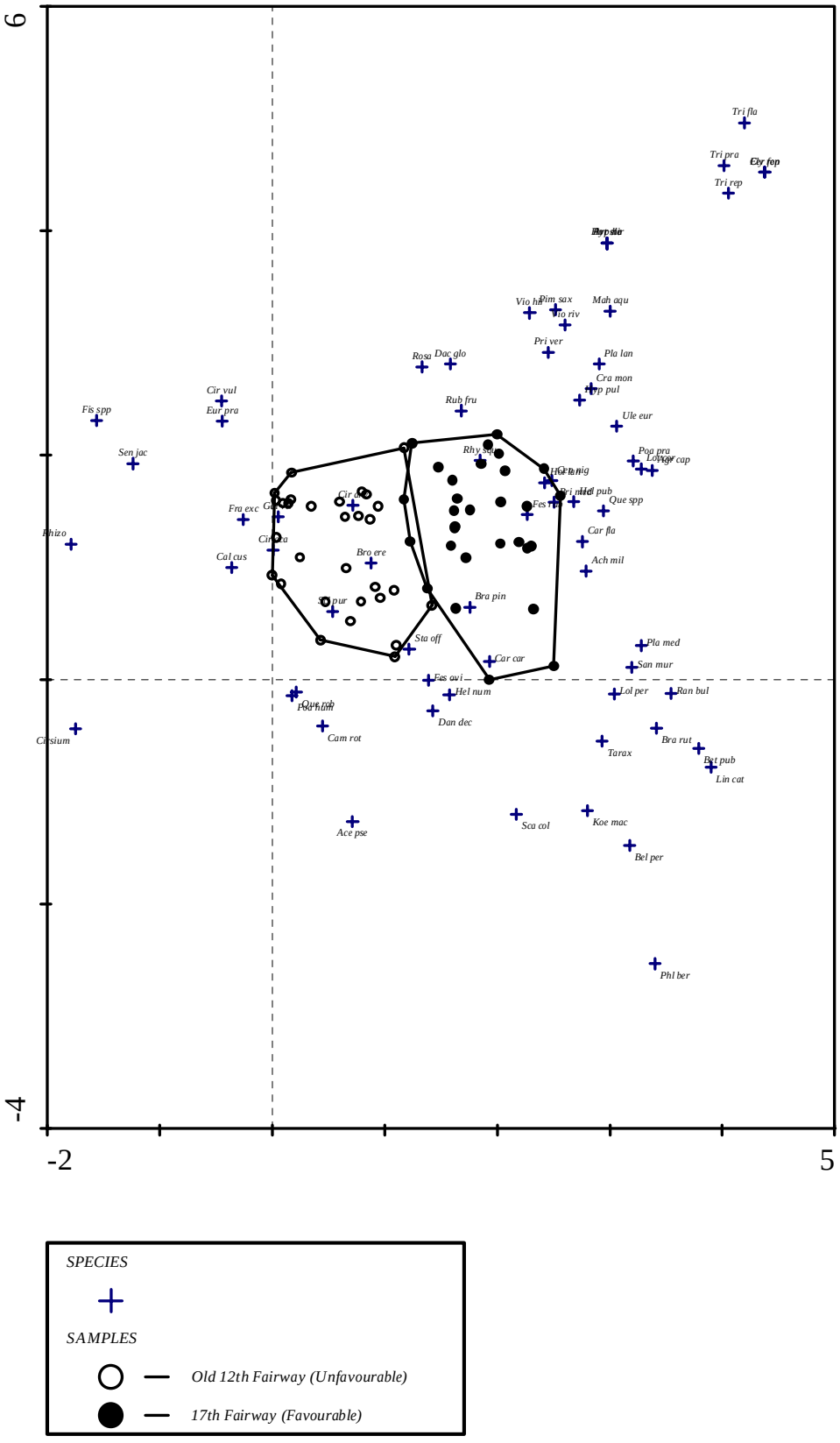


Figure 8 DCA ordination diagram for Lindrick Golf Course CG3 grassland plots

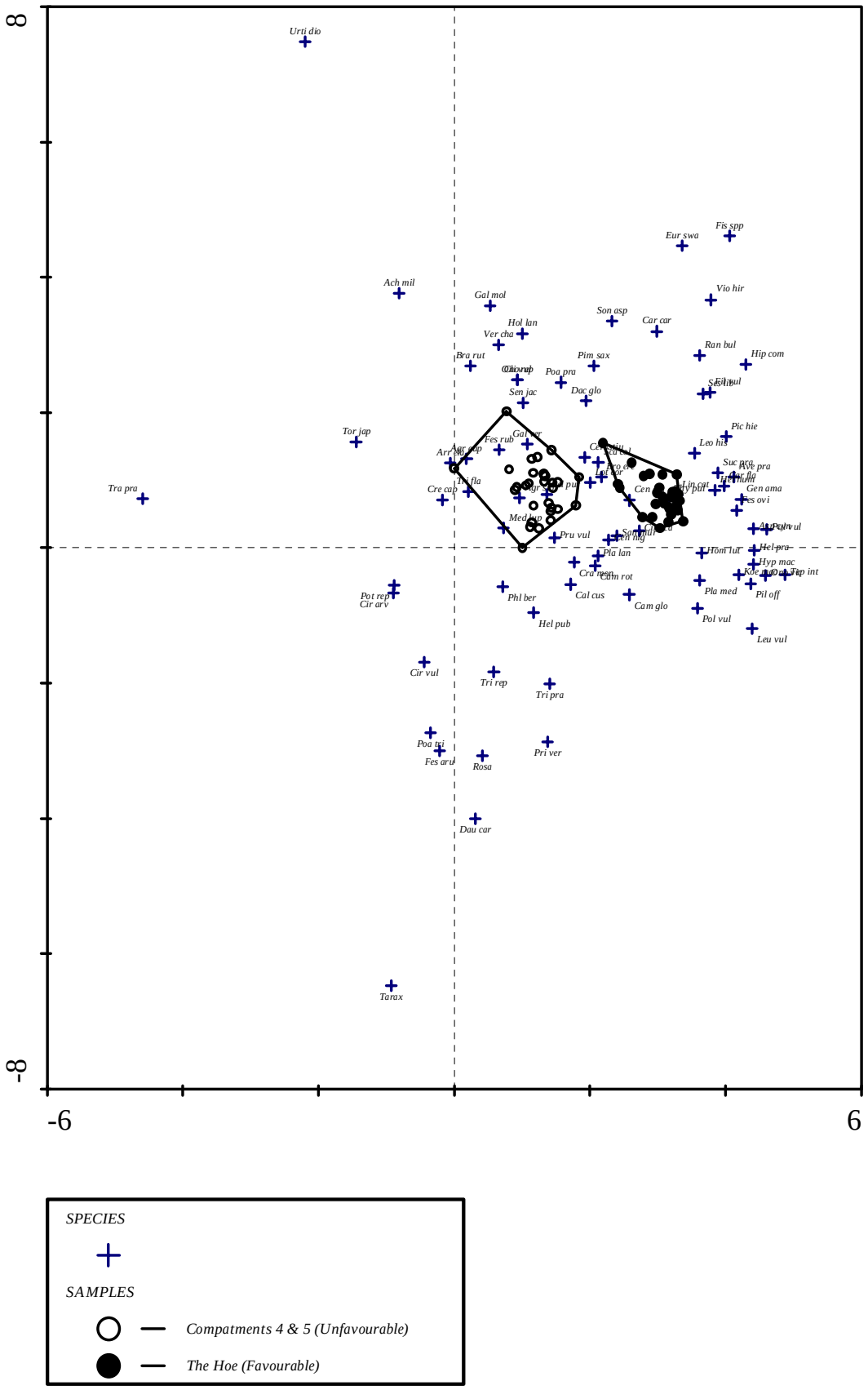


Figure 9 DCA ordination diagram for Knocking Hoe CG3 grassland plots

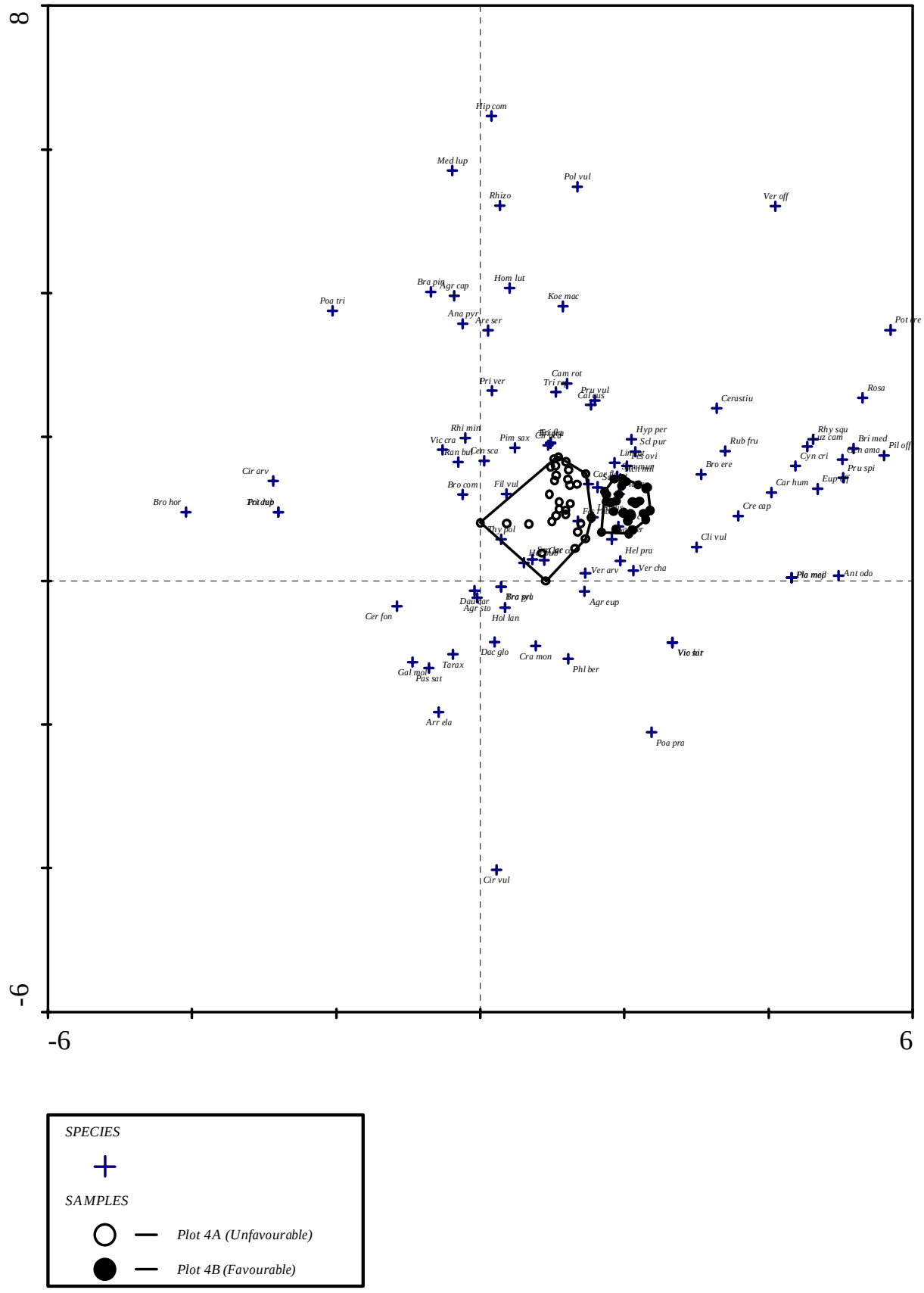


Figure 10 DCA ordination diagram for Queendown Warren CG3 grassland plots

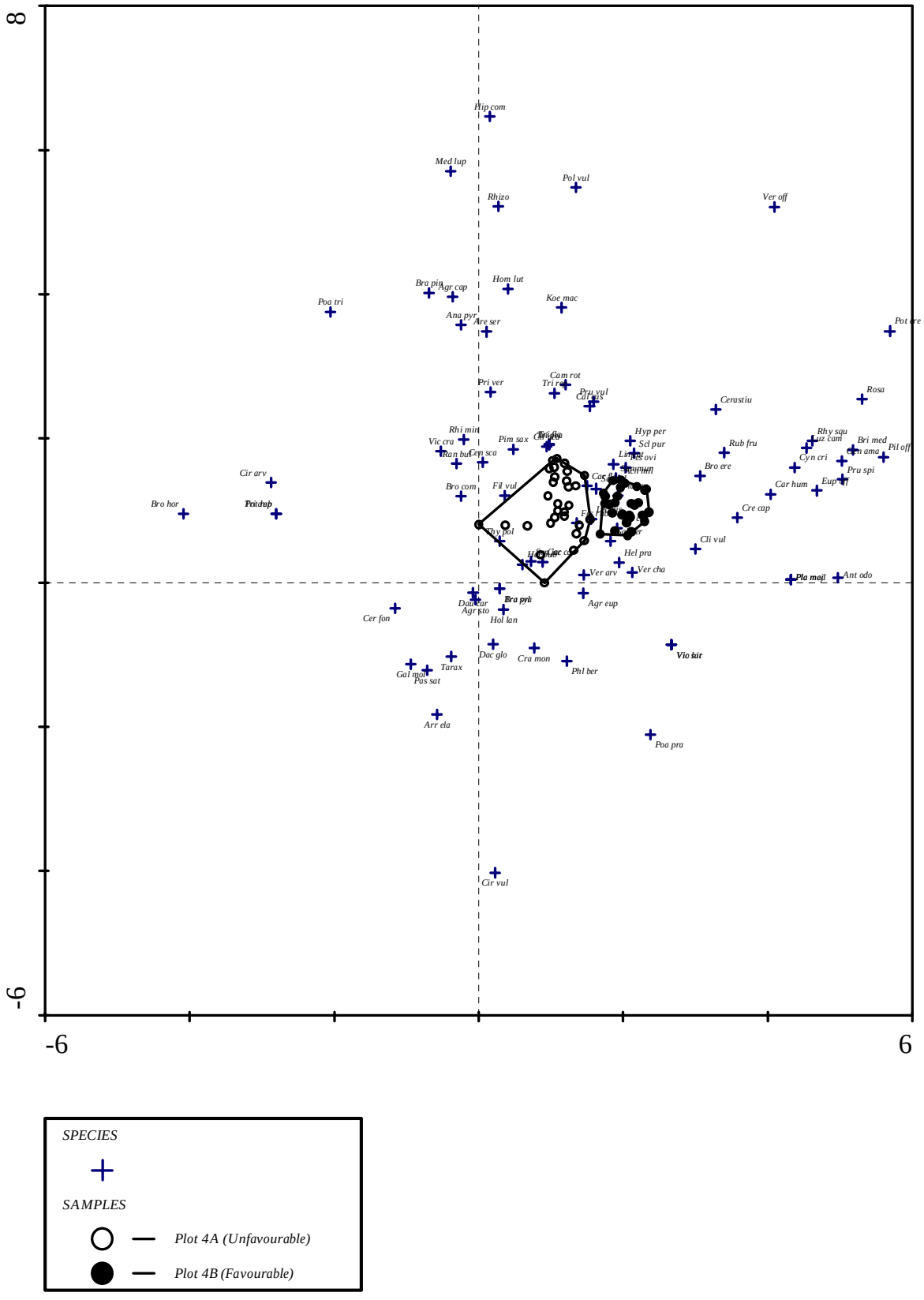


Figure 11 DCA ordination diagram for Martin Down (Plot 4) CG3 grassland plots

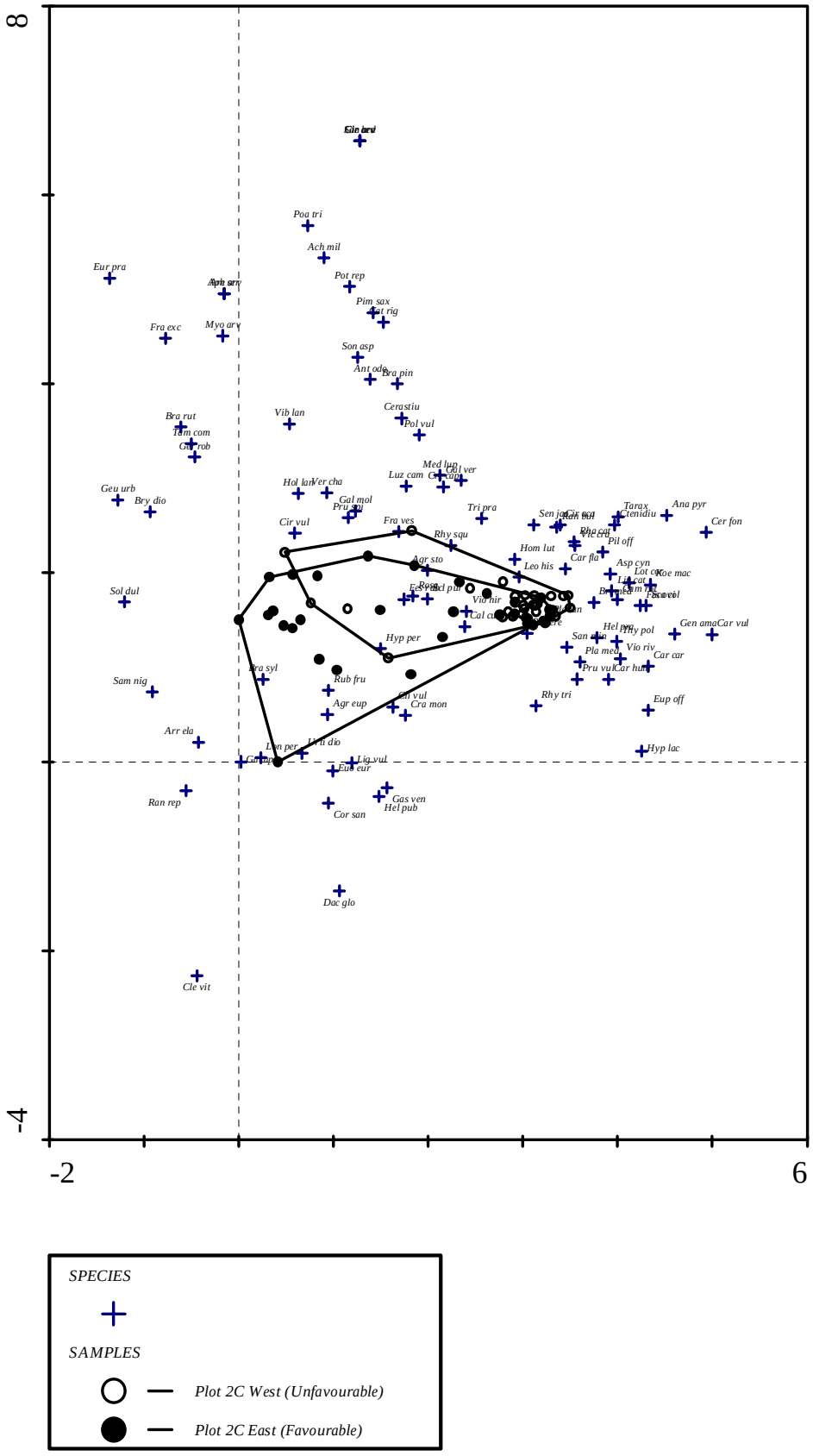


Figure 12 DCA ordination diagram for Martin Down (Plot 2C) CG3 grassland plots

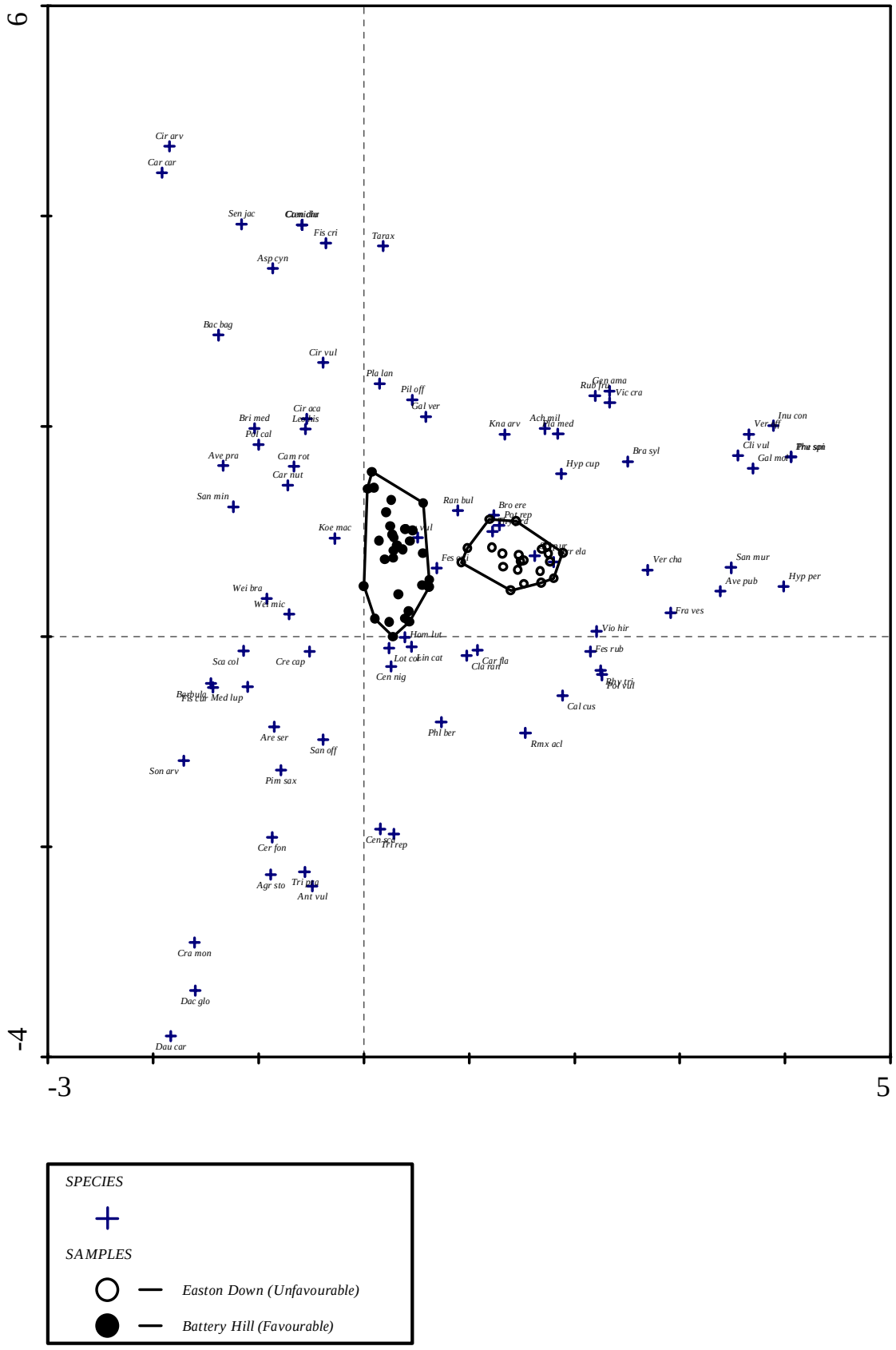


Figure 13 DCA ordination diagram for Porton Down CG3 grassland plots

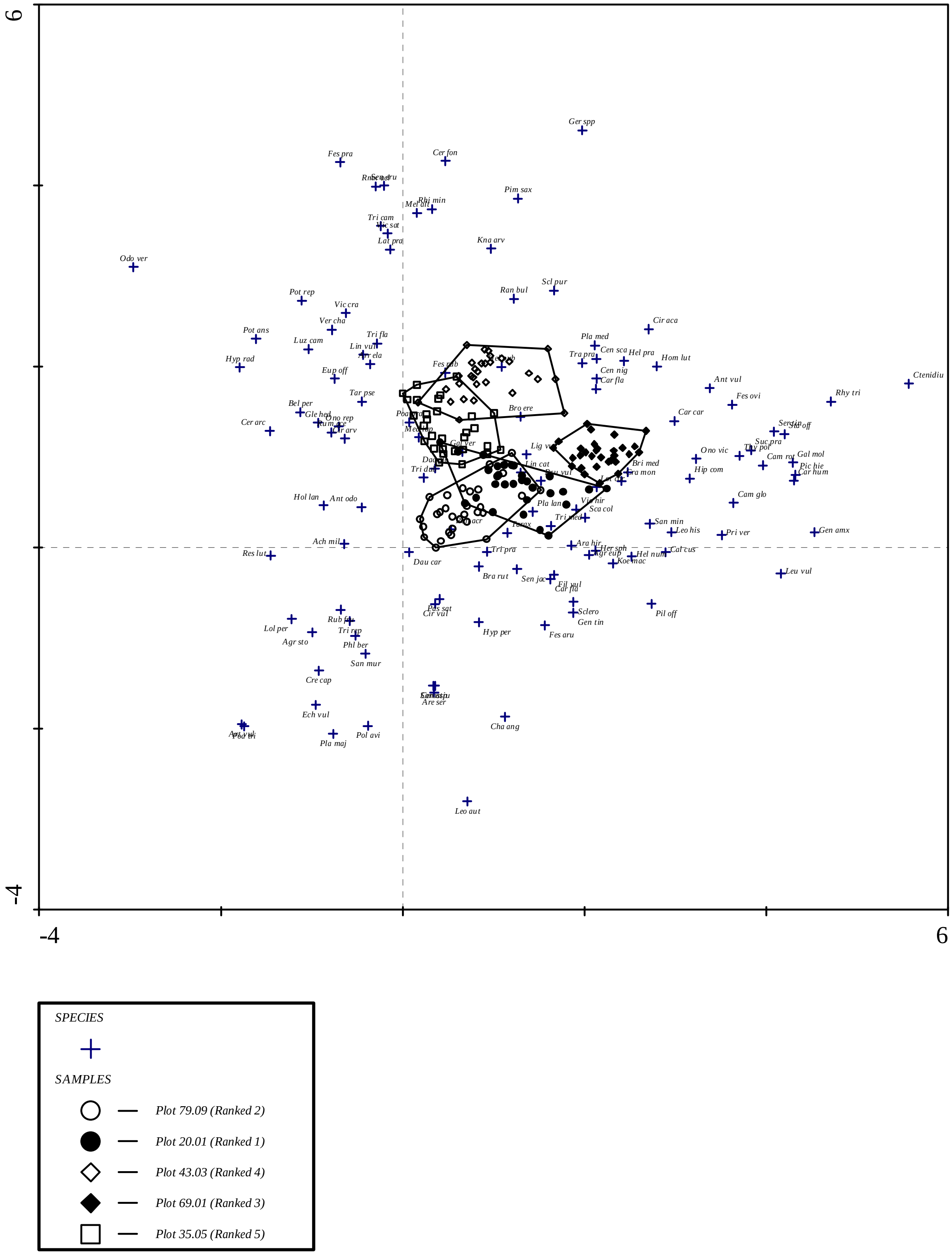


Figure 14 DCA ordination diagram for Salisbury Plain CG3 grassland plots

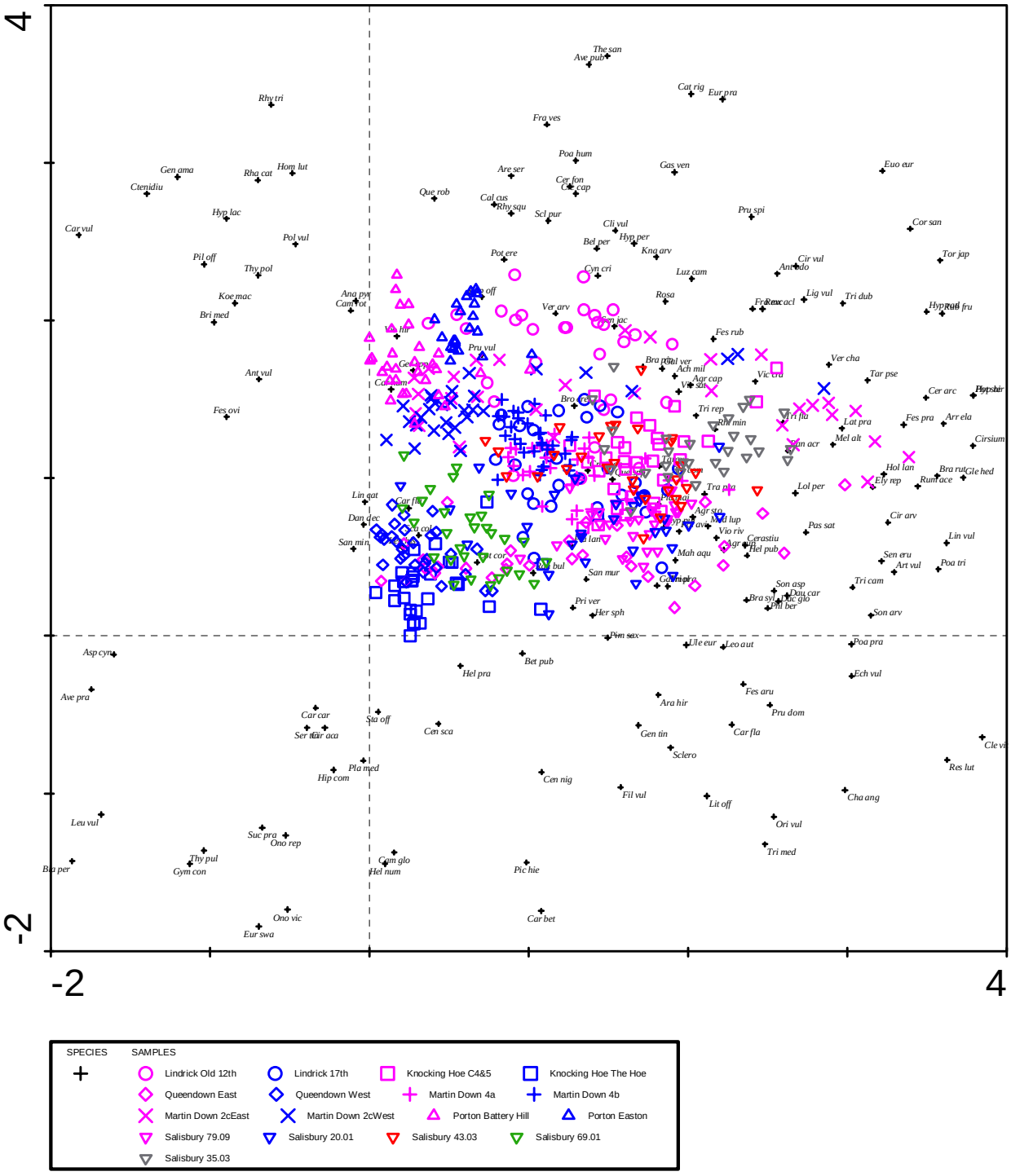


Figure 15 DCA Ordination Diagram for All CG3 Grassland Plots Combined

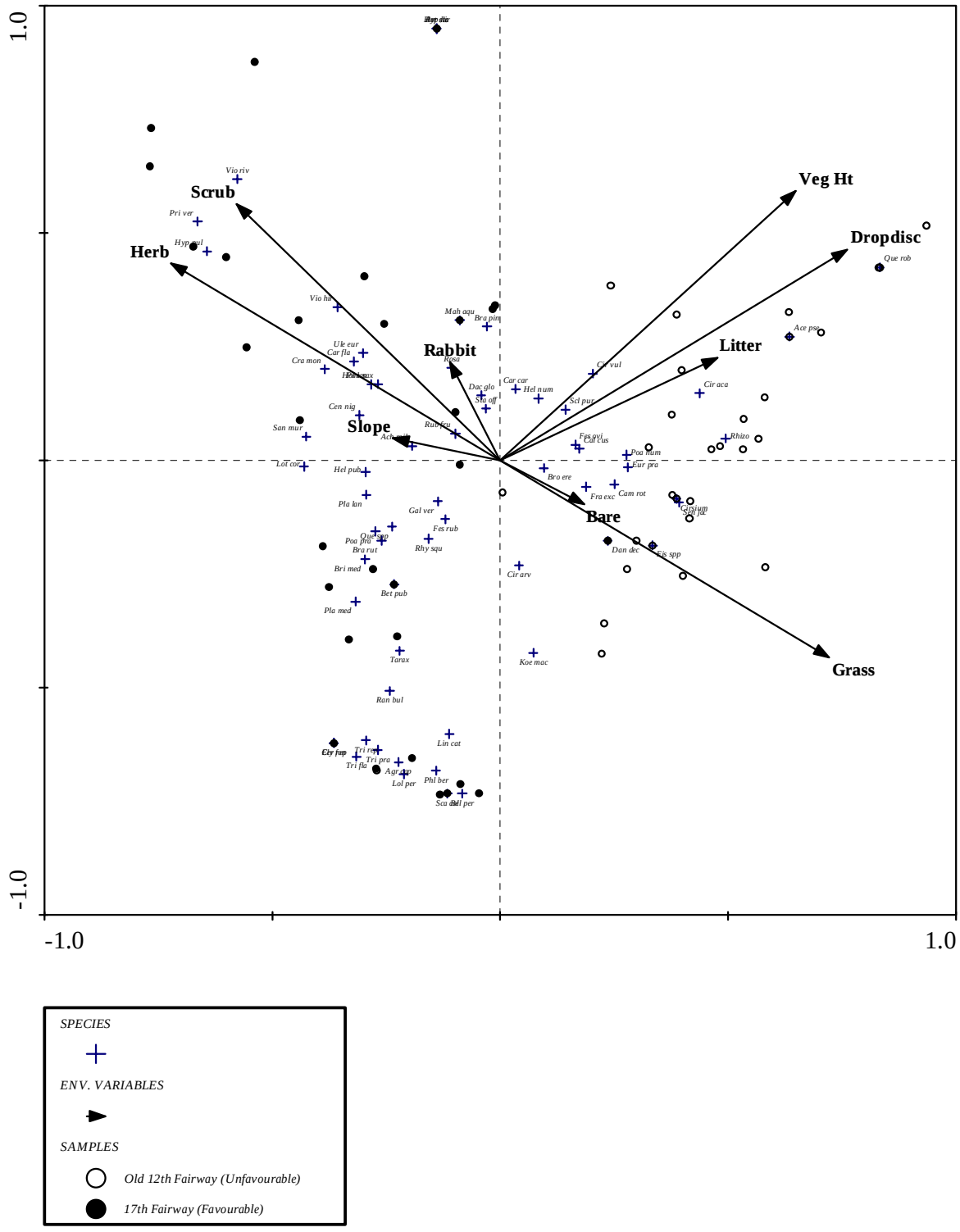


Figure 16 CCA Ordination Diagram for Lindrick Golf Course CG3 Grassland Plots

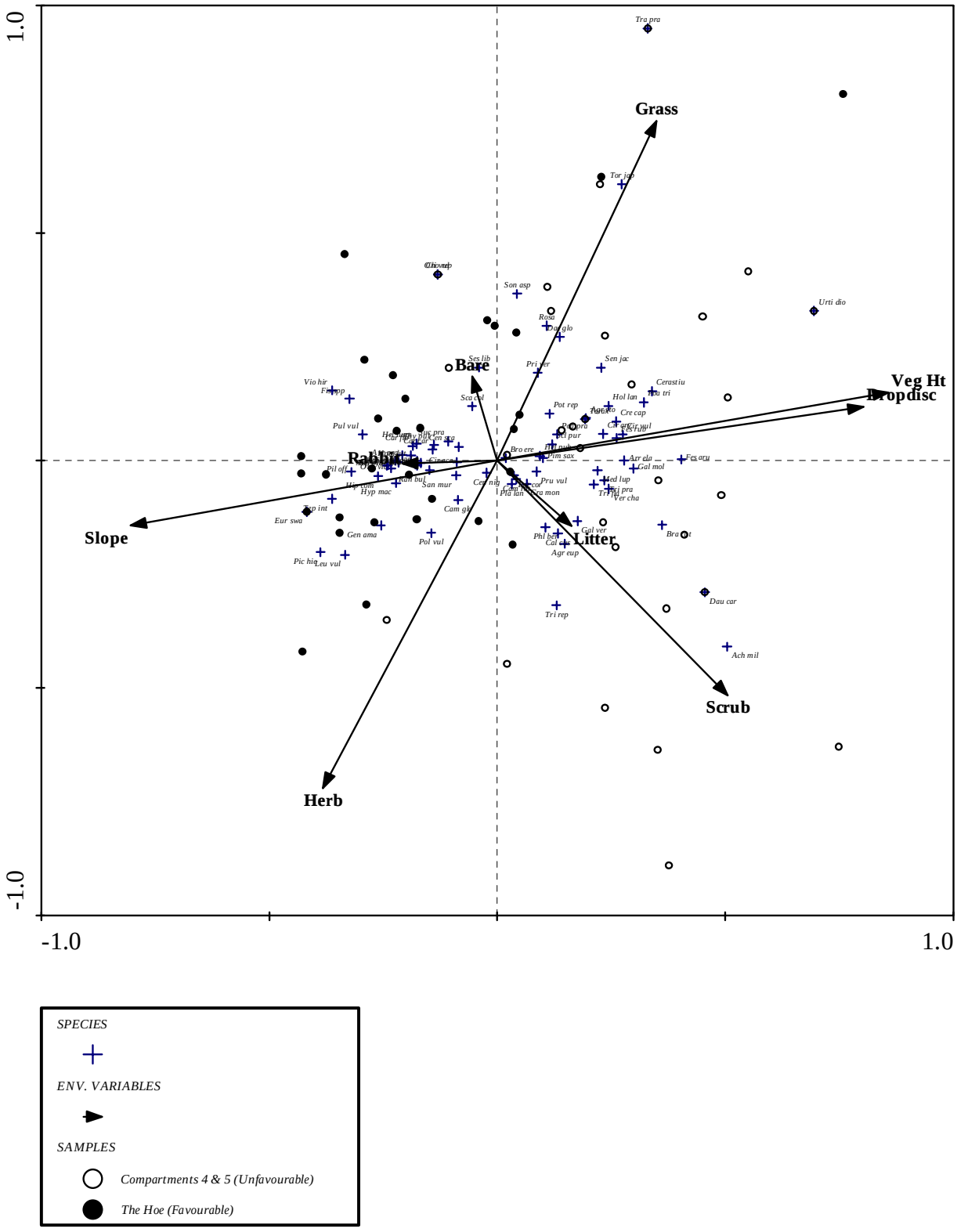


Figure 17 CCA Ordination Diagram for Knocking Hoe CG3 Grassland Plots

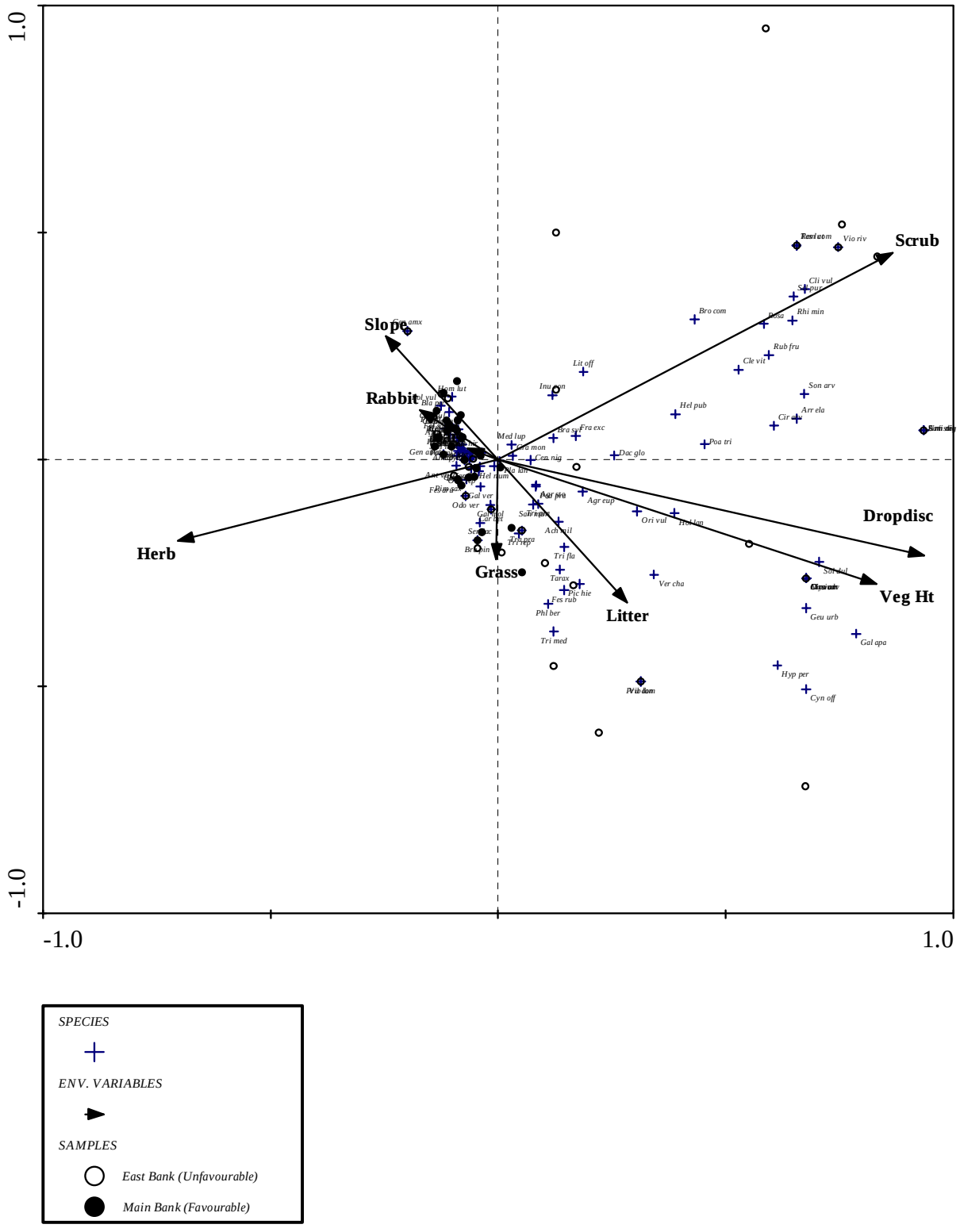


Figure 18 CCA Ordination Diagram for Queendown Warren CG3 Grassland Plots

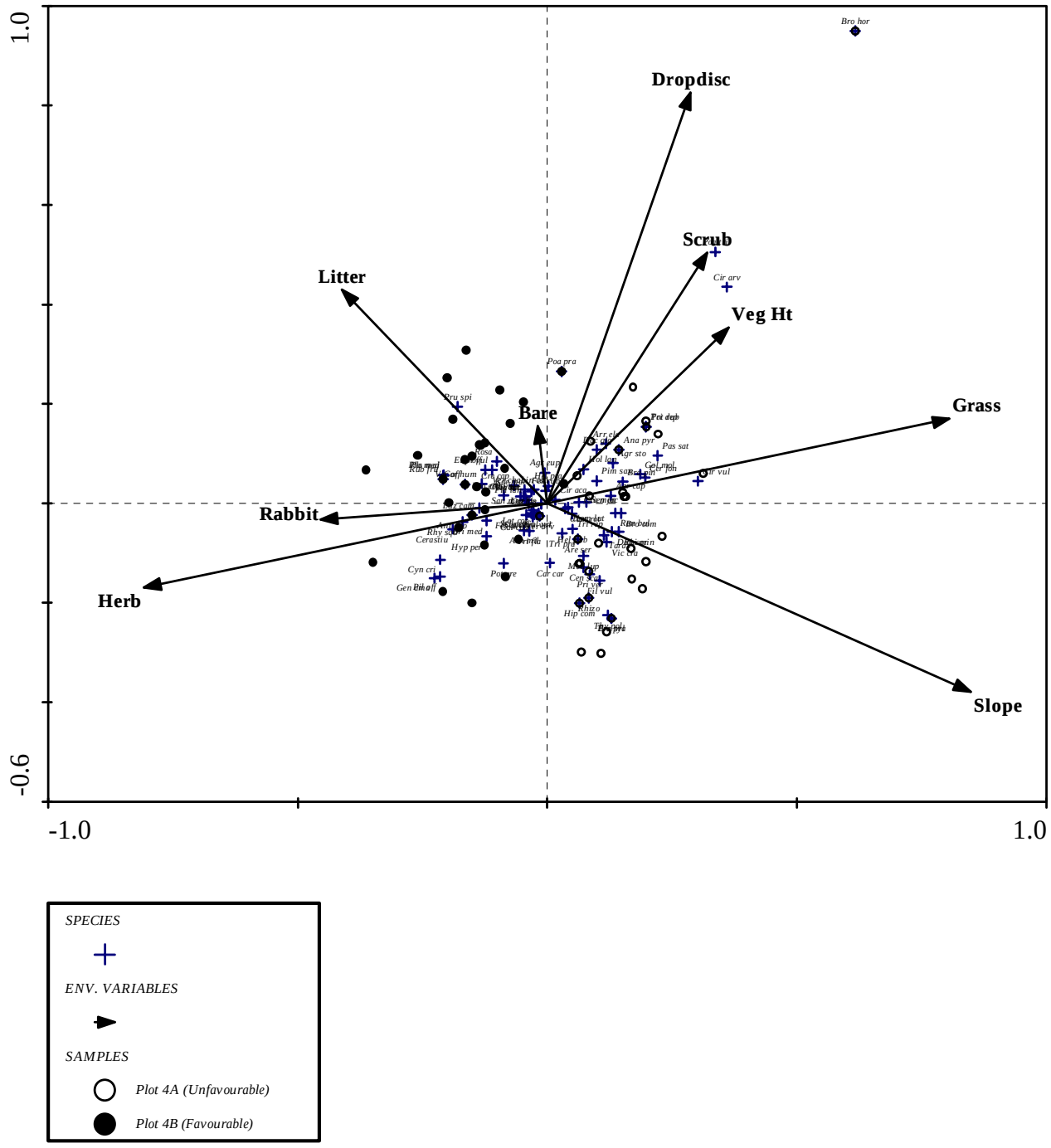


Figure 19 CCA Ordination Diagram for Martin Down (Plot 4) CG3 Grassland Plots

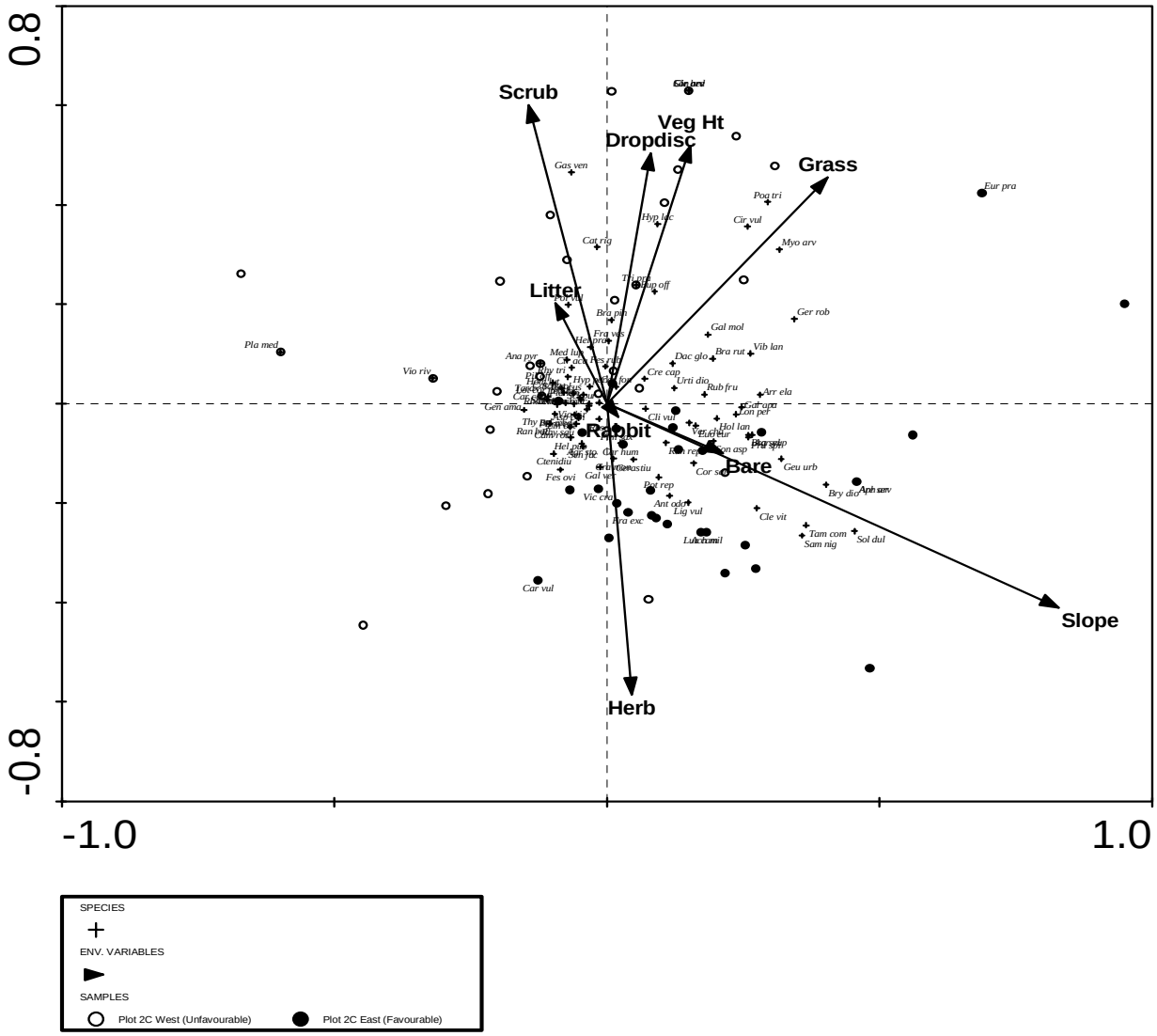


Figure 20 CCA Ordination Diagram for Martin Down (Plot 2C) CG3 Grassland Plots

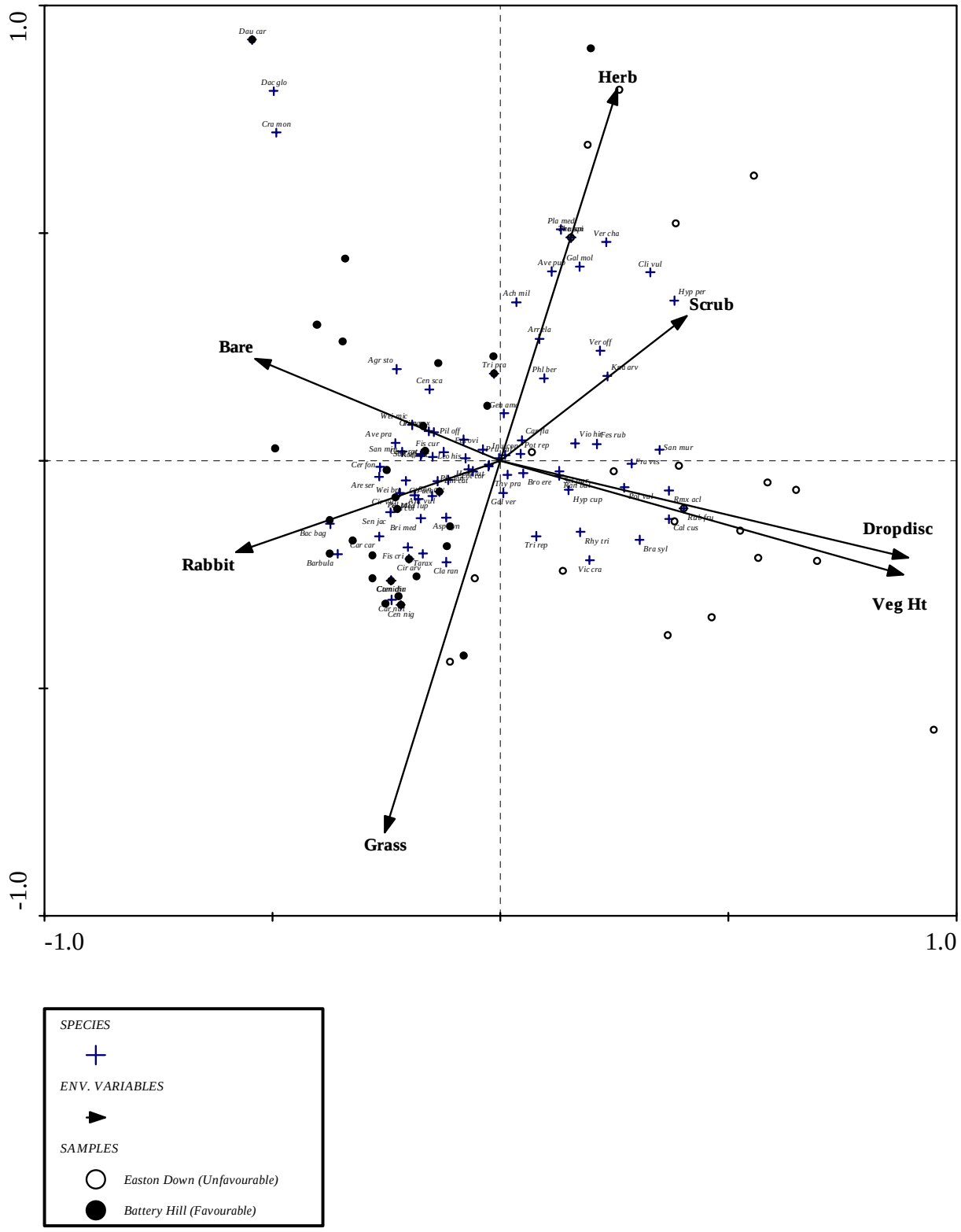


Figure 21 CCA Ordination Diagram for Porton Down CG3 Grassland Plots

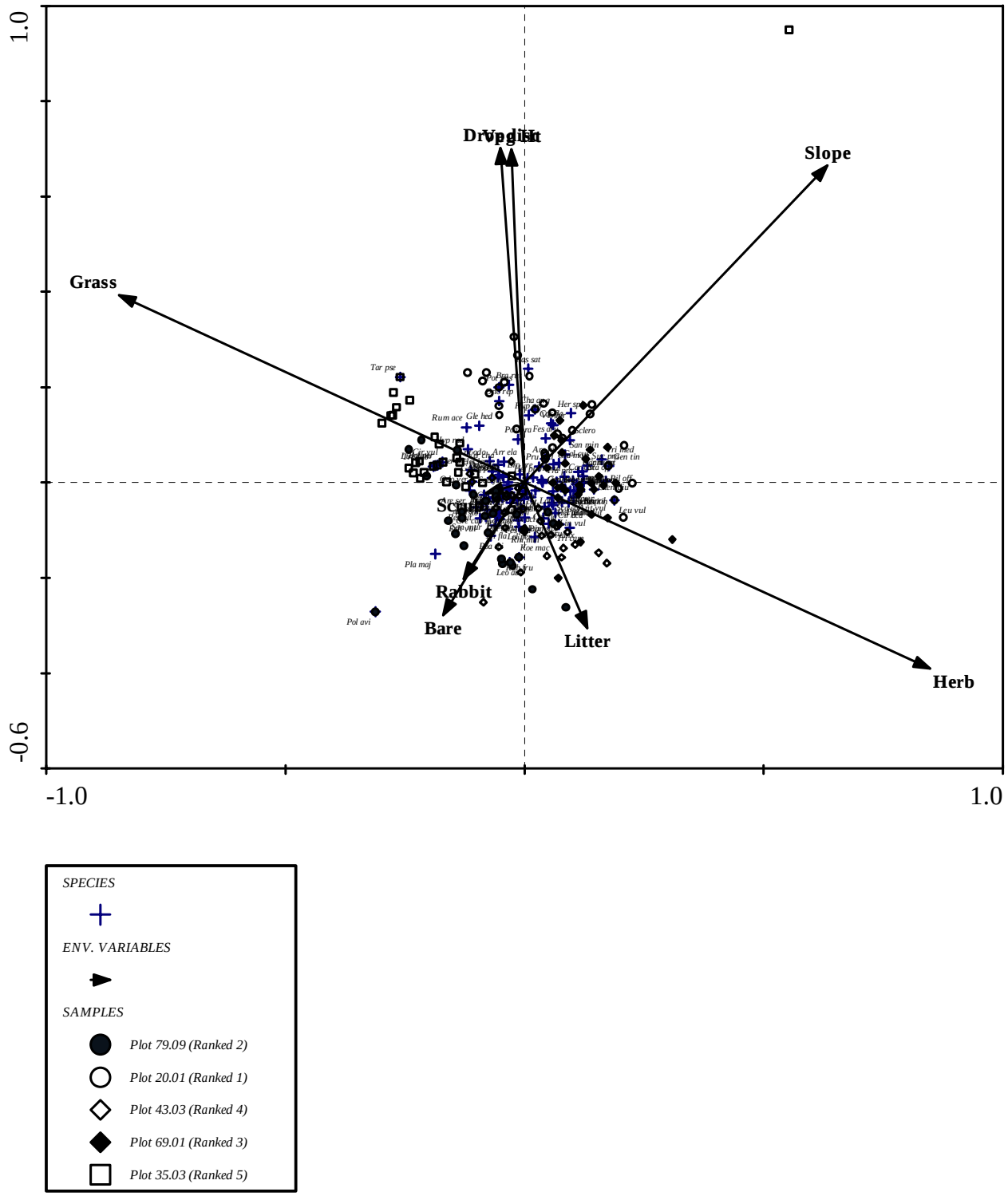


Figure 22 CCA Ordination Diagram for Salisbury Plain CG3 Grassland Plots

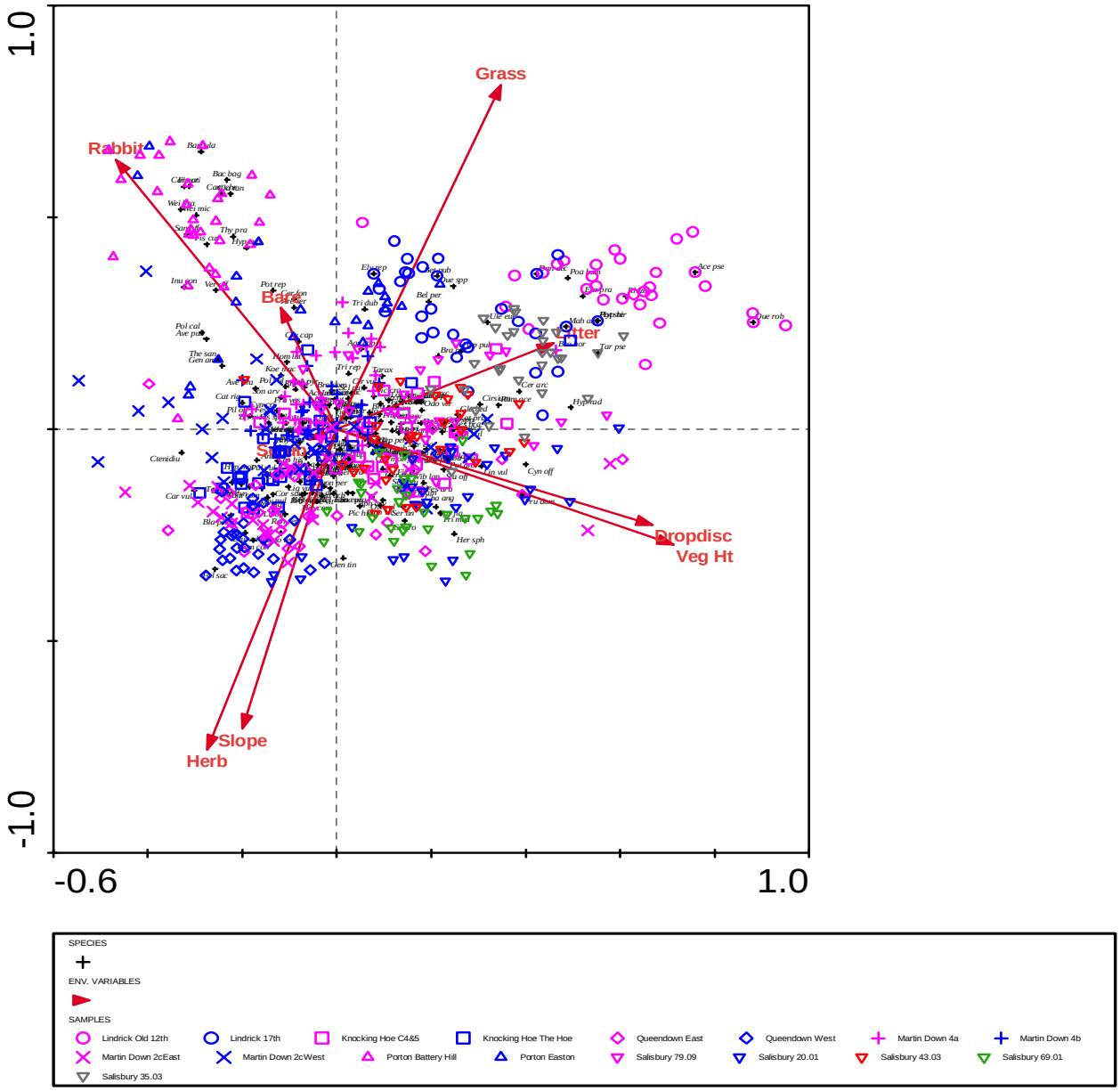


Figure 23 CCA Ordination Diagram for All CG3 Grassland Plots Combined

(Outlier species and samples suppressed)

ENGLISH NATURE

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

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

www.english-nature.org.uk

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

ISSN 0967-876X

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

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

CHARTER MARK
Awarded for excellence