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Ecological Factors Controlling Biodiversity in the British Countryside (ECOFACT)

MODULES 1 & 2

Final Report

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GLOSSARY

CS1990: The Countryside Survey which took place in 1990, but also interconnected with those carried out in 1978 & 1984.

Countryside Information System (CVS): The integrated system developed during ECOFACT for defining vegetation at the landscape level.

National Vegetation Classification (NVC): The classification system developed by John Rodwell at Lancaster University. It describes vegetation in terms of vegetation associations, defined by samples placed in homogenous vegetation.

Vegetation Plot Classes: The 100 classes produced from the classification of all CS1990 vegetation data.

Aggregate Vegetation Classes: The 8 groups of classes derived from the 100 vegetation classes by cluster analysis and used to stratify data for analyses of change.

TWINSPAN (classification): The statistical procedure used for classification of vegetation into classes.

DECORANA (ordination): The statistical procedure used to derive the principal gradients within vegetation.

Species Groups: Species classified by a statistical procedure into groups with relatively constant ecological affinities.

Ordination Axis: The gradient along which vegetation samples are ordered, according to their ecological affinities.

Ellenberg Scores: Scores attributed to species, which define their ecological range in terms of fertility, pH, light, and moisture.

Plot Types: The 6 types of sample vegetation plots placed in different landscape elements in the Countryside Survey (main, streamside, verge, hedge, boundary and habitat).

EXECUTIVE SUMMARY (Ref)

1. A major survey of the British countryside was undertaken in 1990 which repeated and extended a baseline survey of vegetation in 1978. The *Countryside Survey 1990* was published in 1993. The present report presents an extended and more comprehensive analysis of botanical character and change in countryside in Great Britain ~~by using random vegetation samples recorded in 1990 to determine the changes on sites recorded~~ in 1978.

2. These additional analyses are presented in a manner which is accessible to non-specialists and relevant to policy applications. The analyses establish links with other methods for vegetation description used in Great Britain and Northern Ireland. cur.

   This work was undertaken within Modules 1 and 2 of the 'ECOFACT' research programme and was funded by the Department of the Environment. Other components of the ECOFACT programme were funded by MAFF, SOAEFD and NERC.

   The objectives of this work were:

   - to produce overall indicators of stock and change in botanical diversity and its distribution in the wider British countryside;

   - to enable comparison with other systems of classification

3. The Countryside Survey 1990 established a framework for sampling the vegetation of the 'wider countryside'. This framework used the 32 environmental strata of the Institute of Terrestrial Ecology's Land Classification to select random one 1km-squares from the OS National Grid. In 1990, 508 squares were sampled, 256 of which had been included in the baseline survey in 1978. Botanical data were collected from vegetation plots located within each sample square. Within each square, five 'main' plots were selected at random and up to 22 other plots were located along specific landscape features - field boundaries, streamsides and verges. In addition, five plots were placed in areas not covered by any of the other plots in order to cover small fragments that might be of interest to nature conservation - termed 'habitat plots'. Data were colleted from c.12,000 plots in 1990, over 2,000 of which had previously been surveyed in 1978.

4. ~~Species~~ Botanical data from all types of vegetation plots were pooled. Multivariate statistical techniques were used to divide the plots into groups of similar botanical composition (vegetation classes) and to identify groups of species with similar ecological affinities (species groups). This exercise resulted in a ~~new~~ classification of vegetation in the wider countryside of Great Britain, known as the Countryside Vegetation System (CVS). The CVS consists of 100 vegetation classes which are used to describe the character and variation of vegetation. The names of these classes are based on interpretation of their species composition. Full descriptions and distribution maps of each vegetation class are available. The areas of the

vegetation classes, and associated standard errors, have been estimated using novel software developed for this project. Three groups of classes form the dominant vegetation in Britain: those associated with crops, managed grassland and moorland vegetation. Many abundant classes in terms of frequency occupy small areas as they are only found along linear features.

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The 100 vegetation classes have inadequate sample numbers for statistical tests of change to be made between 1978 and 1990. To derive indicators of change classes have been clustered into eight aggregate vegetation classes: Crops/weeds; Tall grassland/herb; Fertile grasslands; Infertile grasslands; Lowland wooded; Upland wooded; Grass mosaic/moorland and Heath/bog. Data from any given vegetation plot may be assigned to this classification. Aggregate classes II and V are dominated by linear features whereas I, III and VIII are dominated by Main plots representing the dominant vegetation in the landscape. The remaining classes have complex mixtures. These results emphasise that the vegetation classification is reflecting real ecological groupings rather than being biased by the different quadrat sizes used and therefore supports the novel approach of using a single classification to describe the total distribution of variation in the vegetation across landscape types.

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6. Both ~~well-established~~ develop and novel techniques have been applied to the vegetation data to present a comprehensive picture of the state of British vegetation in the wider countryside in 1990 and the changes over the preceding 12 years. The analyses comprise: vegetation classification; species group; individual species; species diversity; functional strategy; habitat indicator species; NVC diagnostic species; occurrence of rare species; species frequency; butterfly larval food plants and bird food plants.

Differences in vegetation characteristics are compared between the four major landscape types derived by grouping the individual land classes of the ITE Merlewood Land Classification (ie arable; pastural; marginal upland and upland). Changes in the different plot types representing landscape features (main plots; hedge and boundary plots; streamside plots; verge plots and habitat plots) were also compared between 1978 and 1990.

to technical

7. The primary vegetation gradient is from vegetation dominated by crop plants, through grasslands and woodlands to heaths and bogs. The secondary gradient is ~~primarily~~ related to the degree of tree cover related to disturbance whereas the third gradient is related to wetness of the vegetation. These gradients ~~are related to trends in the underlying~~ have been environmental ~~factors which are usually~~ interpreted using ecological expert knowledge. Ellenberg indicator values nitrogen, light and moisture are highly correlated with the first three vegetation axes. The first gradient is related to fertility with crops at one extreme and bogs at the other. The secondary gradient is related to the degree of shade and the third from vegetation typical of wet situations to the dry conditions of calcareous grassland. Shifts in vegetation from one class to another can be interpreted in terms of these primary ecological gradients and interpreted in terms of processes which will be reported subsequently under Module 6 of the ECOFACT programme.

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8. The vegetation classes are made up of groups of associated species that ~~have~~ different habitats ~~characteristics~~. Changes in the represenation of these groups have been used to

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understand change and provide one measure of biodiversity. The vegetation classes associated with crops are relatively uniform whereas grasslands and moorlands contain a wider range of specific groups. Woodlands are the most complex. Whilst major shifts in vegetation are reflected in shifts between classes smaller changes need to be understood with reference to the species groups; ~~as~~ they reflect qualitative changes within vegetation classes.

Why that?

9. The occurrence of the vegetation classes within Britain is described in relation to the four landscape types: arable; pastural; marginal upland and upland. The most variable of these are the marginal uplands since they can contain both upland and lowland vegetation. Surprisingly, the different landscapes show a relatively even distribution of variation within the landscape elements, except the uplands which have less variability contained within boundaries. At this level, the habitat plots do not differ from other plot categories although subsequently they have been shown to differ in terms of quality criteria. However, these results relate to the objective assessment of botanical variation, for example, the five main plots within arable landscapes often assigned to different vegetation classes because of the management regime within the fields but may not answer the quality criteria outlined below. Analysis of the classes that may be considered as representative of semi-natural as opposed to highly-disturbed or managed vegetation shows a different pattern with the arable and pastural landscapes having the majority of the variability within linear features whereas in the uplands the vegetation is distributed more evenly through the landscape. The maintenance of the small fragments within the landscapes needs to be considered in relation to their management status, so that policies could be developed to maintain the diversity present. It was also shown that the species that comprise the vegetation at the landscape level are drawn from a pool determined by the local environment and that management selects the species that remain within the different elements.

10. Distinctive species were determined by identifying significant positive associations by aggregate class, plot type and landscape using the χ^2 statistic. Although streamsides have the most species overall, the main plots have comparable numbers. Open landscapes with the exception of crop fields, still contain many distinctive species although as the quality analysis shows these may not be considered as important in lowland landscapes. Surprisingly both boundary and habitat plots have few distinctive species since they largely comprise species present elsewhere in the landscape.

11. Hedgerows also have relatively few distinctive species for the same reason. In contrast, where species present only in combinations of aggregate class, plot type and landscape are examined, both boundary and habitat plots have many records. These plot types, therefore, contain many individual species not present elsewhere in the landscape. Streamside, main and roadside plots also contain many such species in all landscapes. Hedgerows have few such species as their flora contains many plants present elsewhere in the landscape such as woodlands. The unique species are present because they either require specific habitat features present in the plot type, or they are relicts from the surrounding vegetation, are inherently rare or have dispersed into the plot type. The large numbers of species involved indicates that there are many species only associated with particular landscape elements that are contributing much to the botanical capital that are not identified by their association with other species.

12. Plant strategy theory, used to characterise the vegetation, shows that Crops/weeds aggregate class is dominated by plants with ruderal strategies. The Tall grassland/herb and Fertile grassland aggregate classes have high proportions of plants with ruderal and competitive strategies. Plants with stress tolerant strategies are characteristic of Infertile grassland, Upland wooded, Grass mosaic/moorland and Heath/bog aggregate classes. These stress tolerant species are associated with low nutrient, semi-natural habitats (eg. heathland, calcareous grassland) often of importance for nature conservation.

13. The distribution of botanical quality in the landscape was measured by examining differences in abundance of seven groups of species. The results highlight the importance of boundary features as refugia for species associated with high vegetation quality and emphasize the rarity and localised distribution of valued species, particularly in the arable and pastural landscapes.

14. There was a significantly greater proportion of records for English Nature (EN) calcareous grassland indicators (8.2%) in Verges than in other plot types in the arable landscape, whereas indicators of unimproved acidic and mesotrophic grasslands occupied a significantly higher proportion of Streamside plots in both arable and pastural landscapes. The lowest counts for EN high-quality grassland indicators were associated with field plots in the arable landscape. A plant community scale quality criterion was used based upon differences in joint distribution patterns of four species that together define the unimproved neutral grassland community MG5 in the NVC. Four characteristic species were found together in only 73 (0.6%) of CS1990 plots. When the joint occurrence of all diagnostic species for MG5 were examined the largest proportion of plots, with 12 or more taxa growing together (2.8%), was attributed to roadside verges in the marginal uplands and not the classically described lowland hay meadow situation. Nationally Scarce and Red Data Book species occurred in only 66 CS1990 plots especially in the uplands. The importance of the vegetation in each aggregate class was examined with respect to the mean number of butterfly host plants; the infertile grasslands of aggregate class 4 had the highest values in all landscapes.

15. In 1990 the mean species number for plots in Britain as a whole varied from 5 in crops/weeds to 21 in moorland/grass mosaic. In Britain as a whole there was a significant loss of species diversity in four of the eight aggregate vegetation classes: there were on average 4 fewer species (-21%) in upland wooded plots; 3 fewer (-14%) in infertile grassland; 2 fewer (-22%) in crops/weeds; and, 1 fewer (-6%) in moorland/grass mosaic. There was an increase of diversity, of on average 1 extra species (6%), in bog/heath plots. Significant changes were not observed in the other aggregate vegetation classes. The variety of common species present in the wider countryside declined substantially between 1978 and 1990.

16. Change in species numbers can mask significant ecological changes within vegetation. The largest change was in the diverse grasslands, where there was a small increase in plants associated with crops but a decrease of six groups of grassland species. Changes within the arable fields showed a shift towards grassland groups as opposed to those of more broadleaved weeds. The uplands showed a loss of moorland plants and an increase in grassland plants. Overall, as reported in CS1990, the groups of

plants from neutral grasslands show the largest losses.

17. The overall balance in aggregate and individual vegetation classes between 1978 and 1990 was relatively stable. Classes associated with fertile grassland and tall grassland/herb increased at the expense of infertile grassland whilst in the uplands there was a shift towards moorland grassland at the expense of heath and bog in the uplands. An additional major shift was from vegetation classes with evidence of afforestation to closed woodland involving the loss of moorland vegetation. These changes are corroborated by detected shifts in the frequency and cover of Sitka Spruce and upland grasses and heathers.

18. Changes in the abundance of high quality indicator species groups were assessed where unconstrained by the lower sample size available for replicate plots compared to CS1990 only plots. Species indicative of unimproved mesotrophic and acidic grasslands declined in abundance over GB. Acid grassland indicators declined significantly in the uplands and mesotrophic indicators in the pastural landscape; the latter trend is in accordance with the observed loss of species from infertile grasslands across GB and suggests that losses include species typical of the best examples of these plant communities. An increase in indicators of unimproved calcareous grassland was detected in coastal sample squares. Nineteen butterfly host plant species declined in abundance between 1978 and 1990, with the most reductions observed in infertile grasslands in the pastural landscape and in eutrophic grasslands in the arable landscape. Three host species increased, most notably the coarse grass *Elymus repens* which saw an increase in three aggregate classes in the arable and pastural landscapes. Overall 35% of British butterflies have host plants that decreased in abundance between 1978 and 1990. Changes in groups of species preferential to each aggregate class but divided into abundant, intermediate or rare categories reinforced functional analysis results and indicate a decline in frequently disturbed vegetation associated with arable cropping and an increase in taller grassland vegetation. Again the decline of species typical of infertile grassland vegetation was confirmed. Degeneration and increased openness in hedgerow plots was suggested by an increase in aggregate class 5 rare species whereas in the uplands rare taxa of upland woods declined.

19. The objectives for Module 2 were set to provide links between the statistically derived CVS and existing classifications, since the Policy Review commissioned by the Department of the Environment identified the necessity of enabling users to gain a better understanding of the implications of the changes described. There are five basic approaches to comparing classifications on a scale of increasing statistical rigour, all of which have been used in the present project. These are:

- Comparisons involving expert judgement (22)
- Direct comparison with vegetation parameters (23)
- Comparison of vegetation class frequencies by similarity coefficients (24)
- Decision trees which follow each step in the classification routine (25)
- Fully integrated statistical analysis (26)

20. Comparisons have been made with the CORINE biotope classification, Phase I Habitat Survey and the UK Biodiversity Steering Group categories. In general, the correspondence is best where the classification concerned is largely based on

vegetation and worst where it is based on cartographic units.

21. The composition of the classes of the CVS has been expressed in terms of the land cover categories of CS1990 main report. The correspondence can then be used for input into the LUCID software package, so that comparisons can be made with the 16 other land cover definition systems included.

22. Frequency profiles for each of the 100 plot classes generated by cluster analysis of CS data were matched with the units of the National Vegetation Classification using the SIMIL program developed at the Unit of Vegetation Science at Lancaster University. The highest similarity was 61.3% between vegetation class 94 and *M15 Trichophorum cespitosum - Erica tetralix* heath. The lowest of the top coefficients was 25.5% between vegetation class 77 and U6b *Juncus squarrosus - Festuca ovina* grassland, *Carex nigra - Calypogeia trichomanes* sub-community. Since such matching is only a guide to the placement of vegetation units the three top matches are given in each of the vegetation class description sheets.

23. A novel statistical procedure has been developed in this project which enables any new or existing data sets to be assigned to the vegetation classes of the CVS. Software for this procedure is now available.

24. A detailed comparison of vegetation sample plots has been made between lowland grasslands in Northern Ireland and Great Britain using multivariate methods to assess the affinities of the vegetation and to investigate the effect of sampling intensity. It was shown that it is necessary to ensure that any data sets where resources need to be compared, need to be balanced. The grasslands in Northern Ireland contained more species associated with low fertility and higher levels of wetness than Great Britain that are related to inherent differences in soil conditions and management regimes.

1. INTRODUCTION

The vegetation and land cover of the British countryside was surveyed in 1990. This large survey repeated and extended the baseline established by a similar survey of the countryside and its vegetation in 1978. The results of *Countryside Survey 1990* were published by the Department of the Environment in 1993 (Barr *et al.* 1993), but a shortage of resources prevented a comprehensive analysis. The work described in this report aims to complete these analyses by describing the botanical characteristics of the British countryside. To do this, vegetation was recorded in random samples throughout Britain in 1990 and compared with the results of a similar survey in 1978.

An important feature of these additional analysis was the requirement to present the results in a manner which was accessible to non-specialists and relevant to the development of countryside policies. To this end, it was necessary to make comparisons and to make links with other approaches to vegetation description used in the European Union, Great Britain and Northern Ireland.

This work was undertaken within Modules 1 and 2 of the ECOFACT (Ecological Factors Controlling Biodiversity in the British Countryside) research programme and was funded by the Department of the Environment, Transport and the Regions (DETR). Other components of the ECOFACT programme are funded by The Ministry of Agriculture, Fisheries and Food (MAFF), Scottish Office Agriculture, Environment and Fisheries Department (SOAEFD) and the Natural Environment Research Council (NERC).

The objectives of this work were:

- to produce overall indicators of change in botanical characteristics in the British countryside;
- to enable comparison with other systems for the classification and description of British habitats and vegetation;
- to describe the botanical characteristics of the countryside and to provide a national context for the more rare and localised elements;
- to develop hypotheses to explain the causes of changes in botanical character;
- to provide accessible and easily understood results, using the Countryside Information System where appropriate.

2. APPROACH: THE RECORDING AND ANALYSIS OF COUNTRYSIDE VEGETATION

2.1 FIELD RECORDING PROGRAMME

The vegetation of the British countryside was surveyed using a 1km-square as a basic recording unit. The location of each 1km-square was determined by reference to the ITE Land Classification of Great Britain (Bunce *et al.* 1996). This classification uses environmental parameters such as altitude and climate to classify the British landscape into a number of land classes and also enables one to estimate the extent of each class in Britain. The 1km-squares to be recorded were distributed in a predetermined way among the different land classes to form a stratified sampling programme. In 1978, 256 1km-squares were recorded throughout Britain: in 1984 the number of squares was increased to 384 and to 508 in 1990 (Barr *et al.* 1993). All of the 256 squares recorded in 1978 were re-recorded in 1990. Within each of the 508 1km-squares vegetation was recorded in up to 27 plots.

The vegetation recording plots (Table 1) were of three types which differed in size and in the way in which they were distributed within each 1km-square. There were:

- five 200 m^2 vegetation plots at stratified random locations - '**Main plots**'. These plots were located at random within five equal-sized sectors of the 1km-square. If they fell on a linear feature they were relocated at random;

- five 4 m^2 vegetation plots placed within semi-natural habitats only - '**Habitat plots**'. These plots were placed in semi-natural habitats not covered by the larger random plots, according to a random allocation procedure;

- up to 17 10m x 1m linear plots placed alongside field boundaries ('**Boundary plots**'), hedges ('**Hedge plots**'), watercourses ('**Streamside plots**'), and roads/tracks (**'Verge plots'**). The five **Boundary plots** were placed at the nearest field boundary to each of the Main plots (if within 100m) - only those Boundary plots that occurred adjacent to hedgerows have been included in the current analysis. Two **Hedge plots** were also placed separately at random within each 1 km square. Each of the **Streamside plots** was placed at the edge of running water, with a second, parallel, 10m x 1m plot being recorded on the water side to record any emergent macrophytic plants; two of the Streamside plots were located at random within the square and three more were placed to sample different sizes of watercourses. **Verge plots** were placed immediately adjacent to the road edge; two of the Verge plots were located at random and three were placed to sample different road types.

In each plot the presence and percentage cover of vascular plants and selected mosses and liverworts (Bryophytes) were recorded. The percentage cover was recorded in five-percentage point bands. For convenience both in this and other documents these plots have been designated as B= Boundary plots, H = Hedge plots, R = Verge plots, S = Streamside plots, X = Main plots and Y = Habitat plots.

Table 1 shows the numbers of vegetation plots that were recorded during the survey in 1990, of these plots, 2534 had been recorded in 1978. Because the Main plots were placed at random within the 1km-squares, the numbers were directly proportional to the extent of the cover types present; this was also true of those linear plots that were placed at random. The Habitat plots were targeted (at semi-natural habitats) and, whilst able to give a measure of the relative abundance of the habitats concerned, they could not be used in a statistical sense to estimate relative frequency. For further details see Barr *et al.* (1997).

In addition to the detailed species information from the vegetation plots, the mapped land cover and landscape features were described using a predetermined list of codes. Land cover was recorded by alpha codes on the maps qualified by numeric codes using standard definitions. Landscape features were recorded as lengths (eg walls and hedges) or points (eg trees or other single features). Where a feature could not be described using the existing codes, unique descriptions were used and coded separately. In order to give as much information as possible about each area of land or landscape feature, combinations of data codes were used to annotate each category on the map. There were two types of code: **primary** (general descriptions of features eg woodland) and **secondary** (giving more detail about the feature, eg tree species, age, management practices, in a wood). In the present report the 58 reporting categories given by Barr *et al.* (1993) were used to help interpret the vegetation classes and to show the correspondence between the two approaches.

2.2 ANALYSIS

The main procedures and concepts followed in the statistical analyses of the vegetation data are described in the CS 1990 Main Report (Barr *et al.* 1993). In summary the procedure involved two steps. First, the computer program called TWINSPAN (Hill, 1979a) was used to group the sample plots from the surveys in 1978 and 1990 into number of classes. This procedure created 100 vegetation classes (Table 2). In the second step, which used the related computer program called DECORANA (Hill, 1979b), an ordination of the 100 classes was generated. The classes were then further grouped by a clustering procedure in to eight aggregate classes depending upon their relative positions on the first five DECORANA axes (Fig. 1). By including data for the plots sampled in 1978 and 1990, as well as for those only recorded in 1990, it was possible to determine shifts between classes and to produce the matrix of vegetation change. The integrated system of classification and its supporting analyses is called the Countryside Vegetation System (CVS). A full technical description of the CVS is provided by Bunce *et al.* (in prep). Details of the vegetation classes and a means of obtaining regional estimates of their extent will be included in the Countryside Information System (CIS).

For the analysis species were grouped into two types. First species which could be clearly defined, that is they are recognised by plant taxonomists as "good" or taxonomically-sound species. Secondly, aggregate species species such as *Rubus fruticosus* which are highly variable and within which some taxonomists recognise a greater number of species or micro-species. Because of this variability these species are often treated in ecological studies as if they were a single or aggregate species. These two types of species were used to make the classification with TWINSPAN. Only the taxonomically-sound species were used to assess changes in species number. The species recorded from the plots were also classified into groups (species groups) that show similar ecological requirements (Bunce, 1977 and Prieto & Sanchez, 1992). Both the vegetation classes and species groups were then simultaneously arranged (ordered) according to the principal gradient, so that they were ranked in the same way in the tables describing the classifications.

Although the types of vegetation plot differ in size it was considered that their overall species composition overrode any effects caused by using data collected from quadrats of different sizes. This is because similar assemblages of species, such as dandelions (*Taraxacum* spp), daisies (*Bellis perennis*) and rye grass (*Lolium perenne*) can grow on verges, along streamsides, or in fields. It was difficult to test statistically that this was so, but judgement and practical considerations, indicated that the unified classification reflected ecological affinities and it was therefore adopted.

Whilst all the 100 vegetation classes, determined by a standard stopping rule, are required to express the variation within the data, many of the classes have too few plots to estimate change between 1978 and 1990. As in the CS 1990 Main Report, the main analyses of change have been carried out using the aggregate classes combined with the four landscape types (arable, pastural, marginal upland and upland) taken from the ITE Land Classification of Great Britain. Some of the subsequent analyses have been carried out from the larger vegetation classes that have an adequate number of plots to enable statistical comparisons to be made. The CVS enables the extent of change to be compared for all landscape components. In most cases, the different plot types are treated separately. Separate analyses have also been carried out for the different plot types to compare trends taking place within them, and to ensure that variations in the plot size has not affected the results.

3 RESULTS: ECOLOGICAL INTERPRETATION

3.1 DESCRIPTION OF THE CLASSIFICATION

The TWINSPAN analysis used the information on the species present in each of the 11,557 plots to group the plots into 100 classes. These classes were further grouped into eight aggregate classes (see Table 2). The classes themselves are constructed mathematically during the analysis. Each class has been given a name designed to give the reader an impression of a consistent type of vegetation and a clear impression of the composition of each class.

The number of plots which make up each of the classes represents a measure of their abundance as described by Barr *et al.* (1993). However, in the present project because many plots lie along linear features any estimate of their abundance is more logically weighted by length of feature than area. For main plots area can be used and a statistical procedure was developed to estimate areas of plot classes based upon main plots only. The larger plot classes are relatively uniform and clearly defined. For example, Class No. 10 Tall grass boundaries has been derived using data from over 800 plots. This is exceptional and most of the classes have been derived from the data collected from between 30 and 50 plots.

Having produced a classification of the vegetation using the data from all of the plots, the next step is to arrange the classes in a way which will enable patterns between them to be recognised. To do this the procedure called ordination was used and in particular the program DECORANA.

One way of presenting the classification is as a scattergram, using the first two axes of the ordination procedure DECORANA (Figure 1). The axes represent a gradient and the classes are arranged (ordered) along them using a mathematical procedure. In this sense the axes are abstracts, but they can be interpreted in terms of the ecology of species which make up each class along the gradient. Although the axes are constructed only in terms of their species composition, they are associated with environmental gradients. The first two axes derived from the DECORANA analysis are presented in Figure 1. On Axis 1 (the x-axis) the vegetation plots show a gradation from arable fields on the left-hand side, through rotational grasslands, fertile grasslands, grass marshes/moorland to heath and bog on the right hand side. Using our knowledge of the ecological requirements of these species, we can see that within the arable fields, the vegetation is made up of species associated with highly disturbed and nutrient-rich soils whereas at the opposite extreme (heath and bog) the vegetation is made up of species associated with nutrient poor peats and podzols. We may therefore consider that Axis 1 represents a gradient of soil nutrients.

Axis 2 (the y-axis) represents another gradient. At the bottom close to the x-axis the vegetation classes contain shot-lived herbaceous species tolerant of disturbance. At the other extreme is woodland vegetation consisting of large long-lived plants associated with much less frequent disturbance. The structure of the vegetation along this axis also affects the light reaching the ground; thus, we may interpret Axis 2 as representing a gradient of disturbance and shade. Heathland and bog vegetation is maintained by management (disturbance) where this management is relaxed succession occurs and we can envisage the vegetation moving diagonally towards the top left-hand corner of the diagram (Figure 1). Using similar reasoning a third axis can be identified from a small group of classes which are linked by association with soil moisture. These three gradients - nutrient level, shade/disturbance and soil moisture - can be recognised in the main vegetation analyses, and it is interesting to note their pre-eminence within the totality of British vegetation.

As stated above, the main objective of combining the plots in a single classification was to enable the variation of vegetation within the British countryside to be partitioned between the plot types. Although the different plot sizes may have an effect, the ecological character of the plots is so strong that the influence is relatively small. Initial interpretation showed that the classification was readily interpretable and, whilst there is some interaction between the aggregate classes and plot type the relationship is weak with only aggregate class I having over 60% of a given plot type. This was confirmed by correlating the percentage of plot types in the aggregate classes with the first axis DECORANA scores for the constituent plots. Three out of ten possible correlations were not significant and all the remainder showed very weak correlations with <10% of the variation explained. The single classification was therefore accepted.

Figure 2 presents the distribution of the plot types between the aggregate classes. The aggregate classes I and VIII (Crops/weeds and Heath/bog) are almost completely dominated by the Main plots, as the vegetation classes they represent cover extensive areas of open countryside throughout Great Britain. By contrast aggregate class II (Tall grassland/herb) is usually associated with linear features; which fits the knowledge of its ecological distribution. Aggregate class VII (Grass mosaic/moorland) consists mainly of Habitat plots, suggesting that in the uplands these plots were selected in grassland or flushes which are more species-rich than the surrounding species-poor heaths and bogs, within which they are intimately mixed. The Lowland wooded (Aggregate class V) is a mixture of all plot types, since it can be either by linear features or in woodlands. Aggregate class VI (Upland wooded) is a mixture of Streamsides and Main plots.

Table 3 shows the numbers of plots available in 1990 by plot type, aggregate class and landscape. It shows that some combinations are absent e.g. Tall grassland/herb, main plots in the upland landscape and that others are present in low numbers. These numbers need to be taken into account when interpreting the subsequent mean values which for low numbers may not be representative. In most analyses only those classes are presented that have more than 10% of the total number of plots in the aggregate class.

3.2 RELATIONSHIP OF VEGETATION CLASSES AND AGGREGATE CLASSES TO ELLENBERG VALUES

Interpretation of vegetation axes derived from the ordination is usually carried out using ecological understanding of the species involved. In the present case, with such a large data set interpretation is difficult. However, it is important to identify the environmental factors which control the vegetation, so that shifts in the composition of the vegetation over periods of time can be interpreted. In a detailed analysis Ellenberg (1974) expressed what he called the ecological behaviour of over 2000 species of vascular plants. To each species he assigned scores (values) which represented the behaviour of the species to the main environmental factors. The first three factors were related to climate, namely light, temperature and continentality of the distribution range. For instance plants which grow in full shadow were assigned a score of 1 while plant growing in full light received a score of 9. The next three factors represented soil moisture, soil acidity and nitrogen supply. Thus, plants growing only in soils very poor in mineral nitrogen were scored 1 and those growing in only soils very rich in mineral nitrogen were scored 9. Ellenberg pointed out that the ecological behaviour of the plant was different from its environmental demands. For instance, species such as ling *(Calluna vulgaris)* when cultivated alone grows well in soil with a higher pH than those in which it grows in the wild. It is confined in the wild to the more acid soils through competition with other species.

The scores calculated from the first three axes of the DECORANA analysis for the 100 classes were compared with the average Ellenberg scores for nitrogen, light and moisture. In this case nitrogen is a measure of soil fertility and light a measure of disturbance. In this way the first three axes of Figure 1 are represented as Ellenberg scores. The Ellenberg values were derived from the CS1990 species data using a statistical procedure, and were combined with a weighting for cover (Figure 3). The weighting for cover was necessary because some species, such as canary grass *(Phalaris arundinacea)* can occur at high cover on water edges but may often be accompanied by species such as cleavers *(Galium aparine)* that are not necessarily associated with water courses.

The relationship between the Ellenberg scores and the scores for the first axis of the DECORANA ordination are plotted in Figure 3. The principal axis identified within the CVS show a highly significant correlation with fertility. Low DECORANA scores are associated with crops or grasslands on highly fertile, mineral soils, whereas at the other extreme heath and bog vegetation grows on infertile, organic soils. Shifts along this vegetation gradient can therefore be used to infer changes in fertility. Figure 3 shows that the second axis is correlated with the Ellenberg scores for light, and the third axis is correlated with soil moisture.

Almost all of the landscape is managed in some way, yet despite this the overriding factors which determine the composition of the vegetation are soil fertility, light (disturbance) and soil moisture. This is also evident from the mean Ellenberg scores for nitrogen when each of the eight aggregate classes is plotted (Figure 4) The mean Ellenberg scores decrease from 6.3 in aggregate class I (Crops/weeds) to 2.1 in aggregate class VIII (Heath/bog). The different plot types within each class exhibit some variability in Ellenberg scores, especially for the woodland groups. Hedge plots have generally higher fertility than other plot types in each class.

3.3 PLANT STRATEGY THEORY AND FUNCTIONAL ANALYSIS

Plant Strategy theory developed by Grime and his co-workers (Grime *et al.* 1988) considers that there are two main determinants of plant distribution in most habitats. The first determinant is stress, which constrains growth (productivity), and the second is disturbance, which destroys biomass. If both these factors are absent and the conditions become optimal for plant growth, then the composition of a plant community is determined by competition between species. As a consequence, it is possible to classify plant species into functional types based on their responses to gradients of productivity and disturbance. The extremes on the gradients of productivity and disturbance are occupied by competitors (C) (under conditions of high productivity and low disturbance), stress-tolerators (S) (plants that can withstand continuously low productivity imposed by nutrient stress) and ruderals (R) (exploiting severely disturbed, productive habitats). To represent these functional types, Grime *et al.* (1988) have developed a triangular model (CSR) in which the functional types are represented by the corners of a triangular ordination with intermediate types in-between (19 types in total). Each functional type can be represented within the triangular ordination by a set of C, S and R co-ordinates. The C, S and R co-ordinates, therefore, relate to, and can be defined by a whole set of attributes that contribute to a species' ability to survive under given conditions of productivity and disturbance.

Functional analyses rely on empirical relationships between measurable plant attributes and ecological processes, such as the relationships described above. For example, plant species having higher potential relative growth rates are found in sites of higher fertility. If a site is subjected to increased nutrient input, then species with certain attributes will increase, whilst others with a different set of attributes will decrease. Similarly, analyses of the vegetation present at a site at two points in time may show that plant species with certain functional attributes have increased whilst others decreased. This can lead to hypotheses about the processes of change in which plants on one functional types replace those of a different type over that period of time.

The compositions of the eight aggregate vegetation classes in terms of plant strategy (CSR) are shown in Figure 5. These have been derived by including all plots, both linear as well as main plots, surveyed in 1978 and 1990.

The composition of the aggregate classes in terms of CSR strategy is as follows:

- *I Crops/weeds*. is dominated by ruderals and competitive ruderals with virtually no stress-tolerators, which reflects the highly disturbed and productive nature of this vegetation.
- *II Tall grassland/herb*. This aggregate class contains the highest proportion of plants with competitive and ruderal strategies and indicates a productive and moderately disturbed system.
- *III Fertile grassland*. Essentially the same general composition as tall grassland. Virtually no stress-tolerators suggests a highly productive habitat.
- *IV Infertile grassland*. A more evenly distribution of strategies. The increasing number of stress-tolerant species suggests a lower productivity habitat.
- *V Lowland wooded*. The general pattern is the same as infertile grassland although it appears to be less productive as it has a greater percentage of stress-tolerators.
- *VI Upland wooded*. Composed mainly of stress-tolerators and competitors and a very small proportion of ruderals
- *VII Grass mosaic/moorland*. The distribution of strategies is skewed towards the stress-tolerant end of the graph suggesting a less productive system.
- *VIII Heaths/bogs*. Mainly composed of stress-tolerators, stress-tolerant competitors and stress-tolerant ruderals with virtually no competitors and ruderals. This suggests a highly undisturbed and unproductive system.

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4 LINKS BETWEEN CLASSIFICATIONS

4.1 INTRODUCTION

The classification of the British countryside vegetation developed in the previous Sections has drawn on vegetation data collected from 11557 plots. This classification recognises 100 vegetation classes which, for convenience, have been grouped into eight Aggregate classes.

A variety of other classifications exist and in this Section comparisons will be drawn between the classification developed from the data collected in the CVS and these existing classifications. The various systems of classification have been developed for different purposes and are based on different analytical procedures.

Vegetation data can be considered as continuously variable (Dale 1988) with no easily recognisable grouping of individuals. With such data it is possible to use statistical procedures to establish boundaries between groups (classes) of individuals. Rather than considering the vegetation of Britain as a whole, other systems erect some major categories first which are frequently cartographic (geographic). For example, we may consider coastal vegetation or mountain vegetation and then develop a classification of the vegetation within each of these locations or strata. Differences of this type makes comparison between various classifications difficult. Further difficulties may arise because of differences in data collection, the structure of the sampling programme, or from analytical procedures.

Figure 6 illustrates some of the difficulties. A series of classes on two axes of an ordination are illustrated diagrammatically, with two classes from another classification superimposed. Class A, fits within the range of one of the initial classes i.e. it reflects a finer division within the range of that class. Class B, overlaps several different classes and therefore is not mutually exclusive to any one class, which demonstrates the problem of linking classifications.

4.2 MAKING COMPARISONS

Comparisons between classifications can be made in five principal ways. In ascending order of statistical rigour they are:

- EXPERT JUDGEMENT Some classifications have been developed based on wide experience of vegetation often by a single individual observer. The classes are qualitative and frequently described only briefly with often no more than one line descriptions of a vegetation classes. It is therefore impossible to make quantitative comparisons between classifications.

- *DIRECT COMPARISON* Data may be available from a consistent database that enables two styles of classification to be compared; for example, the CVS and the mapped land cover categories from CS1990.

- *AVERAGE COMPOSITION COMPARISON* Frequency data and constancy tables from the vegetation classes of different classifications can be compared statistically using a similarity coefficient. A number of computer programs such as MATCH, TABLEFIT and SIMIL which were developed to assign species lists collected in the field to the classes of the National Vegetation Classification (NVC), can be used for this type of comparison.

- *CLASSIFICATION PROCESS SIMULATION* Exactly the same statistical procedure is followed as was used in the development of the classification; for example, the method developed in the present project for fitting new data into the CVS (see below).

- *INTEGRATED ANALYSIS* Data from different regions can be combined and analysed using standard statistical procedures to assess overlap. In this case the interaction between the data sets determines a new classification; for example, the Northern Ireland analysis of the present project.

4.3 THE CORINE BIOTOPE CLASSIFICATION

This is an attempt to provide a classification of the biotopes and not the vegetation occurring within the member states of the European Union. However, it is necessary to use the composition of the vegetation to describe and to compare biotopes. The manual covers 300 pages and has several hundred classes and is an exercise in collating a number of existing classifications The classes which are distributed between a number of higher categories, some of which are cartographically based, are presented in varying levels of detail. In some cases there are lists of constant and preferential species, whereas in others only a broad description is provided. In most cases, the classes are derived from phytosociological analysis with details being provided of the source publications. The CORINE classification, in common with the British National Vegetation Classification, concentrates on semi-natural vegetation (Class 8 - agricultural land and artificial landscapes - covers only 10 of the 267 pages of descriptions). In contrast, CS1990, which is an impartial, random sample of the managed countryside only rarely captures scarce and localised assemblages, especially if they cover a small area. Such small areas will be included in the vegetation class with which they have most species in common. Comparisons have been made between the 100 classes of the CVS and with the 89 major categories of CORINE (the land cover equivalents are provided within LUCID).

The full tabulation of the comparisons can be obtained from the senior author. In conclusion, because the CORINE biotope classification is largely based on vegetation composition, the classes that are in common between Britain and Europe have a generally good correspondence, compared with some of the classifications that contain cartographically defined limits.

4.4 PHASE 1 HABITATS CLASSIFICATION

The Nature Conservancy Council (NCC) has developed a classification of habitats for Britain. This recognises eight major categories of semi-natural vegetation some of which contain a cartographic element (eg Coastlands). The ninth category (Miscellaneous) contains agricultural habitats. The Phase 1 categories have been defined qualitatively. Full comparison between the vegetation classes from the CVS and the Phase 1 Habitat categories can be obtained from the senior author. In general, it was possible to identify reasonable equivalents with most of the categories, although inevitably some vegetation classes needed to be combined. The categories which had no equivalents were either from habitats outside the range of the CVS coverage; for example, shorelines; or those that depended upon cartographic units. In some cases there was a direct correspondence; for example, calcareous grassland; in others, however, vegetation classes had to be assigned arbitrarily between two Phase 1 categories.

4.5 THE UK BIODIVERSITY STEERING GROUP REPORT CLASSIFICATION

A new classification of terrestrial and marine habitats for the UK and the surrounding seas was published in the report of the UK Biodiversity Steering Group (Department of the Environment 1995) as a framework for reporting on biodiversity in the UK. This scheme recognises 37 broad habitats which are introduced in Volume 1 of the Steering Group Report, each is further described as part of a habitat statement in Volume 2 of the report.

Subjective comparisons were made between the CVS and the 37 habitat types of the Steering Group Report; these can be obtained from the senior author. There is a very poor agreement between the two classifications, with only the calcareous grassland and coniferous woodlands showing any reasonable agreement. It is not possible to compare over one third of the categories since these are for geographical units rather than vegetation eg islands and archipelagos. The earlier version of Phase 1 habitats is therefore more appropriate for comparison with the unified vegetation classification because it is more closely related to a vegetation based classification.

Some of the Biodiversity Habitats are spread between several CVS classes. Predominantly, these are semi-natural habitats of conservation interest which are difficult to place in the CVS scheme since they are composed of more than one land cover element , 'Lowland wood pasture and parkland' for example, could include grassland land cover such as 'Non-agriculturally improved grass'.

Some CVS classes are not clearly identifiable among the Biodiversity Habitats' definitions and are probably spread between several classes eg dense bracken, unmanaged grassland and tall herb and Berry-bush heath.

Many of the Biodiversity Habitats include a mixture of vegetation types eg upland heathland or are beyond the coverage of CS1990, eg off-shore seabeds.

4.6 COMPARISON BETWEEN THE CS 1990 LAND COVER CATEGORIES AND THE CVS VEGETATION CLASSIFICATION

Land cover was mapped in CS1990 (Barr *et al.* 1993). The individual plots were attributed to the land parcel in which they were located or, if the plot was by a linear feature, the land cover of the adjacent parcel was used. The full comparisons can be obtained from the senior author. Most of the land cover categories show distinct mixtures of vegetation class but there is no exact correspondence, for the following reasons:

- The quadrat may fall upon a patch of vegetation below the scale of the land cover mapping; for example, on a nettle (*Urtica dioica*) clump in a field which is otherwise virtually pure ryegrass (*Lolium perenne*).
- The CVS is based on analysis of all species and this does not necessarily correspond with land covers determined by single species; for example, wheat or barley.
- The continua in the uplands are defined in the land cover mapping by the dominant species and these may not coincide with the CVS.
- Inevitably there is a degree of background noise in the overlaying process and in observer error in the field mapping, as well as in the vegetation survey.

Nevertheless, some broad generalisations can be made:

- Crops, such as wheat, oil seed rape and sugarbeet, which tend not to be in rotation with grassland, are generally related to CVS vegetation classes 1-5 which consist almost entirely of arable weeds.
- Crops such as barley, kale and roots, which are often in rotation, tend to be related with short-term grassland such as CVS vegetation classes 6, 30 and 31.
- The series of lowland grassland categories - CVS vegetation classes 21-26, were arranged in a sequence of management intensity. Although the vegetation classes are not mutually exclusive, the balance between them reflects a gradient of increasing intensity, as reflected by the Ellenberg scores of Figure 3.
- There is reasonable correspondence with the extreme upland categories of bracken, upland grass, moorland and bog, but with overlaps between them.

- The heath land cover categories - CVS vegetation classes 32 and 33 are not differentiated in their vegetation class composition, nor are the bogs - classes 35 and 36. It could therefore be concluded that the distinction between these categories has been made on criteria other than the species composition such as topographic position.

The relationship between the classes of the CVS and land cover has been entered into LUCID and can be obtained from the senior author. Correspondence can be made with the other 16 land cover classifications available within LUCID. The advantage of the land cover is that it provides a complete breakdown of the land surface of GB and provides a basis for modelling. The relationships defined in this section can be used to relate the mapped land covers to their detailed vegetation composition.

4.7 THE NATIONAL VEGETATION CLASSIFICATION (NVC)

The program SIMIL was used to assign the average composition of the CVS classes to the National Vegetation Classification (NVC) associations. These figures will be included in the summary descriptions and can be obtained from the senior author. In general, the classes are not strongly related to the NVC associations. There is poor agreement because the plots were not located in the field using the criteria demanded by the recording procedures of the NVC. The plots in the CVS were placed at random within the 1km-squares (except the Habitat plots), whereas NVC plots must be placed in patches of homogeneous natural or semi-natural vegetation.

4.8 CONSTRUCTION OF A STATISTICAL PROCEDURE TO ASSIGN VEGETATION PLOTS TO CLASSES WITHIN THE CVS

A main part of the work programme of Module 2 was to provide an automated procedure for allocating any plots recorded since the CVS to the unified classification described in the earlier Sections. A wide variety of statistical methods was considered for this procedure. There is a division between those techniques which allocate plots to a specific class and those which provide a measure of closeness (similarity) to, or probability of membership of all classes. The latter procedure is that used for allocation of data to the National Vegetation Classification by the programs TABLEFIT and MATCH. The following techniques were investigated for the former procedure:

- Classical linear and quadratic discriminant analysis

- Nearest neighbour discriminant analysis

- Classification and Regression Trees (CART) a procedure similar in nature to the process used in TWINSPAN to derive the classifications

- Generalised Canonical Variates Analysis (GCVA)

In addition, the use of the indicators provided by TWINSPAN was considered, but rejected because previous experience had shown that they did not perform satisfactorily when a number of hierarchical levels were involved.

None of the non-hierarchical methods examined performed satisfactorily. Misclassification rates were very high (50% - 60%) although misclassifications are generally into neighbouring classes. The difficulty appears to be that multivariate categorical data do not usually fall into just a few dimensions. Thus, the proportions of variance (or inertia) explained by successive ordination axes are less than the equivalent values for continuous data.

It, therefore, appears that the hierarchical nature of the classifications themselves necessitates a hierarchical method for allocation of vegetation units to classes. For classifications which are artificially constructed rather than representing naturally occurring divisions in the vegetative continuum, the obvious allocation method to use is one related to the methodology originally employed to create the classification.

In order to allocate vegetative units to an existing hierarchical classification a binary decision tree has been constructed. At each node of the tree a decision method, appropriate to the classification being emulated, is implemented. For classifications strictly constructed using TWINSPAN the decisions are based on a partition of multidimensional species space. In these cases the resulting decision tree will produce a deterministic result allocating each vegetation unit to a single vegetation class. It should be emphasized that this procedure gives a precise allocation of each individual plot to all the classes of CVS, and it is based on all the information available on the species content of that plot. Table 4 enables these individual classes to be linked to the aggregate classes.

Representing multivariate data in two dimensions inevitably results in a loss of information. The visual representation of data by the software package is therefore no more than an aid to the user and is not an end in itself. The method chosen has been to plot newly collected data against the three main vegetation gradients in Great Britain, determined from the DECORANA ordinations; a geographical representation is included in the package.

The decision tree structure for allocating vegetation units to the unified classification has been implemented as a software package running under Microsoft Windows^{TM}. This software allows the user to enter species lists for vegetation units either interactively or in batch mode from a previously constructed file. Once a vegetation unit or units have been allocated to a class or classes the software allows the user to plot their positions with respect to the three main vegetation gradients in Great Britain, as determined from the Countryside Survey vegetation data. The addition to this software of further deterministic classifications based on the TWINSPAN procedures can also be carried out and has already been implemented in the SOAEFD classification of vegetation within ECOFACT.

4.9 COMPARISONS BETWEEN THE VEGETATION OF GREAT BRITAIN AND NORTHERN IRELAND

Since 1986 surveys have been carried out in Northern Ireland (NI), using a similar methodology to CS1990. The Province forms part of the UK and there was a policy requirement to determine the extent to which a coordinated programme for recording and classification of the countryside vegetation could be developed.

The first stage was to compare details of the definitions for land cover, and these were computed and entered into LUCID. The second stage was to examine the potential for integration of the botanical data between NI and GB, in order to determine the options for a combined approach.

Botanists have often commented that the lowland grasslands in NI were different from those in GB. Although the two regions are close geographically (the Antrim coast is only 15 km from western Scotland), the rainfall in Ireland is higher and the management of grasslands has traditionally been less intense. Previous work has also suggested that different sampling intensities in the surveys of GB and NI could influence the interpretation of the results. As the first stage of this comparison it was therefore decided to:

- To compare the lowland grassland vegetation in Northern Ireland and GB;
- To investigate the effect of sampling intensity and land classification.

The NI Countryside survey (NICS) recorded the land cover composition of 628, 25 ha sample grid squares between 1986 and 1991 (Murray *et al.* 1992). The vegetation sampling programme was based on the NI Land Classification (NILC) which acted as a sample stratification for field work and defined regional landscape types (Cooper 1986). A subsequent field survey to investigate the botanical composition of NI grasslands was undertaken by recording presence/absence of species in 200 m2 plots (Cooper and McCann 1994). The vegetation data were classified using same procedures as for the CVS.

The results confirmed the anecdotal evidence of botanists. The NI eutrophic grasslands differ from the GB grasslands by containing species, such as creeping bent (*Agrostis stolonifera)* and marsh foxtail (*Alopecurus geniculatus),* that are indicative of wetter conditions. There are also differences in the species of grass sown. Cocksfoot (*Dactylis glomerata)* is less frequent than in southern England where it is often included in seed mixtures as it is drought-resistant. Although some of the differences between these grasslands may be due to climate other differences can be attributed to management, particularly as there is less drainage of grasslands in NI.

This comparison between the vegetation of NI and GB has also highlighted the need to ensure that the sampling programme uses comparable sampling methods. In particular it is important to ensure that the stratification procedure (both environmental class and land cover), sampling intensity (the number of plots recorded) as well as the area-proportionally sampled are comparable. Strictly structured sampling is, therefore, required, otherwise it is misleading to draw comparisons between study areas other than in a purely descriptive way. In making regional comparisons of this type, it is necessary to link the sampling to landscape structure and to make comparisons within landscape types so that too many factors are not included in the classification process. In developing policy, it is important to recognise that conclusions drawn from badly designed analyses may lead to the false identification classes of vegetation because they are the function of the analytical procedure and do not represent real differences in vegetation.

5. RESULTS: VEGETATION CLASSES - DISTRIBUTION OF BOTANICAL CAPITAL IN BRITISH LANDSCAPES

5.1 DISTRIBUTION OF VEGETATION CLASSES

The vegetation classes are arbitrary points along a continuous gradient of vegetation and may be used to define the general patterns of vegetation in the four main landscape types of Britain (Figure 7). The arable landscape is dominated by the Crops/weeds, Tall grassland/herb and Fertile grassland aggregate classes, but it has a small element of aggregate classes VII and VIII. The pastural landscape is similar, but is dominated by Fertile grassland and has a higher proportion of Moorland grass/mosaic. The marginal uplands also have Fertile grassland as the most abundant aggregate class, but they have a good representation of all the other aggregate classes, indicating the inherent variability of the marginal upland landscape. The upland landscape is dominated by Moorland grass/mosaic and Heath/bog aggregate classes.

5.2 CLASS NAMES AND THEIR ESTIMATED AREA IN GREAT BRITAIN

It is difficult to provide short names for such a large number of classes which convey to the reader adequate information about the composition of the classes. In addition to the names, a one page summary sheet with a description for each class has been developed (Figure 8a & b). This sheet provides a description of the class and depicts its extent in Great Britain, its association with the four landscape types in the ITE Land Classification of Great Britain, details of the plant species composition, comparisons with the National Vegetation Classification (NVC) and CORINE Biotopes Classification and a characterisation in terms of the CSR Functional Strategy Theory of Grime *et al.* (1988).

Figure 9 provides a pictorial representation of the changing abundance of 5 ecologically important species through the 100 CVS vegetation classes. This figure demonstrates the continuous nature of the variation within the countryside vegetation. Further details of the class descriptions will be published in due course and are on the CIS. The series starts with vegetation associated with crops, moves through tall grassland with false oat grass (*Arrhenatherum elatius)* and cocksfoot *(Dactylis glomerata),* through to fertile grassland with species such as timothy (*Phleum pratense)* and ryegrass *(Lolium perenne*), to moorland with matgrass *(Nardus stricta)* and heathrush *(Juncus squarrosus),* and finally, to bogs with species such as crowberry (*Empetrum nigrum)* and cotton grass (*Eriophorum vaginatum)*.

Estimates of area and associated error terms have been calculated using a novel procedure developed in this project for the 100 vegetation classes within GB (Table 2). Three groups of classes predominate: crops/weeds, fertile grassland, and moorland. Some classes, which mainly occur by linear features may be common, but occupy a negligible area. In addition, the length of vegetation classes along linear features can also be estimated, using their lengths in each kilometre square. Their area could then be estimated using a standard width but this would be small in comparison with those in Table 2.

Table 4 shows the area figures combined into the eight aggregate classes (Figure 1 and Table 2) with arbitrary subdivisions grouping similar vegetation classes into habitat categories. At a broad level, these estimates agree with those derived from the land cover measurements given by Barr *et al* (1993). For example, all woodland was estimated as 24800 km^2 compared with 26700 km^2 from land cover estimates and upland vegetation was estimated to be 58700 km^2 compared with 51400 km^2. However, as discussed in Section 5, the vegetation classes do not correspond with land cover for many categories because they are derived in different ways. Therefore, the subsequent divisions do not compare, although some categories e.g. calcareous grassland (800 km^2 as opposed to 600 km$^{2)}$ show reasonable correspondence in their overall contribution to British vegetation.

Figure 10 shows that, surprisingly, even in the intensively managed arable landscapes of the lowlands of eastern England (land classes 12, 4, 11 and 3) there is a similar degree of variation, as represented by the mean number of vegetation classes, to the remainder of the lowlands. This is because small fragments of vegetation still remain in the landscape in the various vegetation types and is expressed by the variation within the vegetation classes. The four land classes containing the largest number of plot classes are all within the pastural landscape (land classes 15, 16, 5 and 6). However, the major division is between the lowlands and marginal uplands and the uplands (i.e. that from land classes 17 up to 30). The latter have fewer plot classes present than in the lowland series, but have more semi-natural vegetation.

It is also surprising that, although the habitat plots were placed in areas of apparently more diverse vegetation, this was not in fact the case. The variation is therefore evenly dispersed between the plot types, which means that, as Bunce & Hallam (1993) reported, the most of variation is in the linear features. However, the classification reflects the variation within the vegetation present, much of which is not semi-natural and which may be considered by conservation agencies to have a lower value in its own right. The boundary plots in the uplands show less variability, reflecting the open nature of moorland landscapes. The lower diversity overall in the uplands corresponds with the overall variation in occurrence of vegetation discussed in Section 3.1 and again the division after land class 17. Thus, the present analysis at the landscape level supports the generally held belief that there is more variation in the lowlands, even though it is compressed into linear features and fragmented sites, rather than forming extensive areas.

6. RESULTS: SPECIES DIVERSITY SPECIES GROUPS AND SPECIES

6.1 DESCRIPTION OF THE SPECIES GROUPS

The vegetation classes vary in their complexity. The management practised during crop production creates a narrow, uniform range of ecological conditions suitable for only a few species. As a consequence the vegetation classes associated with crops contain few species. In contrast, the woodland classes often contain mixtures of species tolerant of a variety of ecological conditions such as grassland or dense woodland, and plots on the edge of woodlands may contain species from grassland, scrub and tall woodland conditions. Standard phytosociological procedures use this approach and previous work by Bunce (1977) and Barr *et al.* (1993) have shown that these groups are necessary to explain the variation within the vegetation classes.

Relationships of this type were formalised by the construction of 37 species groups (Table 5), which link species that grow under similar conditions e.g. wet soils or peat soils and were derived from the entire 1990 data set by a new analysis. Changes in the frequency of these groups are used to show shifts in the balance within the vegetation classes. Figure 11 shows the average number of species groups through the series of vegetation classes. With the exception of vegetation Class 77 (Dense Sitka spruce), the Crop/weeds classes are the least complex, and the classes with a high proportion of plots by streamsides are the most diverse because of their variable vegetation structure and ecological ground conditions.

The species groups also show strong distribution patterns through the series of vegetation classes, with groups containing arable weeds, such as charlock (*Sinapsis arvensis*) and shepherd`s purse (*Capsella bursa-pastoris*) being at one extreme and those containing cotton grass (*Eriophorum vaginatum*) and bog asphodel (*Narthecium ossifragum*) at the other. The names show that, although the overall composition of the groups is mainly aligned along the fertility gradient, there are some exceptions. For example classes 12 (Lowland eutrophic roadsides) and 15 (Lowland river banks) are associated with high water levels and, consequently, are differentiated on the third axis in the DECORANA ordination.

6.2 DISTRIBUTION OF SPECIES GROUPS

Table 6 shows the distribution of the species groups within plot types and landscapes. Within any one landscape it is striking that the plot types contain generally the same combinations of species groups showing that many are acting at the landscape level, agreeing with the comments made below. Exceptions are where the plot type contains a specific group. For example, streams within the arable landscape have marshland and hydrophyllic species not present in other landscapes. In the arable and pastural landscapes the crop and crop edge plots occur throughout all the plot types; however, in contrast bog and heath plants are only present in marginal upland or upland landscapes. There is, therefore, a complex gradient from the top left-hand corner of the table to the bottom right which appears as a strong diagonal. A comparable structure was noted by Bunce & Smith (1978) in Cumbria because of the similar balance between upland and lowland systems. In Great Britain the streamsides have the highest diversity and also in three out of four of the landscapes woodlands are also very variable.

In general the Verge plots have a surprisingly high diversity in contrast to the Habitat plots which are generally low. This agrees with analyses presented above and shows that the habitat plots were selected in general for other reasons than diversity of vegetation class.

Another way of examining the response of vegetation at the landscape level is to examine the relationship between the overall characteristics of the vegetation in the different plot types with the individual squares. This was done by correlating the mean DECORANA axis scores between the plot types within each of the 508 1km-squares. All the plot types were highly significantly correlated demonstrating that the species which make up the vegetation at the landscape level are drawn from a common pool determined by the local environment. As the next section shows, however, the different elements in the landscape contain different groups of species depending on their characteristics.

The overriding influence of the environment was confirmed by comparing the total species composition with the underlying environment. This was done by calculating the average DECORANA first axis scores for vegetation with the corresponding score from the initial land classification environment data. The correlation was highly significant, explaining over 80% of the variation. The distribution of botanical diversity within the limits determined by environment are therefore determined by management which modifies the composition of the local species pool.

6.3 DISTRIBUTION OF SPECIES

Table 7 shows the most frequent species recorded in all the vegetation plots and presents an interesting picture of the most common species in British vegetation. Half the species are grasses, with the five most frequently occurring species all belonging to this group. Most of the species belong to species Groups 22, 12 and 5 all of which are dominated by mesotrophic grassland species. Only one species, tormentil *(Potentilla erecta)* could be regarded as an upland species, although it is also widely present on acid soils elsewhere. These frequencies indicate the dominance of neutral grassland species in the flora of the British countryside. The incorporation of the relative areas represented by the Main plots, as shown in Table 2, differs because they include extent as well as overall frequency and, therefore, contrast with the relatively high area of upland vegetation as opposed to high frequency of grassland species.

Table 8 shows the average number of species and proportions within 1 km-squares and by number of land classes within each landscape. In terms of overall species number, the arable and upland landscapes are similar. The marginal uplands, which show great ecological diversity are intermediate, but the highest numbers were recorded in the pastural landscape. Some 1 km-squares, however, have the same numbers in all landscapes suggesting that local factors can override potential.

The number of species per plot (species richness) is lowest on average in the arable landscape and increases progressively through to the upland landscape. The mean figures mask much variation, for example, the arable landscape contains plots in crops with only one or two species but also plots in calcareous grassland with over thirty species.

Considering the wide range of ecological conditions, plot sizes and differences in species assemblages, the number of species is relatively uniform, but:

- The Hedgerow and Boundary plots show relatively small numbers of species in all landscapes, but are comparable with Verges, Streamside and Main plots in arable and pastural landscapes;
- The Verge plots are similar in both the arable and pastural landscapes;
- The Streamside and Main plots become increasingly rich in species from arable to upland landscapes but there is much overlap between categories;
- The species richness of Habitat plots in arable and upland landscapes is similar, but with relatively more species in pastural and marginal upland landscapes; however, there is much overlap;
- The Boundary plots always contain a small proportion of species but there are relatively more species in arable and pastural landscapes, suggesting that they are mainly related to the composition of the fields rather than to distinctive features, such as the steams;
- The Hedge plots have intermediate values for the percentage of species. Hedge plots are absent in the uplands;

- The Verge plots have intermediate values for the percentage of species. These plots occur relatively constantly throughout all landscapes;

- The Streamside plots always have a high proportion of species but where they occur in arable and pastural landscapes their values are lowest;

- The Main plots and habitat plots show similar patterns and show the greatest variability, with low percentages in the arable landscape progressively increasing through the series to the uplands.

Table 9 shows the numbers of distinctive species found in each plot type within each aggregate class and landscape type.

A common feature through all landscapes is the low richness in the Habitat plots indicating that there are few distinctive species present.

Both arable and pastural landscapes have no distinctive species in the Crops/weeds aggregate class I as the component species are present widely elsewhere. For example, annual meadowgrass (*Poa annua)* may occur anywhere in either of these landscapes. The Tall grassland/herb aggregate class II has the highest number of species and shows a very similar pattern with most species by road or streamsides and with low richness in all other plot types. The Fertile grasslands aggregate class III also has few distinctive species in both landscapes for the same reason as their absence in the Crops/weeds aggregate class I. Infertile grasslands aggregate class IV has comparable richness on verges, streamsides and main plots, showing that this class still has distinctive species in fields as well as linear features. Although the Lowland wooded aggregate V class has distinctive species in all plot types in both landscapes, the greatest richness is in hedgerows, emphasizing their importance. The Streamside and Main plots also have quite large numbers of species in the pastural landscape. The Upland wooded aggregate class VI has a small number of species, concentrated by streamsides. The Infertile grasslands aggregate class IV has the highest number of species in the main plots, showing that in contrast to the lowlands, many distinctive species still remain in the fields. The Grass mosaic/moorland aggregate class VII shows most species by the Streamsides, but also many in the Main plots. There are very few species in the Heath/bog aggregate class VIII. This contrasts sharply with the upland landscapes suggesting that this category differs in its composition between these landscapes. Infertile grasslands are still well represented but are mainly by Streamsides in the uplands. Both Grass mosaics/moorland (VII) and Heath/bog (VIII) have the most species in the uplands in the Main plots but also many by Streamsides showing that this plot type contributes more to variation in the uplands.

The summary table shows that Verge and Streamside plots have most species in arable and pastural landscapes. By contrast, the Streamside and Main plots have the most species in the marginal uplands and uplands, but their order is reversed with Streamsides predominating in the marginal uplands and Main plots in the uplands. Although Streamsides have the most species overall, the Main plots have the next highest, suggesting, that in Britain as a whole, the open landscape still has many distinctive species. The sections on species groups and quality indicate, however, that other measures of biodiversity are required to encompass this detail. Surprisingly, both Boundary and Habitat plots have few distinctive species because the former mainly contain species which are present elsewhere in the landscape, and the latter because they were selected as rare habitats and they have many unique species that do not build up sufficient associations to be significant.

The unique species, ie those only found in a particular plot type within each aggregate class and landscape (Table 10), show an entirely different pattern from the distinctive species, in that both Habitat and Boundary plots have many records. These plot types therefore contain many individual species not present elsewhere in the landscape, but do not occur in sufficient numbers to be identified by the χ^2 statistic. Most of the species in these habitats are therefore present elsewhere in the landscape and the unique species are there because they are:

- species with a specific habitat preference eg. watercress (*Nasturtium officianalis)* in a wet Habitat plot;
- relict species from a former widespread vegetation class eg. burnet (*Sanguisurba officinalis)* in a Boundary plot in fertile grassland;
- inherently rare species eg. lesser butterwort (*Pingincula lusitanica)* in a Habitat plot;
- species that have dispersed and happened to be within a given plot type eg. hawthorn *(Crataegus monogyna)* in a Boundary plot.

The large numbers of species records collected show that many species present in low numbers in the landscape are, nevertheless, present within particular landscape elements. The Hedgerows contain few unique species because, in general, the species present may be found in other plot types eg. sterile brome *(Bromus sterlis)* in main plots in fields and hazel (*Corylus avellana)* in main plots in woodland. Most unique species recorded in hedges are present within those hedges occurring in the Lowland wooded aggregate class.

In the arable landscape, Verge and Streamside plots contain the most species but Main plots, Boundary plots and Habitat plots all contain large numbers. In pastural landscapes, Streamsides, Main and Habitat plots have comparable numbers species with Verges and Boundaries having fewer species.

In the marginal uplands and uplands, Streamsides, Main and Habitat plots have comparable numbers with relatively few species in Boundary and Verge plots.

As with the other measures of diversity, therefore, the linear features, especially Streamsides are major reservoirs of the botanical capital. However, the Main plots still have many species and the high frequency in habitat plots suggests that they were located in vegetation patches that have minimal species, especially when the size of plot is also taken into consideration.

6.4 CHANGE: INTRODUCTION

Table 11 shows the relationship between the vegetation groups used in the CS1990 main report (Barr *et al.* 1993) and CVS aggregate classes used here, in order that comparisons can be made. The data for botanical change involved re-recording at the same locations, the sample plots (Main, Hedgerow, Streamside and Roadside) that were recorded in 1978 (Barr *et al.* 1993). The advantage of this approach is that the observed changes are known to have taken place, whereas differences in population of plots over the two dates could be due to sampling error. However, the reliability of the extent of the change needs consideration. In the tables presented below change data, if significant, are omitted if they are within sample numbers below 10% of the samples within that comparison. The summary table showing the acceptable comparison by plot types and landscapes is given in Table 12. Sample number has a major influence in determining significant levels since smaller levels of change can be detected in larger sample numbers.

In discussions following the publication of Barr *et al.* (1993), it was pointed out that the directions of change were comparable across the plot types. One of the objectives of the CVS was to enable integrated assessments of stock and change across entire landscapes. Therefore, in the presentation below all the plot types are combined regardless of the size of the individual plots (1 x 10 m for linear features and 14 x 14 m for Main plots). However the average numbers of species are comparable and provided that the different plot size are borne in mind, the summary results of Table 13 show that the overall trends are for loss of species, whether the plots are aggregated or separated into the plot types. There are major contrasts between the plot types with the hedge plots showing only losses. The Streamsides, with one exception, and the Main plots show twice as many losses as gains, whereas Verges have gained species.

6.5 CHANGE: SPECIES NUMBERS

Table 14 presents the gross changes in species number between 1978 and 1990 in all paired plots, regardless of whether an individual plot had changed classes. There are 40 combinations of landscape types and vegetation aggregate classes compared with 30 combinations in the comparable table of the CS 1990 Main Report. The Crops/weeds aggregate class (I) is directly comparable with the crops group of CS 1990. Aggregate class II is new as this type of vegetation is not represented in the open landscapes which were included in the comparable table in the CS 1990 Main Report. Aggregate class III is comparable to the improved grassland, aggregate class IV to the semi-improved grassland, aggregate class VII to the upland grass mosaics and aggregate class VIII to the heaths and bogs. The single woodland class in CS 1990 Main Report is divided into Lowland wooded (V) and Upland wooded (VI). It must also be borne in mind that in this analysis, using the unified classification, all plots are considered together, regardless of their position in the landscape.

The results show that in ten cases there is an increase in significance level or values have crossed the boundary into being significant at at least the 5% level, whereas previously they only indicated the direction of change. Furthermore, the direction of change in virtually all cases is the same as in the previous analysis. This result suggests that changes are taking place at the landscape level with the direction of change in different elements being in the same direction, otherwise they would cancel each other out. As commented previously, species typical of meadows are known to have been lost from hedges, streamsides and grasslands. It may be that the processes causing these changes are convergent, or that a combination of different processes produces the same result. For example, eutrophication of streamsides may cause an increase in species such as stinging nettle (*Urtica dioica)* which replaces more sensitive species such as common valerian (*Valeriana officinalis)*: an increase in nitrogenous fertiliser application to a field would cause a similar change. The next stage therefore is to analyse the landscape elements separately and to integrate the results with the analyses currently being undertaken in ECOFACT Module 6.

The main new finding is that the separation between the two woodland aggregate classes has revealed that the Lowland wooded class is gaining species, whereas the Upland wooded is losing species significantly. This result was masked in the CS 1990 Main Report because the loss of species in woodlands as a whole masked the differences between the opposing trends. Aggregate class II shows the smallest degree of change. Interpreting the results in the context of plant strategy theory, this is, perhaps, because this class was already overgrown in 1978 and is relatively stable. Within the uplands there is a marked divergence between the moorland grass/mosaic and heath/bog with the former having lost species, whereas the latter has gained species significantly. This is perhaps due to the same process of change acting on different starting points in vegetation terms since these aggregate classes are intimately mixed within a common matrix in the uplands. Whilst this is true of the uplands and GB as a whole, a difference has emerged between the pastural and marginal upland landscapes in that under the new aggregation, significant losses in both these classes are reported in the pastural landscape, but significant gains in the marginal uplands. The underlying structure of these changes will be analysed further in the next stage of the analysis.

The second series of tables (Tables 15-18) shows the breakdown of species numbers between the different plot categories. This is a different procedure than used in the CS1990 main report where separate classifications were used for the different elements. The application of the CVS means that direct comparisons of the direction of change can be made consistently.

The primary conclusion when comparing these tables is that most of the changes take place in the main plots which represent open landscape. These changes dominate the overall picture for Great Britain shown in the previous table. Secondly, most of the changes within the linear features are in the same direction as the overall landscape, with some exceptions pointed out below. Virtually all the changes confirm the conclusions of the CS1990 main report, but by treating the data at the overall landscape level, smaller changes can be detected, because the sample size is larger.

Within the main plots most of the changes are identical to those for the whole of Great Britain. In the arable landscape, for example, aggregate class I shows the same decline as at the national level. Within the pastural and marginal landscapes there are similar losses overall, but two of the changes are no longer significant. In the upland landscape there is the same pattern of change but with lower levels overall which lead to a loss of significance. This is due to the streamside plots being removed as they show a high degree of change. Within the verge plots, there are smaller changes than in either of the other elements. There are only three significant changes which have the same direction as the overall aggregate classes, but these become significant because of the restricted area sampled. Verges are also exceptional in that they are the only plots to show significant increases in species number. Aggregate classes II and III both show gains in species number.

In the Streamside plots all the significant changes involve loss of species. In the arable landscape the direction of change in aggregate class II is the same as in the overall analysis, but becomes significant because of the wider area of coverage. In arable, pastural and marginal uplands, the two woodland aggregate classes both decline suggesting a common pattern throughout the landscapes.

In the Hedge plots only aggregate class 2 in the pastural landscape shows a decline. This conforms with the pattern reported in the CS1990 main report.

6.6 CHANGE IN INDIVIDUAL SPECIES FREQUENCY AND COVER

There are significant changes in individual species which have taken place between 1978 and 1990 and which underlie the changes in species number reported in the previous Section. Within the Crops/weeds aggregate class I, individual species declined significantly between 1978 and 1990. With two exceptions, these are both broadleaved weeds confirming the shift, previously reported towards graminaceous weeds - although there has been no actual overall increase in species such as black grass *(Alopecurus myosuroides)*. There are few changes within the Tall grassland/herb aggregate class II, confirming the suggestion made above that this category is relatively stable. In the Fertile grasslands aggregate class III, although there was no significant overall loss of species, a considerable number of species changed significantly. In the Lowland grasslands 23 species have changed significantly in frequency, in all cases decreasing. Whilst some of these species are not likely to be considered of conservation significance eg. creeping buttercup *(Ranunculus repens)*, others such as bird's foot trefoil *(Lotus corniculatus)* are of importance to conservation and reflect the loss of meadow species. The pattern of change in the woodland categories is far from clear with some evidence of species indicative of disturbance eg. sterile brome *(Bromus sterilis)* expanding in the lowland woods and creeping bent (*Agrostis stolonifera*) expanding in the acid woodlands, perhaps indicating eutrophication. In the upland grasslands the situation may well be confused by the effects of afforestation, and newly afforested plots in 1978 need to be removed from the analysis before further conclusions can be drawn. Within the uplands it is interesting that the ericaceous species, ling (*Calluna vulgaris*) and cross-leaved heath (*Erica tetralix)* have declined, whereas heath sedge (*Carex binervis)* and carnation grass (*Carex panicea)* have increased.

There are relatively few significant changes in cover between 1978 and 1990. As expected the cover in the values Crop/weeds aggregate class I are very low with some evidence of an overall increase in the cover of grassland species, perhaps due to undersowing. Within the Tall grassland aggregate class II there are 11 species which have changed significantly, all but two have increased in their cover and all are species from eutrophic or overgrown situations - linking to the conclusions described in the section of plant functional strategies. Within eutrophic grasslands there have generally been reductions in cover which could be due to the increasing use of silage, which leaves fields more frequently bare of cover than traditional hay making. The woodlands show a similar pattern of decline in species frequency with a majority of species showing the same patterns. There are few changes within the upland grasslands and in the moorlands the most striking changes are the decrease in four ericaceous species. As with the previous section further analysis is required to separate the changes between the different elements in the landscape.

Changes in cover and frequency of individual species are implicated in observed changes in species groups but have ecological significance in their own right.

Change analyses were stratified by:

- landscape, aggregate class and plot type;
- aggregate class and plot type;
- aggregate class and landscape type;

Each stratification divides the variation in the data set in different ways. Similarities and differences in detected changes reflect the interplay between interaction effects and differences in sample size.

Reductions in arable crops such as oats and potatoes have occurred in the arable landscape in the Crops/weeds aggregate class I, whereas in the pastural landscape rye grass (*Lolium perenne)* and white clover (*Trifolium repens)* have increased.

In the arable landscape and tall grasslands in Hedgerows and on Verges there has been an expansion in coarse weeds and common grasses such as cleavers (*Galium aparine),* couch grass (*Elymus repens),* Yorkshire fog (*Holcus lanatus)* and sterile brome (*Bromus sterilis).* In Streamsides, within the same landscape and aggregate class, creeping thistle *(Cirsium arvense),* cleavers *(Galium aparine)* and Yorkshire fog (*Holcus lanatus)* all increased.

In the Fertile grasslands (aggregate class III) in Main plots, changing species suggest a decline in management intensity within a still highly fertile system. The grassland ley species white clover (*Trifolium repens)* and rye grass (*Lolium perenne)* declined in cover in the arable landscape whilst the agricultural weed creeping thistle (*Cirsium arvense)* increased at the GB scale and in the pastural landscape. Changes in this species were so well marked as to be detected in the much smaller set of samples that did not shift aggregate class between 1978 and

1990.

Other species increasing in cover in the Fertile grasslands include bramble *(Rubus fruticosus)*, red fescue *(Festuca rubra)* and creeping bent *(Agrostis stolonifera)*. The same trends appeared to be occurring on roadside verge plots for the aggregate class as well as main plots.

The Infertile grasslands aggregate class IV encompasses a suite of less improved grassland vegetation types including relatively species rich wetland, acid and calcareous communities. The corollary of the demonstrated decline in botanical quality in this aggregate class is the observed increase in common species favoured by increased fertility. These include stinging nettle (*Urtica dioica)*, cleavers (*Galium aparine)*, rye grass *(Lolium perenne)*, creeping bent (*Agrostis stolonifera*) and red fescue (*Festuca rubra)*. Evidence of this trend towards increasing fertility extends over all landscapes since even in the marginal uplands, infertile grassland plots showed an increase in cover in red fescue (*Festuca rubra)*, creeping bent (*Agrostis stolonifera)* and Yorkshire fog (*Holcus lanatus)*.

The detected increase in stinging nettle (*Urtica dioica)* in GB streamsides within the Infertile grasslands corroborates local changes reported by the Botanical Society of the British Isles (BSBI) for some counties in southern England. The accompanying increase in other nitrophiles such as cleavers (*Galium aparine)*, great hairy willowherb (*Epilobium hirsutum)* and creeping bent (*Agrostis stolonifera*) persuasively suggest a trend towards more fertile and less disturbed conditions on lowland streamsides.

In hedgerows in the lowland wood/hedge aggregate class an increase in weeds favoured by high fertility is manifested by cleavers (*Galium aparine)* and sterile brome (*Bromus sterilis)* over the whole of GB and particularly in the arable landscape. Within the pastural landscape creeping bent (*Agrostis stolonifera)*, rye grass (*Lolium perenne)* and bramble (*Rubus fruticosus)* increased in cover.

Changes in shrub abundance, show divergent patterns between landscapes within the lowland wooded hedgerow plots: In the arable landscape hazel (*Corylus avellana)*, hawthorn (*Crataegus monogyna)*, ash (*Fraxinus excelsior)*, ivy (*Hedera helix)*, blackthorn (*Prunus spinosa)* and elder (*Sambucus nigra)* all declined whilst in the pastural landscape hazel (*Corylus avellana)* declined but hawthorn (*Crataegus monogyna)* and ivy *(Hedera helix)* increased.

In the upland landscapes one of the most marked changes was the obvious increase in Sitka spruce (*Picea sitchensis)* in the moorland/grass mosaic VII and heath/bog VIII aggregate classes.

It is also noteworthy that the common grass Yorkshire fog (*Holcus lanatus)* which has increased over a wide range of plots and vegetation types in the lowlands also showed increases in cover in the marginal uplands moorland vegetation. The ubiquitous agricultural ley species rye grass (*Lolium perenne)* and white clover (*Trifolium repens)* also increased in cover in GB-wide moorland vegetation in main plots.

Change in the heath/bog aggregate class VIII are difficult to interpret at the GB scale and centre upon increases among a number of pleurocarpous mosses and on species such as bent grass (*Agrostis capillaris),* Yorkshire fog (*Holcus lanatus)* and heath bedstraw *Galium saxatile*.

Within the marginal upland heath/bog main plots however, there was a decline in the sub-shrubs ling (*Calluna vulgaris)* and crowberry (*Empetrum nigrum)* and increasing mat grass (*Nardus stricta)*.

6.7 CHANGE: SPECIES GROUPS

The change in species groups complement the figures on overall species loss but enable the type of species being lost to be identified. The following are the principal changes.

I. *Aggregate class I, main plots.* Plants associated with crops have decreased whereas grassland plants have increased reflecting a shift towards graminaceous weeds.

II. *Aggregate class II, hedges.* Grassland species have been lost and all significant changes have been negative.

III. *Aggregate class II, streamsides.* One small significant increase in grassland plants.

IV. *Aggregate class II, verges.* Significant increases in three species groups reflect the increase in species number reported in the previous Section. The main increases are in species groups associated with grassland on fertile soils.

V. *Aggregate class III, verges.* As with the previous Section, the significant changes are increases, but in this case it is woodland plants associated with humus-rich or fertile soils.

VI. *Aggregate class III, main plots.* The largest decline is in grassland species but there is also an increase in species of plants associated with crops indicating a change in balance between the species within fields.

VII. *Aggregate class IV verges.* Although this class did not show losses of species overall, there was a large loss in one of the grassland species groups again suggesting that the balance was changing overall.

VIII. *Aggregate class IV, main plots.* This class shows the largest change over all the combinations examined and confirms the suggestion made in the CS1990 Main Report of major losses within the neutral grasslands. Six groups of grassland plants have declined overall and it is interesting to note that there is a small increase in plants associated with crops, confirming the shift within the fertile grasslands.

IX. *Aggregate class IV, streamsides.* This class shows a balance between species groups that have declined significantly which are generally associated with grasslands as opposed to those that have increased and which are mainly wood edge and woodland species. This emphasises that the balance of the species that make up vegetation can change independently of overall species number.

X. *Aggregate class IV, hedges.* A small decline in two species groups mainly linked by being grassland plants.

XI. *Aggregate class V, hedges.* This class shows a striking loss of woodland and wood edge species, but an increase in plants associated with crops on fertile soils suggesting a major shift in the balance of species within this class.

XII. *Aggregate class VI, streamsides.* This class shows a significant loss of four species groups all involving woodland species.

XIII. *Aggregate class VII, streamsides.* This class shows three significant losses affecting mainly grassland species groups.

XIV. *Aggregate class VII, main plots.* This class shows a balance between losses and gains with grassland plants generally declining but heath and bog plants increasing.

XV. *Aggregate class VIII, main plots.* The main changes in this class involve a loss of moorland plants and a gain in grassland plants reflecting the shift reported elsewhere away from ericaceous species to more general grassland plants.

The analyses of changes in cover for species groups omitted records for each species when their cover in a plot was estimated to be less than 5% in both 1978 and 1990. The focus, as with analysis of individual species, is therefore on changes in cover within plots rather than changes in frequency between plots. The distinction may be of ecological significance since some aggregate classes as expressed within certain plot types appear to show either many more species group frequency changes than cover while others show the reverse. Gross changes in count data are more likely to result in a shift in aggregate class than gross changes in cover within plots only. However, increases in cover within plots are likely to be implicated in the loss of less abundant species from plots. If these are uncommon overall in CS data, then it is clear that both types of change can have potent effects on species richness and composition.

Overall more changes in species group frequency were detected than species group cover although failure to detect trends in cover maybe as much to do with the smaller sample size used than the absence of trends at the within quadrat scale. Of interest however, are those changes that were detected in species group cover but not in frequency within the same aggregate class and plot type.

Some changes were detected at GB level but not at the individual landscape level. This may be due partly to the greater sample size available and to interaction between landscape trends over time. Where sample size is adequate changes detected at the landscape level, but not over the whole dataset, suggest the operation of interaction effects and change in different directions between landscapes.

The matrices of change in replicate plot membership between the aggregate classes are presented in Table 19. In general, the overall pattern is that of stability, but with the shifts described below reflecting the changes already described at the species and species group level. Within Great Britain as a whole, there are losses from aggregate classes III and IV (the Fertile and Infertile grassland) which have shifted mainly into aggregate class II (Tall grassland/herb). The other major loss is from aggregate class VIII (Heath/bog) which has shifted mainly into aggregate class VII (Grass mosaic/moorland) which in turn has shown shifts into aggregate class VI (Upland wooded), reflecting the planting of new coniferous plantations. There is a small loss from the aggregate class I (Crops/weeds) perhaps reflecting a change in balance of rotation.

Within the arable landscapes, the major shift is from aggregate class III (Fertile grassland) into aggregate class II (Tall grassland/herb) perhaps indicating that roadside verges, streamsides and hedgerows have become more overgrown, as indicated in the section above.

Within the pastural landscapes, the major shift is from aggregate class IV (Infertile grassland) into aggregate classes II (Tall grassland/herb), but this masks a considerable movement between aggregate classes IV and III.

Within the marginal upland landscapes, the wooded aggregate classes V and VI have gained at the expense of Infertile grassland aggregate class IV and there have also been losses in aggregate classes VII and VIII, mainly into the Upland wooded class.

Within the uplands, the situation is relatively stable, apart from a loss of aggregate class VIII into aggregate class VII perhaps reflecting the losses of ericaceous species reported elsewhere.

The changes in the numbers of the individual vegetation classes show that most of the classes are relatively stable but that some have changed dramatically; however this is masked in the matrices of aggregate class described above. The largest shifts are in the grassland classes 14 (increasing), 30 (increasing) whereas 40 and 31 have declined. Class 14 (lowland verges/crop boundaries) has gained at the expense of a range of less-disturbed classes whereas class 30 (mixed eutrophic) has gained largely at the expense of classes 40 (ryegrass/Yorkshire fog grassland) and 31 (ryegrass/clover grassland) reflecting in both cases, movements up the fertility gradient. The major decline in class 5 (mixed weeds in cereal crops) has been into the less diverse classes 1, 2 and 3 reflecting the decline in diversity within crops reported above.

Otherwise major shifts have taken place within class 75 (upland coniferous plantations on moorland/upland grassland) which has gained at the expense of a range of upland vegetation classes and class 77 (dense Sitka spruce) which has largely increased from class 75. There has also been a major increase in class 86 (moorland/streamsides on peaty gleys) which has acquired plots from a range of different classes perhaps due to increased uniformity.

7. RESULTS: BOTANICAL QUALITY EVALUATION OF STOCK WITHIN LANDSCAPE TYPES AND BETWEEN PLOT TYPES

7.1 INTRODUCTION

Species and vegetation differ in the values attached to them by the conservation agencies, policy makers and the public. To meet policy requirements it was necessary to develop a procedure for evaluating the quality of botanical variation. A set of principles for the evaluation of sites using botanical quality have been proposed by Usher (1986). The procedure developed in this project is based on using a range of different approaches to quality assessment as they identify different aspects of vegetation as shown in Table 20. For example, the flowers of the creeping thistle (*Cirsium arvense*) are important for moths and butterflies and the seeds are an important source of food for birds. This species would therefore be termed a quality species for the conservation of these taxa. By contrast, creeping thistle would not be regarded as having a high conservation value within vegetation assemblages.

Quality measure can be divided into four broad categories:

- Lists based upon expert judgement
  eg. English Nature grassland indicators;

- Published plant community profiles
  eg. National Vegetation Classification (NVC) constancy data

- Statistically derived measures
  eg. Preferential species for aggregate classes;

- Proven ecological associations
  eg. Plants that are food for butterflies;

Because species associated with high quality vegetation are likely to be relatively localised and therefore uncommon in the landscape as a whole, the approach was to examine differences in the proportion of plots of each type eg hedge and field, having at least one recorded occurrence for any species in the quality indicator group. Where larger numbers of records were available differences in the total numbers of quality species within each plot were analysed. Where possible analysis of change in abundance between 1978 and 1990 was carried out for the same groups but using the smaller number of replicate plots recorded in both years.

Results are expressed as differences between plot types within the four landscape classes (arable, pastural, marginal upland and upland) but including an overlapping coastal zone comprising all sampled 1km-squares containing maritime fringe features such as sea, estuary, sea cliff, salt marsh and dunes. The coastal zone is the same as that defined in Parr *et al.* (1996).

The following indicators of quality were examined but others could be included now that the procedure has been developed.

7.2 HABITAT INDICATOR SPECIES FOR UNIMPROVED GRASSLANDS

Conservation agencies in Britain have identified species which they consider on the basis of expert judgement to be indicative of high quality habitats. These lists are explicitly based on judgement, but can be used as a basis for interrogating the CS1990 database in order to determine the representation of these species in the whole countryside. Only one example of this type of analysis has been carried out, that of the species regarded as indicative of unimproved grassland by English Nature. The concept of the approach is, however, that a variety of different lists could be used in order to rank landscape elements and vegetation types in terms of botanical quality.

Three groups were tested; indicators of unimproved calcareous grasslands in England and Wales, acidophilous grassland species and mesotrophic grassland species in GB (Table 21). Calcareous grassland indicators occurred in a significantly greater number of verge plots than other plot types in the arable landscape, whereas in the pastural and coastal landscapes the indicators occurred in the greatest numbers in the main plots. The analysis was not carried out for upland or marginal upland plots because northern limestone species are not included in the list.

In all landscapes mesotrophic and acidic grassland indicators were recorded from a significantly greater proportion of Streamside plots than any other plot type. Many of these species can occur in species-rich wet grasslands; however, the importance of streamsides as refugia is highlighted in the arable and pastural landscapes where the total number of records over all plot types in each group was much lower than the other landscapes.

7.3 RARITY INDICATOR SPECIES

Nationally scarce and Red Data Book (RDB) species were recorded in 66 plots in CS 1990; 22 in the arable landscape, 20 in the upland landscape, 18 in pastural landscape and 6 in the marginal uplands (Table 22). However, as a proportion of the total number of plots in each landscape significantly more records were found in the uplands. The same preference for the upland landscape was found for species occurring in 101-200 hectads in GB. The plot type preferences of both groups of infrequent species were examined by combining all records for each group across GB.

No significant difference in numbers of records between plot types was detected for species occurring in 101-200 hectads. Nationally scarce and RDB species showed significant differences in plot type preference with records more likely in field and Streamside plots.

7.4. NVC DIAGNOSTIC SPECIES

In order to evaluate the status of those more common species whose joint occurrence nevertheless characterises less common plant communities, the plot type and landscape preferences of species that characterise the NVC unimproved grassland community MG5 (Rodwell, 1991) were analysed. The technique is illustrated by application to this community but can be easily applied to other NVC units.

Many of the species that *together* typify MG5 grow in abundance in other communities where they exhibit patterns of joint association with other species and may characterise other communities. The first step was therefore to define a list of species whose joint occurrence is considered characteristic of MG5 vegetation. To do this all species of constancy 3 or more were selected from floristic table for MG5 published in the *National Vegetation Classification, Volume 3* (Rodwell 1991). Species were then excluded if they were also common in other habitat types, as evaluated using Biological Records Centre (BRC) grades generated for the DoE Wildlife Indicators project (Parr *et.al.* 1996). Thus grade 3 species were those most strongly associated with fewer habitat types across the range of NVC data and only grade 3 species were retained from the list of MG5 species resulting in a list of 21 species (Table 23) which are here termed faithful species.

Two subsets of CVS plots recorded in 1990 were then defined for analysis using the list of faithful species: First, a subset of plots was selected such that each contained a minimum identifiable floristic element of MG5. To define this minimum representation the published key to the grasslands chapter of British Plant Communities (Rodwell,1991) was examined and those species highlighted as being most powerful in distinguishing between MG5 and floristically similar grasslands were used; these were bird's foot trefoil *(Lotus corniculatus)*, bent grass *(Agrostis capillaris)*, red clover *(Trifolium pratense)* and sweet vernal grass *(Anthoxanthum odoratum)*. Consequently 73 out of 13,587 plots (0.6%) were selected because they all contained all 4 species. When these plots were grouped by plot type no significant differences in total count of the remaining 19 faithful species was detected. The small size of the data set indicates how uncommon the assemblage is in the landscape as a whole.

The second approach was to examine between plot-type and landscape differences in the joint occurrence patterns of all MG5 faithful species. For this analysis any plot that contained at least one or more of the faithful species was included.

The entire distribution of MG5 faithful species covers extremes where at one end only one species maybe present in many plots and at the other extreme where very few plots contain the majority of the species in the list. Examination of the shape of the distribution pattern between these extremes can convey differences in the relative joint abundance of MG5 species for each plot type and each landscape.

Figure 12 presents this distribution which describes the increasing numbers of species contributing to a joint association of MG5 species in different plot types, but the generally increasing rarity of the association when based upon increasing numbers of MG5 faithful species. The upland landscape is omitted as plots are outside the expected distribution range of the community. Where only one or more species are present there can hardly be said to be any hint of the target community present, but as numbers of faithful species in each plot increase, the representation of species considered diagnostic of MG5 becomes more marked.

Again it should be emphasised that this technique sidesteps the arbitrary process of assigning a particular sward to a particular unit but is an objective expression of the joint occurrence patterns of species that together are considered diagnostic of the synoptic unit as published in Rodwell (1991).

In Figure 12, if a high percentage of plots were occupied by high numbers of MG5 species, the distribution would be skewed to the top right of each graph. In any event, points with high values on both axes would be desirable. The highest percentage of plots with the highest numbers of MG5 species in each plot was found on roadside verges in the marginal uplands, although even here only 2.8% of plots had 12 MG5 species growing together.

The highest percentages of plots having between 4 and 8 species were all found on roadside verges in all landscapes and boundary plots in the marginal uplands.

The most impoverished landscape and landscape element in terms of the total representation of MG5 species is conveyed by the total area under the graph and highlights, as expected, main plots in the arable landscape.

Only 25 plots contained over 14 MG5 faithful species. These are listed in Table 24.

Given the often heterogeneous vegetation represented by the random samples in Countryside Survey data it is more appropriate to identify a core assemblage which is typical of a valued plant community even though it is likely to be accompanied by species perhaps typical of other community types. This is because many of the CS plots are more likely to represent the noisy tails of the distributions of plant species rather than vegetation in which their patterns of joint occurrence are strongest leading to relatively greater homogeneity and greater ease in assignment to NVC units. However, it was seen as important to try and examine situations where traces of a community could still be discerned since poor expression might be linked to vegetation change, small patch size or an otherwise atypical floristic and environmental context. The question that is addressed is whether the building blocks of valued plant communities occur in the landscape generally and outside of easily identifiable and manageable sites.

The joint occurrence analysis technique has proved to be a useful way of examining abundance patterns of recognisable sets of NVC diagnostic species in the wider countryside and is thus a subtle but effective way of using the NVC framework to interpret changes in CS data.

7.5 ABUNDANCE OF PREFERENTIAL SPECIES

Those species most strongly associated with each of the eight CVS aggregate classes were identified by a chi-square analysis and then divided into three groups; abundant, intermediate and rare, based upon their frequency in CS data. Depending upon the aggregate class, different levels of botanical quality can be equated with each abundance category. For example all categories of the infertile grasslands are indicative of high quality since the class itself represents unimproved species-rich grasslands which are not only uncommon in CS data but have also declined in species richness between 1978 and 1990. In the lowland wooded class, however, rare and intermediate species (many of which are ancient woodland indicator species) accompanied by a decline in abundant species would indicate higher quality. The abundant category strongly characterises the vegetation but is not associated with high quality within the vegetation.

Most of the significant differences in mean count between plot types are shown by abundant species (Table 25).

In the arable, pastural and marginal upland landscapes the richest infertile grassland plots were found in the field and roadside verge plots. Landscape differences are however very marked with the richest plots in the arable landscape (main) being as rich as the most species-poor plots in the marginal uplands (hedges).

Abundant species that characterise the tall grassland/herb class form the richest assemblages in hedge plots in the arable landscape and verges in the pastural.

In the upland landscape the richest grass mosaic/moorland vegetation in terms of abundant preferential species, is associated with streamside plots whereas species preferential to heath/bog form the richest assemblages in main plots.

The marginal uplands therefore encompass the richest infertile grassland vegetation. Hedges and verges in the lowlands are most important for the richer tall grasslands. In the uplands, watercourses are associated with the richest upland grasslands but the richest heath/bog is found in open moor and mountain away from linear features and streams.

7.6 BUTTERFLY LARVAL FOOD PLANTS

Lists of butterfly species and their host plants were obtained from the database of the Biological Records Centre (BRC) at ITE Monkswood. For each landscape type and aggregate class combination, the mean counts of butterfly host plants per CS plot were generated from 1990 data only.

The results which are shown in Table 26 again emphasise the importance of the infertile grasslands of aggregate Class 4. In all landscapes the highest mean counts of host plants were for this class with a maximum value of 9.2 species per plot in the marginal uplands. The lowest numbers of host plants were for the crops/weeds aggregate class I in the arable, pastural and upland landscapes and for lowland wooded aggregate class V in the marginal uplands.

7.7 BIRD FOOD PLANTS

Plant species were selected from the review of the diet of lowland farmland birds by Wilson *et al.* (1996). The bird species were selected from the list of 24 declining, 5 stable and 11 increasing bird species in Campbell and Cooke (1997). A total 133 relevant food plant species were recorded in the CS 1990 database. Although some relationships are not explicit, the table shows that sufficient information is available to carry out an analysis of change as shown in Section 7. Campbell and Cooke's (1997) report implicated the indirect effect of pesticides in the decline of a number of bird species. Their effect can be to reduce food resources in three ways:

1. Insecticides can reduce the abundance of invertebrates.

2. Herbicides may reduce the number of host plants thus reducing the abundance of dependent invertebrates.

3. Herbicides may reduce the abundance of weeds and seeds directly exploited as food.

Results from CS data were screened for detected changes in those plant species listed as "..present in diet and quantified or described as an important dietary component." for those birds listed in Campbell and Cooke (1997).

Stock analyses are presented for food plants of 14 declining bird species. Separate information is given for four of the most severely declining species the Tree Sparrow, Cirl Bunting, Grey Partridge and Bullfinch.

Table 27 gives the percentage of total plant species records taken up by bird food plants in the lowland aggregate classes and landscapes.

Crops and ruderal species such as *Stellaria media*, *Poa annua* and *Polygonum* spp feature prominently in the list of food plants, and it is, therefore, not surprising that the highest figures refer to the cops/weeds aggregate class I in both landscapes, the pastural landscape having the highest percentage (50.2%).

Plant cover rather than simple presence is a better reflection of the abundance of a food source in a particular place. For four bird species Table 28 summarises food plant abundance in terms of mean cover in plots and gives the percentage of plots in which total cover equalled or exceeded 10%.

The importance of cultivated land as a source of food plants for Grey Partridge, Tree Sparrow and Cirl Bunting is well illustrated as both the highest mean cover and highest proportion of high cover plots were all found in the crops/weeds class in both landscapes with the second highest figures picking out eutrophic grasslands.

Table 27 also shows that the highest mean cover values were associated with plots in the pastural landscape.

The greatest abundance of food plants for the bullfinch is found in the lowland wooded aggregate class V related to the presence in the diet of species such as stinging nettle *(Urtica dioica)*, hawthorn *(Crataegus monogyna)* and elder (*Sambucus nigra)* in addition to ruderal plants.

7.8 CHANGE IN QUALITY CRITERIA

NCC unimproved grassland indicator species

A significant increase in the number of plots containing at least one calcareous grassland indicator was detected in the coastal landscape with 55 records in 1978 and 87 in 1990. A significant reduction in records for acidophilous grassland indicator species was detected for the whole of GB (-4%) and separately in the upland landscape (-2%). A significant reduction in records for mesotrophic indicators was detected for the whole of GB (-8%) and for the pastural landscape (-11%) - see Table 29. Species that are less strictly confined to unimproved mesotrophic grasslands are given a value of 1 in the English Nature grassland indicator list and are described as "..often found in other habitats and including some species able to 'hang on' in semi-improved swards...". These were removed and the analysis re-run using only the more strict mesotrophic indicators. As shown in Table 30, the decline becomes even more marked revealing a 22% reduction in the number of records in the arable landscape as well as increasing the percentage decline in GB to 9% and in the pastural landscape to 15%.

Uncommon species in GB

No change in number of records was detected for either species rarity group.

NVC diagnostic species

For this analysis the variable of interest was the median number of 'faithful' species in each MG5 core, ie. having pre-selected a group of plots possessing a minimum floristic element of MG5 we go on to test whether, between years, there are any differences in median richness of the remaining MG5 indicators in Table 13 and therefore any increase or decrease in similarity to MG5.

Only 17 replicate plots had all 4 species recorded together in 1978 and a nonparametric matched pairs test detected a significant increase in richness of MG5 faithful species in the 17 replicate plots. The environmental and ecological situations of these plots were initially examined as part of a research programme on the causes of change in biodiversity in the countryside. Preliminary results highlighted the likely importance of common constraints on fertility related to climate and soil, coincidental but fortuitous low intensity management, but also the vulnerability of the sampled swards to land-use change.

Abundance of preferential species

Table 31 shows the changes that occurred in numbers of preferential species for each aggregate class divided into 3 abundance groups; abundant, intermediate or rare.

The most easily interpretable changes accord with trends detected in functional analyses of change in CS data by the Unit of Comparative Plant Ecology (UCPE) and with analyses of change in species richness by landscape and aggregate class.

A decline in the most common crop/weed species was detected across the whole data set and in plots in the arable landscape. This is in agreement with UCPE results and detected shifts in aggregate class membership which indicate a large movement of previously tilled land into grassland.

An increase in the commonest characteristic tall grassland species occurred in the arable and pastural landscapes and is also in agreement with functional analyses which indicated a shift to large-seeded, competitive species characteristic of less disturbed, shaded habitats.

Reduction in mean count of both abundant and intermediate infertile grassland species occurred across the whole dataset and a reduction in abundant species was detected in the arable and pastural landscapes. These trends when considered alongside the decline in unimproved grassland indicator species and quality distribution results from 1990 data suggest that it is the higher quality lowland vegetation in GB that is experiencing the most marked decline in botanical character.

Butterfly larval food plants

Butterfly host plants for which significant changes in frequency between 1978 and 1990 were detected are listed in Table 32. Table 33 lists the butterfly species for which host plants either increased or decreased. Stratification was by aggregate class and landscape type.

Nineteen butterfly host plants decreased in frequency between 1978 and 1990 whilst 3 species increased (Table 34). Overall, 35% of the butterflies listed by BRC had host plants that declined although differences in the range of each butterfly and its host species plus the presence of more than one host plant for many butterflies suggests that the consequences of these changes are likely to be far from simple.

A number of butterfly species have expanded in range between at least 1976 and 1991 particularly in the south east. Trends in nine of these were analysed by Pollard *et al.* (1995) of which 5 have couch grass *(Elymus repens)* as a foodplant and 2 others utilise stinging nettle *(Urtica dioica)*. Both plant species have increased in CS data between 1978 and 1990 in the British lowlands although for *Urtica dioica* the increase was in mean cover on streamside plots in the arable landscape only.

The only host plant for which an increase in the uplands was detected was Devil's-bit (*Succisa pratensis)*. This is the food-plant for the scarce and declining Marsh Fritillary (*Eurodryas aurinia*) which is unlikely to benefit unless increases result in the greater availability of the preferred larger and leafier individuals of the food-plant which are typical of 'boggy meadows' (Heath *et al.*, 1984).

The largest number of declining species was recorded from the infertile grasslands in the pastural landscape including the prostrate herb of unimproved grasslands bird's-foot trefoil *(Lotus corniculatus)*; the food-plant for 7 butterfly species. It decreased in frequency in the pastural landscape in the infertile grasslands aggregate class along with other typical species rich grassland plants such as *Cynosurus cristatus, Trifolium pratense* and *Plantago lanceolata*.

Bird food plants

For each bird species listed in Table 35 the number of significant changes in food plant abundance were calculated as follows. A plant species was classified as an increaser or decreaser based upon the difference in number of observed increases or decreases in frequency (between plots) and cover (within plots) found from analysis of CS data stratified by aggregate class, landscape and plot type. The number of increasing and decreasing food plants was then summed for each bird species in each of three landscapes (arable, pastural and marginal uplands) and for GB overall.

Of all food plant changes detected, 14 species decreased in at least one landscape, aggregate class or plot type combination. 8 species increased and 10 species showed both an increase and a decrease in different strata (Table 36).

Net decreasers included arable crops and weed species particularly important in the diet of severely declined birds such as Tree Sparrow, Cirl Bunting, Grey Partridge and Corn Bunting (Table 37).

Changing patterns of food plant abundance however, fail to separate the three groups of stable, increasing and decreasing species (confirmed by using Detrended Correspondence Analysis, terBraak,1987). For example, high counts for decreasing food plants are associated with increasing birds such as Wood Pigeon, House Sparrow and Stock Dove. Factors such as polyphagy, range restriction and nesting habitat specialisation are also likely to be implicated in the cause of decline in different species.

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TABLE CAPTIONS

Table 1	Types and numbers of the vegetation plots surveyed in the 768 1km squares in the Countryside Survey 1990.
Table 2	Names of the eight aggregate classes derived from cluster analysis of the 100 vegetation classes, together with estimates of area and standard errors derived from the relative coverage of vegetated land by the main plots in the 1km squares.
Table 3	Numbers of plots recorded in the Countryside Survey 1990 summarised by the four landscape types, aggregate class and plot type.
Table 4	Areas covered by the 100 vegetation classes linked to interpreted groupings and then to the eight aggregate classes.
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Table 13	Numbers of tests available and significance level for the combinations available, as described in Table 12. + = significant gain in species; - = significant loss in species; NS = not significant.
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Table 15	Change in average species number per plot by main plots within the eight aggregate classes of the Countryside Vegetation System. Ag = arable; PA = pastoral; MA = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $P < 5\%$; ** $P = < 1\%$.
Table 16	Change in average species number per plot by verge plots within the eight aggregate classes of the Countryside Vegetation System. Ag = arable; PA = pastoral; MA = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $P < 5\%$; ** $P = < 1\%$.
Table 17	Change in average species number per plot by hedge plots within the eight aggregate classes of the Countryside Vegetation System. Ag = arable; PA = pastoral; MA = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $P < 5\%$; ** $P = < 1\%$.
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Table 22	Analysis of uncommon species occurring in 1-100 hectads or 101-200 hectads in Great Britain, by plot type, using Countryside Survey data for 1990 only. * $p < 0.05$; ** $p < 0.01$. Data in italics indicates plot types with the highest preference values. Habitat plots were omitted. X = main plots; R+V = verge plots; B = boundary plots; H = hedge plots; StW = streamside plots.
Table 23	Species faithful to unimproved neutral grassland defined as MG5 within the National Vegetation Classification (Rodwell, 1992). The four species most diagnostic of MG5 have been identified.
Table 24	Number of plots in the Countryside Survey 1990 database that contain over 14 of the faithful species of MG5 within the National Vegetation Classification (Rodwell, 1992).
Table 25	Differences in median counts of aggregate classes preferential species between the six plot types and four landscape types. Species were classified by 33.3 and 66.7 percentile frequencies. The figures represent mean counts per plot by abundant (A), intermediate (I) and rare (R). Italics indicate highest and lowest mean counts. B = boundary plots; H = hedge plots; R+V = verge plots; StW = streamside plots; X = main plots.
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Table 27	Number of records of food plants for 14 declining birds listed in Table 35, as a percentage of the total number of plant records recorded in the Countryside Survey 1990 database. Highest and lowest figures are highlighted.
Table 28	Number of records of food plants for four lowland birds that have declined over the last 20-30 years (Campbell & Cooke, 1997). Italics indicate the highest and lowest mean cover for an aggregate class in each of the four landscape types, based on the Countryside Survey 1990 database. The first figure is the average cover for each plot. The figure in brackets is the percentage of plots in which total cover was > = 10%.
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Table 32	Numbers of butterfly host plants that have changed frequency between 1978 and 1990. Column labels indicate the eight aggregate classes of the Countryside

	Vegetation System. AG = arable; PA = pastural; MA = marginal upland; UP = upland. The number of dependent butterfly species for each plant is given in Column B.
Table 33	Butterfly species whose host plants have changed frequency between 1978 and 1990. Column labels indicate the eight aggregate classes of the Countryside Vegetation System. AG = arable; PA = pastural; MA = marginal upland; UP = upland. Figures are the numbers of host plant species.
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Table 37	Bird food plant species that have changed in frequency between 1978 and 1990. a = arable; p = pastural; ma = marginal upland; + = gain in species frequency; - = decline in species frequency.

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Plot type	Max per square	Total
Main plots (200 m2)	5	2531
Habitat plots (4 m2)	5	2529
Hedge plots (10 m x 1 m)	2	564
Boundary plots (10 m x 1 m)	5	1807
Verge plots (10 m x 1 m) - random	2	789
Additional Verge plots (10 m x 1 m)	3	1165
Streamside plots (10 m x 1 m) - random	2	885
Additional streamside plots (10 m x 1 m)	3	1287
Total		**11557**

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	Aggregate vegetation class	Dominant landscape elements
I	Crops/weeds	Fields
II	Tall grassland/herb	Riverbanks, patches, boundaries, hedges
III	Fertile grassland	Fields, verges
IV	Infertile grassland	Fields, riverbanks, patches, verges
V	Lowland wooded	Hedges, woodlands, riverbanks
VI	Upland wooded	Open mountain, streamsides
VII	Moorland grass/mosaic	Open mountain, streamsides
VIII	Heath/bog	

Vegetation Class No.	Name	Area (km^2)	Standard Error (km^2)
1	Almost weed free wheat/other crops	7361	852
2	Scattered weeds in various crops	5731	790
3	Grassy weeds in cereal crops	9532	1062
4	Broadleaved weeds in mixed crops	3579	658
5	Mixed weeds in cereal groups	3507	604
6	Weedy leys/undersown cereal crops	6269	789
7	Crop hedges/boundaries	89	87
9	Boundaries/open crop hedges	250	147
10	Tall grass boundaries	275	150
11	Streamside banks within crops	433	214
12	Lowland eutrophic roadsides	842	264
13	Lowland mesotrophic roadsides	112	109
14	Lowland roadsides/crop boundaries	1059	282
15	Lowland river banks	104	74
16	Shady eutrophic streamsides	276	135
17	Lowland wetlands/water edges	55	48
18	Eutrophic shaded ditches	160	111
19	Eutrophic riverside/wetland tall herb	81	77
20	Grassy roadside verges	200	139
21	Diverse lowland hedgerows	154	107
23	Eutrophic mixed grassland	801	240
24	Dry base rich woodland	1157	304
25	Shaded grassland/hedges	607	235
27	Rye grass roadsides	502	194
28	Eutrophic tall herb/grassland	600	224
29	Rye grass swards	9739	895
30	Mixed eutrophic grassland	14573	1000
31	Rye grass/clover grassland	8819	823
33	Marshy grassland	140	89
34	Mixed grassland scrub	214	111
35	Diverse base rich woodland/hedgerows	3105	592
36	Shaded moist stream banks	182	121
38	Enriched mesotrophic grassland	556	194
40	Ryegrass/Yorkshire fog grassland	14000	1005
42	Woodland on heavy soils	2204	537
43	Rye grass/bent grass swards	5462	588
44	Calcareous grassland	804	368
45	Shaded grassy streamsides	95	93
46	Shaded nutrient rich streamsides	420	182
47	Diverse mesotrophic pasture	344	143
48	Marshy riversides	92	69
49	Acidic woodland fragments	672	247
50	Acidic woodlands	1585	424
51	Wet rushy grasslands	2046	410
52	Mesotrophic grasslands	1483	318
53	Diverse mesotrophic/acid grasslands	242	132
54	Marshes/wet tall herb	124	73
55	Rushy mesotrophic/acid grasslands	1143	275
56	Mesotrophic diverse moist grasslands	2417	538
57	Enriched moorland flushes	606	256
58	Rushy diverse streamside/flushes	969	273
59	Upland semi shaded acidic streamsides	503	229
60	Streamsides/flushes within acidic grasslands	140	102

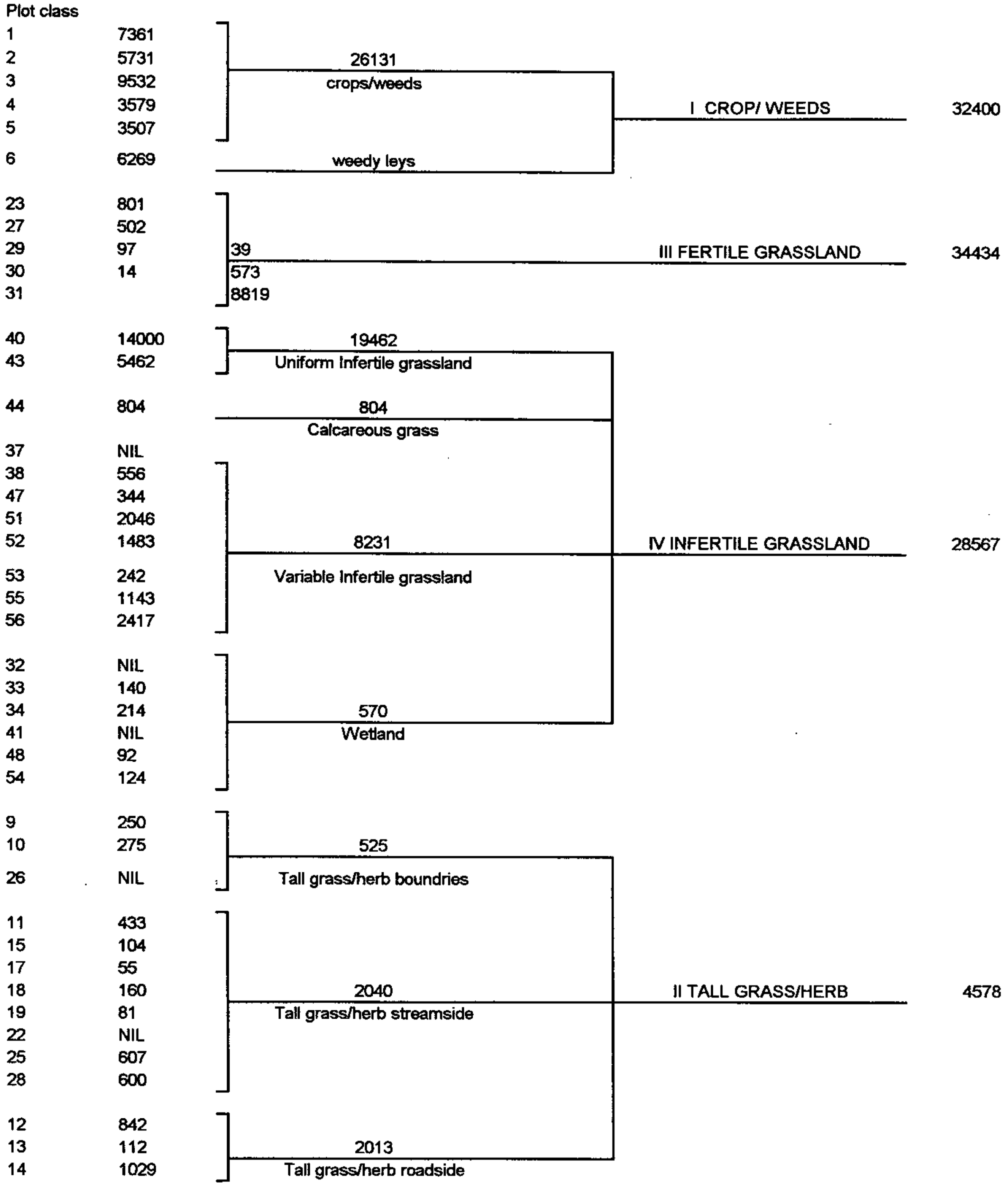
2 controle

Vegetation Plot Class		Area (km^2)	Standard Error (km^2)
61	Herb rich upland grassland	857	252
62	Acidic lowland woodland	1315	376
63	Diverse upland streamsides/grasslands	1129	273
64	Agrostis/Fescue/Bracken	2693	464
65	Acidic herbrich grass/heath	343	110
66	Streamsides/flushes in moorland vegetation	103	93
67	Moorland grass	1958	470
68	Acidic oak/birch woodland	2093	514
69	Open acidic heathy birch woodland	192	93
70	Shady acidic streamside	745	261
71	Herbrich moorland grass/heath	1255	388
72	Acid peaty streamsides/flushes	137	95
73	Moorland grass on wet peat	3832	531
74	Streamsides/flushes in wet moorland grass	16	13
75	Upland coniferous plantations on moorland/upland grassland	2444	577
76	Diverse streamsides/flushes in moorland vegetation	794	227
77	Dense Sitka spruce	1636	389
78	Complex montane/moorland grass	519	151
79	Mountain streamsides and slightly enriched moorland grass	1643	359
80	Moorland grass/heath on peaty gleys	4183	643
81	Heath/montane acidic grasslands	1046	274
82	Wet moorland heath vegetation	1199	327
83	Heather moorland on peats	2358	475
84	Heather moorland	512	332
85	Streamsides/flushes on peats	8	6
86	Moorland/streamside on peaty gleys	2443	478
87	Moorland/bog on peats	2172	390
88	Montane moorland/heath	4002	751
89	Montane heather moorland	3047	739
90	Wet heathland	775	238
91	Upland heather moor	4507	576
92	Ombotrophic bog	2087	369
93	Montane heath vegetation class	1601	441
94	Sphagnum bogs	2824	541
95	Species poor blanket bog	1580	837
96	Wet bogs	1012	280
97	Northern blanket bog vegetation class	1685	507
98	Cotton grass bog	393	157
99	Saturated bog vegetation class	6526	864
100	Inundated bog/wetland peat	487	208

3

		Plot type						
Landscape	**Aggregate class**	**B**	**H**	**R+V**	**S+W**	**X**	**Y**	**Total**
Arable	1	29	2	24	0	281	26	362
	2	344	89	388	336	41	257	1455
	3	91	3	249	53	146	105	647
	4	89	10	93	135	94	200	621
	5	179	165	8	51	44	118	565
	6	15	1	6	43	29	38	132
	7	10	0	7	13	12	28	70
	8	3	0	2	5	15	22	47
Total		760	270	777	636	662	794	3899
Pastural	1	11	1	10	1	124	13	160
	2	265	68	296	173	15	106	923
	3	113	2	206	72	250	83	726
	4	148	25	170	161	193	294	991
	5	118	150	22	88	35	89	502
	6	34	7	18	112	44	76	291
	7	14	0	8	29	29	48	128
	8	3	0	0	12	29	41	85
Total		706	253	730	648	719	750	3806
Marginal Upland	1	0	0	1	0	9	1	11
	2	16	12	23	9	0	4	64
	3	31	0	59	9	40	5	144
	4	89	13	106	79	92	97	476
	5	4	8	1	10	5	8	36
	6	21	9	16	66	46	61	219
	7	42	0	42	129	93	112	418
	8	8	0	4	39	97	94	242
Total		211	42	252	341	382	382	1610
Upland	1	1	0	0	0	2	0	3
	2	1	0	3	1	0	1	6
	3	7	0	16	3	10	6	42
	4	35	0	65	48	29	45	222
	5	1	0	0	0	0	0	1
	6	10	0	13	47	51	48	169
	7	40	0	78	289	129	232	768
	8	25	0	13	143	333	206	720
Total		120	0	188	531	554	538	1931
Grand Total		1797	565	1947	2156	2317	2464	11246

4


Plot class
1 7361
2 5731
3 9532
4 3579
5 3507
6 6269
26131
crops/weeds
weedy leys
I CROP/ WEEDS
32400
23 801
27 502
29 97
30 14
31
39
573
8819
III FERTILE GRASSLAND
34434
40 14000
43 5462
19462
Uniform Infertile grassland
44 804
804
Calcareous grass
37 NIL
38 556
47 344
51 2046
52 1483
53 242
55 1143
56 2417
8231
Variable Infertile grassland
IV INFERTILE GRASSLAND
28567
32 NIL
33 140
34 214
41 NIL
48 92
54 124
570
Wetland
9 250
10 275
26 NIL
525
Tall grass/herb boundries
11 433
15 104
17 55
18 160
19 81
22 NIL
25 607
28 600
2040
Tall grass/herb streamside
II TALL GRASS/HERB
4578
12 842
13 112
14 1029
2013
Tall grass/herb roadside

4 contd.

7	89	243	Hedgerows	V LOWLAND WOODED	10425
8	NIL				
21	154				
24	1157	9724	Woodlands		
35	3105				
42	5462				
16	276	458	Streamsides		
36	182				
39	NIL				
45	95	1763	Streamside	VI UPLAND WOODED	14393
46	420				
59	503				
70	745				
49	672	5857	Woodland		
50	1585				
62	1315				
68	2093				
69	192				
64	2693	2693			
75	2444	4080	Conifer plantations		
77	1636				
57	606	5537	Grass mosiac/moor streamside	VII GRASS MOSIAC/ MOOR	19530
58	969				
60	140				
63	1129				
66	103				
72	137				
74	16				
76	794				
79	1643				
61	857	2974	Herb rich grass mosiac		
65	343				
71	1255				
78	519				
67	1958	11019	Moorland		
73	3832				
80	4183				
81	1046				

4 contd.

82	1199	9351	Heather moor	VIII HEATH BOG	39218
83	2358				
84	812				
90	775				
91	4507				
85	8	4623	Streams/		
81	2443				
87	2172				
88	4002	8650	Mountain heath		
89	3047				
93	1601				
92	2087	8176	Bog		
94	2824				
95	1580				
97	1685				
96	1012	8418	Satuated bog		
98	393				
99	6526				
100	487				

5

Number	Species group name
1	Crop or crop edge plants on fertile soils
2	Crops, crop edge or grassland on eutrophic soils
3	Woods, tall grasslands or wood edge plants on brown earth soils
4	Tall grassland plants on calcareous brown earths
5	Wood edge, tall grassland or grassland plants on brown earths, often humus rich
6	Water edge plants on wet alluvial soils
7	Crops or crop edge plants on brown earth soils
8	Woodland edge or scrub plants on brown earth soils
9	Grassland, tall grassland plants on wood edges on variable soils
10	Maritime saline or fresh water edge plants on gleyed brown earths
11	Water edge plants on saturated gleyed alluvial soils
12	Grassland or tall grassland plants on brown earth soils
13	Grassland plants on brown earths, often skeletal and calcareous
14	Wood or wood edge plants on calcareous or neutral brown earths
15	Tall grassland plants on damp gleyed brown earths
16	River edge or aquatic plants on wet alluvial soils
17	Woodland or wood edge plants on brown earth soils
18	Grassland plants on semi-fertile, sometimes rocky, brown earths
19	Grassland plants on calcareous brown earths
20	Wood or wood edge plants on damp fertile brown earths
21	Water edge or aquatic plants on hydromorphic soils
22	Grassland wood edge or scrub plants on brown earths
23	Marsh, wood edge or woodland plants on wet gleyed brown earths
24	Marsh or water edge plants on soil water gleys
25	Woodland or woodland edge plants on acid brown earths
26	Plants of maritime habitats on variable soils
27	Wood, wood edge, scrub, grassland or heath plants on acid or neutral brown earths
28	Grassland marsh or water edge plants on moist brown earth or gleyed soils
29	Grassland or wood edge plants on acid or brown podzolic soils
30	Water edge or aquatic plants on wet humic soils
31	Flush, moorland or water edge plants on soil water gleys
32	Moorland plants on peaty gley soils
33	Moorland or grassland plants on gley or peaty podzolic soils
34	Moorland plants on wet peaty gley soils
35	Heath or moorland plants on podzols or brown podzolic soils
36	Bog, water edge or aquatic plant on peaty soils
37	Bog or heath plants on deep, raw peat soils

6

Species group	GB						ARABLE						PASTURAL						MARGINAL UPLAND						UPLAND				
	B	H	R	S	X	Y	B	H	R	S	X	Y	B	H	R	S	X	Y	B	H	R	S	X	Y	B	R	S	X	Y
Crop or crop edge plants on fertile soils	+	+	+	.	+	.	+	+	+	+	+	+	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.
Crops, crop edge or grassland on eutrophic soils	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.
Woods, tall grasslands or wood edge plants on brown earth soils	+	1	1	+	.	+	+	2	1	+	.	+	+	1	1	+	.	+	.	+	+	.	.	.	.	.	.	.	.
Tall grassland plants on calcareous brown earths	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood edge, tall grassland or grassland plants on brown earths, often humus rich	1	2	1	1	.	+	2	2	2	2	+	1	2	2	2	1	+	+	+	2	+	+	.	.	.	.	.	.	.
Water edge plants on wet alluvial soils	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Crops or crop edge plants on brown earth soils	+	.	+	.	+	.	+	.	+	.	+	.	+	.	+	.	+	.	+	+	+	.	+	.	.	.	.	.	.
Woodland edge or scrub plants on brown earth soils	+	2	.	.	.	.	+	2	.	.	.	.	+	2	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Maritime saline or fresh water edge plants on gleyed brown earths	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Grassland, tall grassland plants on wood edges on variable soils	+	+	+	+	+	+	+	+	+	1	+	+	+	+	+	+	+	+	+	+	+	+	+	.	+	+	.	.	.
Water edge plants on saturated gleyed alluvial soils	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Grassland or tall grassland plants on brown earth soils	1	1	3	+	1	+	1	+	3	+	1	+	2	1	3	+	2	+	1	2	3	+	1	+	+	1	.	.	.
Grassland plants on brown earths, often skeletal and calcareous	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood or wood edge plants on calcareous or neutral brown earths	+	1	+	+	.	+	+	+	+	+	+	+	+	1	+	1	.	+	.	1	+	+	.	.	.	.	.	.	.
Tall grassland plants on damp gleyed brown earths	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
River edge or aquatic plants on wet alluvial soils	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Woodland or wood edge plants on brown earth soils	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.
Grassland plants on semi-fertile, sometimes rocky, brown earths	+	+	2	+	+	+	+	+	2	+	+	+	+	+	2	+	1	+	+	1	2	+	+	+	+	1	+	+	+
Grassland plants on calcareous brown earths	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.
Wood or wood edge plants on damp fertile brown earths	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	+	.	+	.	.	.	.	.	.	.
Water edge or aquatic plants on hydromorphic soils	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	+	.	.	.	.	.	.	.
Grassland wood edge or scrub plants on brown earths	3	2	4	3	3	2	2	1	3	3	2	2	3	2	4	3	4	3	4	4	5	4	4	2	4	5	3	1	1
Marsh, wood edge or woodland plants on wet gleyed brown earths	.	.	.	+	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	.	+	.	+	.	.	+	.	.
Woodland or woodland edge plants on acid brown earths	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	+	+	+	+	.	+	+	+	+	.
Marsh or water edge plants on soil water gleys	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	+	.	+	.	.	+	.	.
Plants of maritime habitats on variable soils	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wood, wood edge, scrub, grassland or heath plants on acid or neutral brown earths	+	+	+	+	+	+	+	.	+	+	+	+	+	+	+	+	+	+	1	1	1	1	1	+	+	2	1	+	+
Grassland marsh or water edge plants on moist brown earth or gleyed soils	+	.	+	1	+	+	.	.	.	+	+	+	+	.	+	1	+	+	+	+	+	2	1	+	1	2	2	+	+
Grassland or wood edge plants on acid or brown podzolic soils	+	.	+	1	+	+	.	.	.	.	+	+	+	.	+	+	+	+	1	+	1	2	2	1	2	2	3	2	2
Water edge or aquatic plants on wet humic soils	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Flush, moorland or water edge plants on soil water gleys	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	+	.	+	.		.	1	+	+	+	+	1	+	+
Moorland plants on peaty gley soils	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.		.	+	+	+	+	+	2	+	+
Moorland or grassland plants on gley or peaty podzolic soils	+	.	+	1	+	+	.	.	.	.	.	.	.	.	.	+	+	+	+	.	+	2	2	1	1	2	3	3	2
Moorland plants on wet peaty gley soils	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.		.	+	+	+	+	+	+	1	+
Heath or moorland plants on podzols or brown podzolic soils	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	+	1	+	+	+	2	3	1
Bog, water edge or aquatic plant on peaty soils	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.		.	.	.	.	.	.	+	+	+
Bog or heath plants on deep, raw peat soils	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.		.	+	+	+	+	.	1	3	1
Mean number of species groups per quadrat	7	8	8	10	6	7	7	7	8	9	6	6	8	8	9	10	7	7	7	10	8	10	7	6	8	9	9	7	6

7

		Number of records	Species group
1	*Holcus lanatus*	5853	22
2	*Dactylis glomerata*	5114	12
3	*Agrostis stolonifera*	4872	22
4	*Lolium perenne*	4679	12
5	*Urtica dioica*	4282	5
6	*Ranunculus repens*	4221	22
7	*Agrostis capillaris*	3922	27
8	*Trifolium repens*	3867	22
9	*Festuca rubra*	3562	22
10	*Arrhenatherum elatius*	3392	5
11	*Taraxacum officinale*	3230	18
12	*Rubus fruticosus*	3155	14
13	*Cirsium arvense*	3105	9
14	*Elymus repens*	3068	2
15	*Cerastium fontanum*	3011	22
16	*Poa annua*	2918	12
17	*Galium aparine*	2863	5
18	*Anthoxanthum odoratum*	2813	29
19	*Potentilla erecta*	2710	33
20	*Plantago lanceolata*	2617	22

8

a)

% of species	BOUNDARY			HEDGE			ROADSIDES				STREAMSIDES					MAIN					HABITAT			
	20	30	40	10	20	30	20	30	40	50	30	40	50	60	70	20	30	40	50	60	30	40	50	60
Arable	-	6	3	2	7	-	-	-	9	-	-	7	2	-	-	4	3	2	-	-	1	7	1	-
Pastural	-	10	-	4	6		-	1	9	-	-	7	3	-	-	-	5	5	-	-	-	10	-	-
Marginal upland	1	5	-	-	3		-	1	4	1	-	1	3	2	-	-	-	2	3	1	-	4	1	1
Upland	2	5	-	-	-		1	1	5	-	-	-	1	5	1	-	-	1	3	3	-	-	6	1

b)

mean species richness	BOUNDARY			HEDGE			ROADSIDES			STREAMSIDES			MAIN			HABITAT		
	<10	20	20	<10	10	20	<10	11-20	21-31	<10	11-20	21-30	<10	11-20	21-31	<10	11-20	21-31
Arable	2	7	-	2	7	-	-	9	-	1	8	-	5	4	-	4	5	-
Pastural	-	10	-	-	10	-	-	9	1	-	9	1	1	9	-	1	5	-
Marginal upland	-	6	-	-	3	-	-	6	-	-	4	2	-	5	1	1	5	-
Upland	-	7	-	-	-	-	-	4	3	-	2	5	-	2	5	3	3	-

c)

mean species richness	60-70	71-90	91-110
Arable	4	4	-
Pastural	1	5	4
Marginal upland	1	5	-
Upland	3	3	1

9

Agregate Class		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Arable Landscape	*1 Crops/weeds*	5	1	10	8	77	19
	2 Tall grass/herb	33	7	43	73	8	35
	3 Fertile grassland	22	2	65	57	21	34
	4 Infertile grassland	23	1	30	74	18	62
	5 Lowland wooded	39	28	5	34	24	27

Aggregate Class		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Pastural Landscape	*1 Crops/weeds*	13	0	7	0	121	19
	2 Tall grass/herb	43	8	48	59	15	25
	3 Fertile grassland	27	0	21	51	44	39
	4 Infertile grassland	13	3	25	48	38	77
	5 Lowland wooded	21	21	2	41	26	24
	6 Upland wooded	12	1	5	82	20	28

Aggregate Class		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Marginal Upland Landscape	*4 Infertile grassland*	10	3	34	40	22	49
	5 Lowland wooded	3	11	6	28	16	9
	6 Upland wooded	6	2	9	68	9	29
	7 Moorland/grass mosaic	5	-	14	49	33	41
	8 Heath/bog	2	-	2	6	47	34

Aggregate Class		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Upland Landscape	*4 Infertile grassland*	8	-	32	40	13	28
	6 Upland wooded	2	-	5	38	31	31
	7 Moorland/grass mosaic	3	-	8	46	27	36
	8 Heath/bog	2	-	1	23	59	24

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		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Arable Landscape	*1 Crops/weeds*						
	2 Tall grass/herb	4	5	32	26	6	1
	3 Fertile grassland			7	4	1	
	4 Infertile grassland	2		12	15	13	
	5 Lowland wooded	4	11	3	2	3	1

		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Pastural Landscape	*1 Crops/weeds*	-	-	-	-	-	-
	2 Tall grass/herb	1	4	30	11	2	1
	3 Fertile grassland	-	-	2	3	2	-
	4 Infertile grassland	-	6	24	33	29	2
	5 Lowland wooded	2	13	13	23	14	-
	6 Upland wooded	4	3	5	18	7	-

		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Marginal Upland Landscape	*4 Infertile grassland*	3	5	8	14	22	-
	6 Upland wooded-	-	-	-	-	-	
	7 Moorland/grass mosaic	-	-	14	54	34	-
	8 Heath/bog	1	-	-	2	8	-

		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
Upland Landscape	*4 Infertile grassland*	1	-	9	27	11	-
	6 Upland wooded	-	-	4	15	2	1
	7 Moorland/grass mosaic	4	-	22	37	48	1
	8 Heath/bog	1	-	2	8	-	-

		BOUNDARY	HEDGE	ROADSIDES	STREAMSIDES	X	Y
All Landscapes	*Arable*	10	16	54	47	23	2
	Pastural	7	26	74	88	54	3
	Marginal upland	4	5	22	70	62	0
	Upland	5	-	35	98	101	2
	All	16	47	185	303	240	7

CS1990 Group		CVS Aggregate Class	
1	Weeds/crops	I	Weeds/crops
		II	Tall grassland/herb
2	Improved grassland	III	Fertile grassland
3	Unimproved grassland	IV	Infertile grassland
		V	Lowland wooded
		VI	Upland wooded
4	Woodland		
5	Grass mosaic	VII	Grass mosaic/moorland
6	Heath/bog	VIII	Heath/bog

		Plot type				
Landscape	**Aggregate class**	**H**	**R**	**S**	**X**	**Total**
AG	1	1	6	0	**190**	**197**
	2	47	**53**	**37**	7	**144**
	3	2	**67**	**15**	**85**	**169**
	4	8	13	**23**	**64**	**108**
	5	**72**	**4**	**12**	13	**101**
	6	0	0	7	7	14
	7	0	0	0	6	6
	8	0	0	0	**8**	**8**
AG Total		130	143	94	380	747
MA	1	0	0	0	5	5
	2	7	**1**	2	0	10
	3	2	**17**	1	**18**	**38**
	4	**10**	**25**	**16**	**59**	**110**
	5	2	0	1	1	**4**
	6	3	3	**12**	13	**31**
	7	0	5	**19**	**45**	**69**
	8	0	0	**6**	**34**	**40**
MA Total		24	51	57	175	307
PA	1	0	3	2	**84**	**89**
	2	**42**	**45**	**25**	9	**121**
	3	3	**40**	**12**	**111**	**166**
	4	**18**	**31**	**32**	**112**	**193**
	5	**58**	**8**	**18**	10	**94**
	6	3	3	**22**	24	52
	7	0	3	7	17	27
	8	0	0	2	18	20
PA Total		124	133	120	385	762
UP	1	0	0	0	2	2
	3	0	3	0	9	12
	4	0	9	9	5	23
	5	0	0	1	0	1
	6	0	1	10	**33**	**44**
	7	0	16	**56**	**57**	**129**
	8	0	1	**25**	**203**	**229**
UP Total		0	30	101	309	440
GB	1	1	9	2	**281**	293
	2	**96**	**99**	**64**	16	275
	3	7	**127**	28	**223**	385
	4	**36**	**78**	**80**	**240**	434
	5	**132**	12	32	24	200
	6	6	7	**51**	77	141
	7	0	24	**82**	**125**	231
	8	0	1	33	**263**	297
GB Total		278	357	372	1249	2256

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	TOTAL	+	-	NS
All Plots	28	3	13	12
Main plots	20	3	8	9
Hedge plots	10	0	4	6
Verge plots	14	4	0	10
Streamside plots	22	1	7	11

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Land scape Type	*Aggr Cl.*	*Plot Count*	*Mean Species 1978*	*Mean Species 1990*	*Change in Mean*	*Change in %*	*T Value*
AG	**1**	**173**	**6.49**	**4.15**	**-2.34**	**-36.06**	**-4.97****
	2	**118**	**12.07**	**12.67**	**0.60**	**4.99**	**1.08**
	3	**139**	**13.18**	**10.86**	**-2.32**	**-17.36**	**-3.78****
	4	**91**	**20.14**	**16.73**	**-3.42**	**-16.97**	**-4.23****
	5	**77**	**10.79**	**12.86**	**2.06**	**19.13**	**2.44***
	6	*12*	*25.08*	*20.58*	*-4.50*	*-17.94*	*-0.83*
	7	*5*	*29.60*	*23.20*	*-6.40*	*-21.62*	*-1.88*
	8	*8*	*11.25*	*15.50*	*4.25*	*37.78*	*-3.57***
PA	**1**	**75**	**7.56**	**7.37**	**-0.19**	**-2.47**	**-0.26**
	2	**100**	**14.39**	**15.04**	**0.65**	**4.52**	**0.83**
	3	**152**	**11.91**	**12.34**	**0.43**	**3.59**	**0.71**
	4	**169**	**21.14**	**17.18**	**-3.95**	**-18.70**	**-5.58****
	5	**71**	**14.34**	**12.45**	**-1.89**	**-13.16**	**-2.29***
	6	**47**	**16.32**	**12.43**	**-3.89**	**-23.86**	**-3.42****
	7	**27**	**24.26**	**19.96**	**-4.30**	**-17.71**	**-2.67***
	8	*18*	*16.50*	*13.06*	*-3.44*	*-20.88*	*-2.44**
MA	*1*	*4*	*7.50*	*14.25*	*6.75*	*90.00*	*2.45*
	2	*9*	*17.89*	*15.56*	*-2.33*	*-13.04*	*-1.84*
	3	**32**	**13.13**	**15.34**	**2.22**	**16.90**	**1.47**
	4	**96**	**22.11**	**21.11**	**-1.00**	**-4.52**	**-1.07**
	5	*3*	*14.33*	*17.33*	*3.00*	*20.93*	*1.41*
	6	**25**	**20.80**	**13.84**	**-6.96**	**-33.46**	**-3.58****
	7	**65**	**17.77**	**20.37**	**2.60**	**14.63**	**2.26***
	8	**35**	**12.06**	**14.29**	**2.23**	**18.48**	**1.99**
UP	*1*	*2*	*5.00*	*7.00*	*2.00*	*40.00*	*2.00*
	3	*10*	*9.60*	*11.80*	*2.20*	*22.92*	*1.66*
	4	*19*	*22.32*	*21.00*	*-1.32*	*-5.90*	*-0.63*
	6	**41**	**23.44**	**20.41**	**-3.02**	**-12.90**	**-1.54**
	7	**113**	**23.74**	**21.03**	**-2.72**	**-11.44**	**-2.53***
	8	**209**	**18.90**	**19.98**	**1.08**	**5.69**	**1.92**
GB	**1**	**254**	**6.81**	**5.28**	**-1.53**	**-22.43**	**-3.86****
	2	**227**	**13.32**	**13.83**	**0.51**	**3.8**	**1.12**
	3	**333**	**12.49**	**11.99**	**-0.50**	**-3.97**	**-1.20**
	4	**375**	**21.21**	**18.27**	**-2.93**	**-13.83**	**-6.38****
	5	**151**	**12.53**	**12.75**	**0.23**	**1.80**	**0.37**
	6	**125**	**20.39**	**16.11**	**-4.28**	**-20.99**	**-4.27****
	7	**210**	**22.10**	**20.74**	**-1.36**	**-6.16**	**-1.85**
	8	**270**	**17.63**	**18.65**	**1.02**	**5.78**	**2.14***

X-PLOTS

Land scape Type	Agg Cl	Plot Count	Mean Species 1978	Mean Species 1990	Change in Mean	Change in %	T Value
AG	1	167	6.47	3.84	-2.63	-2.63	-5.60**
	2	4	16.50	12.75	-3.75	-3.75	-2.02
	3	63	10.30	7.51	-2.79	-2.79	-3.46**
	4	52	20.67	17.21	-3.46	-3.46	-2.88**
	5	12	12.92	20.83	7.92	7.92	2.38*
	6	6	17.67	18.67	1.00	1.00	0.13
	7	5	29.60	23.20	-6.40	-6.40	-1.88
	8	8	11.25	15.50	4.25	4.25	3.28*
PA	1	72	7.56	7.19	-0.36	-4.78	-0.50
	2	9	9.67	15.22	5.56	57.47	1.41
	3	103	10.88	10.90	0.02	0.18	0.03
	4	105	21.84	16.84	-5.00	-22.90	-5.30**
	5	10	14.10	12.10	-2.00	-14.18	-1.14
	6	24	14.79	10.54	-4.25	-28.73	-4.40**
	7	17	25.71	22.35	-3.35	-13.04	-1.70
	8	16	15.63	12.25	-3.38	-21.60	-2.16*
MA	1	4	7.50	14.25	6.75	90.00	2.45
	3	16	122.31	13.06	0.75	6.09	0.30
	4	54	22.22	21.61	-0.61	-2.75	-0.49
	6	13	21.23	11.77	-9.46	-44.57	2.96
	7	43	17.60	20.35	2.74	15.59	1.87
	8	31	12.16	14.55	2.39	19.63	1.89
UP	1	2	5..00	7.00	2.00	40.00	2.00
	3	8	9.00	10.75	1.75	19.44	1.15
	4	4	22.50	25.75	3.25	14.44	1.25
	6	31	23.00	20.39	-2.61	-11.36	-1.17
	7	49	23.94	22.43	-1.51	-1.51	-0.79
	8	186	18.67	19.48	0.81	0.81	1.42
GB	1	245	6.80	5.02	-1.77	-26.07	-4.45**
	2	13	11.77	14.46	2.69	22.88	0.91
	3	190	10.73	9.95	-0.78	-7.26	-1.47
	4	215	21.67	18.29	-3.37	-15.56	-5.25**
	5	22	13.45	16.86	3.41	25.34	1.55
	6	74	19.59	15.54	-4.05	-20.69	-3.14**
	7	114	22.06	21.67	-0.39	-1.79	-0.37
	8	241	17.39	18.24	0.85	4.89	1.74

R-PLOTS

Land scape Type	Agg Cl.	Plot Count	Mean Species 1978	Mean Species 1990	Change in Mean	Change in %	T Value
AG	1	6	7.00	12.67	5.67	80.95	2.67**
	2	43	13.21	14.60	1.40	10.56	1.66
	3	60	15.30	13.85	-1.45	-9.48	-1.41
	4	12	19.33	16.92	-2.42	-12.50	-1.00
	5	3	11.67	20.00	8.33	71.43	1.00
PA	1	1	10.00	18.00	8.00	80.00	1.00
	2	40	13.90	17.05	3.15	22.66	2.75**
	3	36	13.61	15.50	1.89	13.88	1.79
	4	24	20.88	19.63	-1.25	-5.59	-0.81
	5	4	17.50	17.25	-0.25	-1.43	-0.09
	6	3	21.67	17.67	-4.00	-18.46	-2.32
	7	3	22.00	15.33	-6.67	-30.30	-1.71
MA	2	1	7.00	11.00	4.00	57.14	1.00
	3	14	14.64	17.43	2.79	19.02	1.79*
	4	20	18.35	18.80	0.45	2.45	0.32
	6	1	29.00	16.00	-13.00	-44.83	-1.00
	7	4	18.00	18.25	0.25	1.39	0.06
UP	3	2	12.00	16.00	4.00	33.33	1.22
	4	9	18.44	19.44	1.00	5.42	0.44
	6	1	10.00	15.00	5.00	50.00	1.00
	7	16	21.56	21.38	-0.19	-0.87	-0.08
	8	1	21.00	24.00	3.00	14.29	0.00
GB	1	7	7.43	13.43	6.00	80.77	3.23*
	2	84	13.46	15.73	2.26	16.80	3.24**
	3	112	14.62	14.87	0.25	1.71	0.36
	4	65	19.48	18.85	-0.63	-3.24	-0.71
	5	7	15.00	18.43	3.43	22.86	0.88
	6	5	20.80	16.80	-4.00	-9.23	-1.35
	7	23	21.00	20.04	-0.96	-4.55	-0.52
	8	1	21.00	24.00	3.00	14.29	0.00

H-PLOTS

Land scape Type	***Aggr. Cl.***	***Plot Count***	***Mean Species 1978***	***Mean Species 1990***	***Change in Mean***	***Change in %***	***T Value***
AG	**2**	**38**	**11.58**	**9.95**	**-1.63**	**-14.09**	**-1.64**
	3	*2*	*14.00*	*5.50*	*-8.50*	*-60.71*	*-1.78*
	4	*6*	*14.50*	*8.50*	*-6.00*	*-41.38*	*-2.81**
	5	**52**	**9.85**	**10.67**	**0.83**	**8.40**	**1.14**
PA	**2**	**31**	**14.16**	**12.23**	**-1.94**	**-13.67**	**-1.85**
	3	*3*	*12.67*	*11.00*	*-1.67*	*-13.16*	*-0.78*
	4	*11*	*16.82*	*14.64*	*-2.18*	*-12.97*	*-1.23*
	5	**43**	**13.44**	**11.95**	**-1.49**	**-11.07**	**-1.37**
	6	*1*	*31.00*	*11.00*	*-20.00*	*-64.52*	*0.00*
MA	*2*	*7*	*19.29*	*16.29*	*-3.00*	*-15.56*	*-2.29*
	3	*1*	*9.00*	*9.00*	*0.00*	*0.00*	*0.00*
	4	*7*	*18.00*	*19.14*	*1.14*	*6.35*	*0.35*
	5	*2*	*122.50*	*16.50*	*4.00*	*32.00*	*1.22*
	6	*1*	*28.00*	*25.00*	*-3.00*	*-10.71*	*-1.00*
GB	**2**	**76**	**13.34**	**11.46**	**-1.88**	**-14.10**	**-2.85****
	3	*6*	*12.50*	*8.83*	*-3.67*	*-29.33*	*-1.82*
	4	**24**	**16.58**	**14.42**	**-2.17**	**-13.07**	**-1.54**
	5	**97**	**11.49**	**11.36**	**-0.13**	**-1.17**	**-0.21**
	6	*2*	*29.50*	*18.00*	*-11.50*	*-38.98*	*-1.35*

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S-PLOTS

Land scape Type	*Aggr Cl.*	*Plot Count*	*Mean Species 1978*	*Mean Species 1990*	*Change in Mean*	*Change in %*	*T Value*
AG	**2**	**33**	**10.61**	**13.27**	**2.67**	**25.14**	**2.53***
	3	14	16.93	13.86	-3.07	-18.14	-1.45
	4	**21**	**20.90**	**17.76**	**-3.14**	**-15.03**	**-2.62***
	5	10	12.90	12.50	-0.40	-3.10	-0.23
	6	6	32.50	22.50	-10.00	-30.77	-1.27
PA	1	2	6.50	8.50	2.00	30.77	0.45
	2	20	17.85	15.30	-2.55	-14.29	-1.59
	3	10	16.10	16.10	0.00	0.00	0.00
	4	**29**	**20.45**	**17.38**	**-3.07**	**-15.01**	**-1.74**
	5	14	16.36	12.86	-3.50	-21.40	-1.64
	6	19	16.63	14.05	-2.58	-15.51	-1.07
	7	7	21.71	16.14	-5.57	-25.66	-1.41
	8	2	23.50	19.50	-4.00	-17.02	-1.00
MA	1	1	19.00	15.00	-4.00	-21.05	-1.00
	3	1	9.00	29.00	20.00	222.22	1.00
	4	15	28.67	23.33	-5.33	-18.60	-1.75
	5	1	18.00	19.00	1.00	5.56	1.00
	6	10	18.70	15.20	-3.50	-18.72	-1.55
	7	18	18.11	20.89	2.78	15.34	1.35
	8	4	11.25	12.25	1.00	8.89	1.21
UP	4	6	28.00	20.17	-7.83	-27.98	-1.62
	6	9	26.44	21.11	-5.33	-20.17	-1.13
	7	**48**	**24.27**	**19.48**	**-4.79**	**-19.74**	**-3.46****
	8	**22**	**20.77**	**24.00**	**3.23**	**15.54**	**1.42**
GB	1	2	6.50	8.50	2.00	30.77	0.45
	2	**54**	**13.44**	**14.06**	**0.61**	**4.55**	**0.65**
	3	**25**	**16.28**	**15.36**	**-0.92**	**-5.56**	**-0.45**
	4	**71**	**22.96**	**18.99**	**-3.97**	**-17.30**	**-3.66****
	5	**25**	**15.04**	**12.96**	**-2.08**	**-13.83**	**-1.49**
	6	**44**	**21.27**	**16.91**	**-4.36**	**-20.51**	**-2.42***
	7	**73**	**22.51**	**19.51**	**-3.00**	**-13.33**	**-2.59***
	8	**28**	**19.61**	**22.00**	**2.39**	**12.20**	**1.30**

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Arable landscape; matrix of change between aggregate classes

					90					
		1	2	3	4	5	6	7	8	
	1	**115**	16	16	2					149
	2	4	**88**	13	6	22	1			134
	3	26	36	**60**	23	3				148
78	4	3	13	18	**59**	8	1			102
	5		25		1	**63**	3			92
	6			1	5	2	**6**			14
	7				2		2	**1**	1	6
	8			1				2	**5**	8
		148	178	109	98	98	13	3	6	653

Change 78 to 90

	78	90	78 to 90
1	149	148	-1
2	134	178	44
3	148	109	-39
4	102	98	-4
5	92	98	6
6	14	13	-1
7	6	3	-3
8	8	6	-2

Gross movement of fertile grassland to tall grassland.
Movement of infertile grassland to fertile and tall grassland.

Pastural landscape; matrix of change between aggregate classes

					90					
		1	2	3	4	5	6	7	8	
	1	**45**	3	23	3					74
	2	1	**62**	12	11	27	2			115
	3	16	19	**87**	36	2				160
78	4	7	24	37	**97**	5	8	5		183
	5	1	25		2	**50**	10			88
	6		3	1	7	6	**30**	1	1	49
	7				4		6	**14**	3	27
	8				1		2	2	**15**	20
		70	136	160	161	90	58	22	19	716

Change 78 to 90

	78	90	78 to 90
1	74	70	-4
2	115	136	21
3	160	160	0
4	183	161	-22
5	88	90	2
6	49	58	9
7	27	22	-5
8	20	19	-1

Infertile grassland to tall grassland.
Smaller trend from moorland/grass mosaic to upland wooded.

Marginal Upland landscape; matrix of change between aggregate classes

					90					
		1	2	3	4	5	6	7	8	
	1	**1**		3	1					5
	2		**4**	2	3	1				10
	3	3	2	**18**	14		1	1		39
78	4		7	14	**71**	3	9	6		110
	5					**2**	2			4
	6		1			6	**21**		1	29
	7				9		5	**47**	8	69
	8				2		- 1	10	**27**	40
		4	14	37	100	12	39	64	36	306

Change 78 to 90

	78	90	78 to 90
1	5	4	-1
2	10	14	4
3	39	37	-2
4	110	100	-10
5	4	12	8
6	29	39	10
7	69	64	-5
8	40	36	-4

Increase in lowland and upland wooded.
Losses from infertile grassland.

Upland landscape; matrix of change between aggregate classes

					90					
		1	2	3	4	5	6	7	8	
	1			2						2
	2									0
	3	2		**5**	4				1	12
78	4			1	**14**		3	5		23
	5									0
	6				1		**19**	18	4	42
	7				11		12	**78**	24	125
	8				1		8	36	**174**	219
		2	0	8	31	0	42	137	203	423

Change 78 to 90

	78	90	78 to 90
1	2	2	0
2	0	0	0
3	12	8	-4
4	23	31	8
5	0	0	0
6	42	42	0
7	125	137	12
8	219	203	-16

Loss of heath/bog
to moorland/grass mosaic.

Whole of GB; matrix of change between aggregate classes

					90					
		1	2	3	4	5	6	7	8	
	1	**161**	19	44	6					230
	2	5	**154**	27	20	50	3			259
	3	47	57	**170**	77	5	1		1	358
78	4	10	44	70	**241**	16	21	16		418
	5	1	50		3	**115**	15			184
	6		4	2	13	14	**76**	19	6	134
	7				26		25	**140**	36	227
	8			1	4		11	50	**221**	287
		224	328	314	390	200	152	225	264	2097

Change 78 to 90

	78	90	78 to 90
1	230	224	-6
2	259	328	69
3	358	314	-44
4	418	390	-28
5	184	200	16
6	134	152	18
7	227	225	-2
8	287	264	-23

Increase in tall grassland and losses from fertile and infertile grassland.
Losses from heath/bog to upland wooded and moorland/grass mosaic.
Losses from tall grassland and infertile grassland to lowland wooded.

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	STOCK	CHANGE
Indicator species for unimproved grasslands	YES	YES
Notable/rare species in a) 1-100 hectads b) 101-200 hectads.	YES	YES
All species 'faithful' to unimproved, neutral grassland (=MG5 defined by NVC)	YES	NO
Species defining minimum representation of MG5	YES	YES
Butterfly larval food plants	YES	YES
CVS aggregate class preferentials grouped by abundance	YES	YES
Food plants for lowland farmland birds	YES	YES

CALCAREOUS GRASSLAND INDICATORS

Arable	**X**	**R+V**	**B**	**H**	**S+W**	**Sig**	**Y**
Total count	128	***95***	91	11	43	*	79
% of plots with at least 1 present	5.6	***8.2***	6.4	2.9	5.8		4.6

Pastural							
Total count	***117***	68	41	1	51	**	214
% of plots with at least 1 present	***9.9***	8.1	4.8	0.4	6.6		14.6

Coastal							
Total count	***155***	41	36	0	***83***	**	136
% of plots with at least 1 present	***32.7***	16.5	14.7	0	***31.2***		26.4

ACID GRASSLAND INDICATORS

Arable	**X**	**R+V**	**B**	**H**	**S+W**	**Sig**	**Y**
Total count	640	405	451	53	***747***	**	874
% of plots with at least 1 present	24.6	28.5	28.7	16.2	***40.4***		38.9

Pastural							
Total count	1268	657	710	154	***1429***	**	1629
% of plots with at least 1 present	43.8	47.1	46.8	40.3	***61.7***		62.3

Marginal Uplands							
Total count	2267	694	612	70	***2189***	**	1907
% of plots with at least 1 present	86.8	75.2	83.9	73.8	***93.9***		93.5

Uplands							
Total count	5731	937	650	_	***5358***	**	3684
% of plots with at least 1 present	94.2	88.3	93.3	_	***98.9***		97.1

Coastal							
Total count	1673	431	332	12	***1398***	**	1095
% of plots with at least 1 present	66.7	57.5	56	22.6	***80.5***		72.2

21 contd.

MESOTROPHIC GRASSLAND INDICATORS

Arable	**X**	**R+V**	**B**	**H**	**S+W**	**Sig**	**Y**
Total count	500	485	415	69	***772***	**	971
% of plots with at least 1 present	22.3	33.5	27.8	20.6	***47.5***		44.7
Pastural							
Total count	909	660	538	106	***1319***	**	1565
% of plots with at least 1 present	34.2	44.5	36.9	26.5	***65.7***		63.7
Marginal Uplands							
Total count	981	400	272	45	***1329***	**	1055
% of plots with at least 1 present	70.4	62.2	53.6	50	***88.1***		79.5
Uplands							
Total count	2265	505	314	0	***2811***	**	1780
% of plots with at least 1 present	84.3	79.8	78.3	0	***94.4***		81.9
Coastal							
Total count	1010	281	248	9	***1007***	**	838
% of plots with at least 1 present	60.9	50.9	47.8	22.6	***81.8***		71.9

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LANDSCAPE AFFINITY

1 to 100 hectads	**Arable**	**Pastural**	**Marginal Uplands**	**Uplands**	**Sig**
Total count	22	18	6	***20***	**
% of plots with at least 1 present	0.5	0.5	0.4	***1***	

101 to 200 hectads					
Total count	38	79	18	***39***	**
% of plots with at least 1 present	0.9	1.9	1.1	***2***	

PLOT TYPE AFFINITY

1 to 100 hectads; all GB	**X**	**R+V**	**B**	**H**	**S+W**	**Sig**	**Y**
Total count	***18***	4	4	2	***15***	*	23
% of plots with at least 1 present	***0.7***	0.2	0.2	0.4	***0.7***		0.9

101 to 200 hectads; all GB							
Total count	43	18	15	3	32	ns	63
% of plots with at least 1 present	1.5	0.9	0.8	0.5	1.4		2.4

23

Species	Constancy
Achillea millefolium	3
Lolium perenne	3
Prunella vulgaris	3
Ranunculus acris	3
Ranunculus bulbosus	3
Rumex acetosa	3
Trisetum flavescens	3
Luzula campestris	3
Hypochaeris radicata	3
Leontodon autumnalis	3
Agrostis capillaris	4
Anthoxanthum odoratum	4
Dactylis glomerata	4
Holcus lanatus	4
Trifolium pratense	4
Trifolium repens	4
Centaurea nigra	4
Cynosurus cristatus	5
Festuca rubra agg.	5
Lotus corniculatus	5
Plantago lanceolata	5

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	Arable	Pastural	Marginal upland
Y	1	6	-
R+V	-	-	2
S+W	-	-	1
X	-	7	8

Arable landscape

Aggregate class	Abundance	B	H	R+V	S+W	X	Sig
1	A	1.56	*1.26*	1.50	1.30	*2.14*	***
2	A	4.30	*4.88*	4.83	4.62	*2.04*	***
3	A	2.16	*1.67*	*3.37*	1.98	2.51	***
4	A	3.48	*2.35*	4.45	4.36	*4.46*	***
4	R	1.48	1.17	1.36	*1.08*	*2.26*	**
5	A	2.51	2.92	*1.89*	2.32	*3.17*	***
5	I	1.32	1.24	*1.23*	1.28	*1.76*	*

Marginal upland landscape

Aggregate class	Abundance	B	H	R+V	S+W	X	Sig
3	A	2.23	2.10	*3.05*	*1.73*	2.61	***
4	A	5.21	*4.42*	6.52	6.09	*6.55*	***
6	A	1.83	2.59	*1.81*	*2.98*	2.20	***
7	A	3.84	*2.10*	3.71	6.48	*5.56*	***
8	A	2.97	-	*2.18*	3.29	*5.46*	***

Pastural landscape

Aggregate class	Abundance	B	H	R+V	S+W	X	Sig
1	A	1.49	*1.18*	1.45	1.30	*2.08*	***
2	A	3.54	3.84	*4.46*	3.59	1.99	***
2	I	*1.35*	*1.15*	1.16	1.44	1.19	**
3	A	2.49	*1.78*	*3.41*	2.25	3.12	***
4	A	4.01	*2.95*	5.11	5.02	*5.54*	***
4	I	1.47	*1.07*	1.28	1.55	*1.60*	***
5	A	2.99	*3.87*	*2.83*	2.90	3.67	***
5	I	*1.16*	1.23	*1.16*	*1.55*	1.41	***

Upland landscape

Aggregate class	Abundance	B	R+V	S+W	X	Sig
6	A	1.83	*1.53*	*2.39*	1.97	***
7	A	5.80	*5.59*	*8.47*	6.46	***
7	I	*1.49*	1.73	2.00	*2.08*	*
8	A	4.20	*2.77*	4.99	*8.48*	***
8	I	1.77	*1.33*	2.00	*2.51*	***

	Aggregate class							
Landscape type	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Arable	***2.4***	6.0	6.7	***8.1***	4.5	4.8	7.2	4.6
Marginal Upland	4.1	7.4	7.2	***9.2***	***3.9***	5.4	7.5	4.8
Pastural	***3.1***	7.1	7.1	***8.8***	5.1	5.3	8.1	4.7
Upland	***3.3***	6.0	6.7	***8.5***	-	5.1	7.8	5.3

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	Aggregate class				
Landscape type	**1**	**2**	**3**	**4**	**5**
Arable	***45.0***	32.2	37.9	31.6	***29.5***
Pastural	***50.2***	34.9	41.0	32.2	***28.4***

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		Aggregate class				
Bird species	**Landscape type**	**1**	**2**	**3**	**4**	**5**
Tree Sparrow	**Arable**	***13.4 (19.6)***	1.9 (1.4)	4.1 (4.2)	***1.4 (0.8)***	2.7 (1.1)
	Pastural	***23.2 (34.4)***	2.4 (2.0)	2.7 (2.8)	1.6 (1.0)	***1.5 (0.4)***
Cirl Bunting	**Arable**	***10.3 (14.1)***	***4.6 (10.9)***	6.8 (15.5)	5.2 (10.3)	5.2 (5.1)
	Pastural	***17.7 (25.6)***	5.6 (10.7)	5.8 (14.9)	5.1 (8.1)	***4.3 (4.2)***
Grey Partridge	**Arable**	***15.3 (23.8)***	5.0 (13.1)	10.4 (30.1)	7.9 (25.3)	***4.6 (5.3)***
	Pastural	***26.1 (41.9)***	6.2 (15.2)	11.9 (37.7)	8.3 (25.3)	***3.7 (4.6)***
Bullfinch	**Arable**	***4.7 (7.7)***	15.4 (35.5)	4.8 (8.8)	5.5 (10.8)	***38.3 (74.7)***
	Pastural	6.5 (14.4)	18.9 (48.1)	***4.9 (10.1)***	7.4 (13.3)	***32.8 (68.3)***

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Calcicoles	Sig	Total 78	Total 90	% change	Chi-square
GB	ns	255	276	-	1.4
Arable	ns	54	40	-	3.44
Pastural	ns	56	61	-	0.05
Coastal	**	55	87	58.2	14.56
Mesotrophic species					
GB	**	1156	1068	-7.6	16.38
Arable	ns	226	195	-	1.39
Pastural	**	333	296	-11.1	7.01
Marginal upland	ns	219	214	-	0.25
Upland	ns	378	363	-	3.44
Coastal	ns	166	171	-	0.36
Acidophiles					
GB	**	1243	1189	-4.3	6.92
Arable	ns	201	180	-	2.72
Pastural	ns	370	352	-	1.45
Marginal upland	ns	264	258	-	0.57
Upland	*	408	399	-2.2	4.27
Coastal	ns	173	178	-	0.28

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	Sig	Total 78	Total 90	% change	Chi-sqr
GB	**	685	624	-8.9	9.5
Arable	*	86	67	-22.1	3.9
Pastural	*	153	130	-15	4.14
Marginal Upland	ns	128	122	-	0.36

Landscape		Aggregate class	Abundance	Change	SIG
AG	I	Crops/weeds	A	-	***
AG	II	Tall grassland/herb	A	+	***
AG	III	Fertile grasslands	A	-	***
AG	IV	Infertile grasslands	A	-	**
AG	V	Lowland wooded	A	.	ns
AG	I	Crops/weeds	I	.	ns
AG	II	Tall grassland/herb	I	.	ns
AG	III	Fertile grasslands	I	+	**
AG	IV	Infertile grasslands	I	.	ns
AG	V	Lowland wooded	I	.	ns
AG	I	Crops/weeds	R	.	ns
AG	II	Tall grassland/herb	R	.	ns
AG	III	Fertile grasslands	R	.	ns
AG	IV	Infertile grasslands	R	.	ns
AG	V	Lowland wooded	R	+	*
PA	I	Crops/weeds	A	.	ns
PA	II	Tall grassland/herb	A	+	**
PA	III	Fertile grasslands	A	.	ns
PA	IV	Infertile grasslands	A	-	***
PA	V	Lowland wooded	A	.	ns
PA	I	Crops/weeds	I	.	ns
PA	II	Tall grassland/herb	I	-	*
PA	III	Fertile grasslands	I	.	ns
PA	IV	Infertile grasslands	I	.	ns
PA	V	Lowland wooded	I	-	**
PA	I	Crops/weeds	R	.	ns
PA	II	Tall grassland/herb	R	.	ns
PA	III	Fertile grasslands	R	.	ns
PA	IV	Infertile grasslands	R	.	ns
PA	V	Lowland wooded	R	.	ns
MA	III	Fertile grasslands	A	.	ns
MA	IV	Infertile grasslands	A	.	ns
MA	VI	Upland wooded	A	.	ns
MA	VII	Moorland/grass mosaic	A	.	ns
MA	VIII	Heath/bog	A	.	ns
MA	III	Fertile grasslands	I	.	ns
MA	IV	Infertile grasslands	I	.	ns
MA	VI	Upland wooded	I	.	ns
MA	VII	Moorland/grass mosaic	I	.	ns
MA	VIII	Heath/bog	I	+	*
MA	IV	Infertile grasslands	R	.	ns
MA	VI	Upland wooded	R	.	ns
MA	VII	Moorland/grass mosaic	R	.	ns
MA	VIII	Heath/bog	R	.	ns
UP	II	Tall grassland/herb	A	.	ns
UP	VI	Upland wooded	A	.	ns
UP	VII	Moorland/grass mosaic	A	.	ns
UP	VIII	Heath/bog	A	.	ns
UP	II	Tall grassland/herb	I	.	ns
UP	VI	Upland wooded	I	-	**
UP	VII	Moorland/grass mosaic	I	-	**
UP	VIII	Heath/bog	I	.	ns
UP	VI	Upland wooded	R	-	**
UP	VII	Moorland/grass mosaic	R	+	**
UP	VIII	Heath/bog	R	.	ns
GB	I	Crops/weeds	A	-	***
GB	II	Tall grassland/herb	A	+	***
GB	III	Fertile grasslands	A	-	*
GB	IV	Infertile grasslands	A	-	***
GB	V	Lowland wooded	A	.	ns
GB	VI	Upland wooded	A	.	ns
GB	VII	Moorland/grass mosaic	A	.	ns
GB	VIII	Heath/bog	A	.	ns
GB	I	Crops/weeds	I	.	ns
GB	II	Tall grassland/herb	I	.	ns
GB	III	Fertile grasslands	I	+	**
GB	IV	Infertile grasslands	I	-	*
GB	V	Lowland wooded	I	-	**
GB	VI	Upland wooded	I	-	***
GB	VII	Moorland/grass mosaic	I	-	***
GB	VIII	Heath/bog	I	.	ns
GB	I	Crops/weeds	R	.	ns
GB	II	Tall grassland/herb	R	.	ns
GB	III	Fertile grasslands	R	.	ns
GB	IV	Infertile grasslands	R	.	ns
GB	V	Lowland wooded	R	.	ns
GB	VI	Upland wooded	R	-	***
GB	VII	Moorland/grass mosaic	R	.	ns
GB	VIII	Heath/bog	R	.	ns

HOST PLANTS INCREASING

Plant species	B	2	3	5	5	8
		PA	PA	AG	PA	UP
Agrostis capillaris	1					✓
Elymus repens	9	✓	✓	✓	✓	
Succisa pratensis	1					✓

HOST PLANTS DECREASING

Plant species	B	1	3	3	4	4	4	5	6	6	7	7	8
		AG	AG	PA	AG	MA	PA	PA	PA	UP	MA	UP	UP
Agrostis capillaris	1				✓		✓		✓			✓	
Anthoxanthum odoratum	1											✓	
Arrhenathrum elatius	1							✓					
Calluna vulgaris	1												✓
Cynosurus cristatus	1						✓						
Dactylis glomerata	7		✓										
Digitalis purpurea	1								✓				
Elymus repens	9	✓											
Festuca ovina	4											✓	
Holcus lanatus	5		✓				✓			✓			
Lolium perenne	1		✓	✓									
Lotus corniculatus	7						✓						
Nardus stricta	2										✓		
Plantago lanceolata	2				✓	✓	✓					✓	
Plantago major	1		✓				✓						
Poa annua	8	✓	✓	✓									
Rumex acetosa	1						✓						
Trifolium pratense	4						✓						
Trifolium repens	4		✓	✓			✓						

HOST PLANTS INCREASING

Butterfly species	**2**	**3**	**5**	**5**	**8**
	PA	**PA**	**AG**	**PA**	**UP**
Ringlet	1	1	1	1	
Marsh Fritillary					1
Grayling	1	1	1	1	
Wall	1	1	1	1	
Meadow Brown	1	1	1	1	
Marbled White	1	1	1	1	
Large Skipper	1	1	1	1	
Speckled Wood	1	1	1	1	
Hedge Brown	1	1	1	1	1
Essex Skipper	1	1	1	1	

HOST PLANTS DECREASING

Butterfly species	**1**	**3**	**3**	**4**	**4**	**4**	**5**	**6**	**6**	**7**	**7**	**8**
	AG	**AG**	**PA**	**AG**	**MA**	**PA**	**PA**	**PA**	**UP**	**MA**	**UP**	**UP**
Ringlet	2	2	1									
Green Hairstreak						1						
Small Heath	1	1	1			1				1	1	
Clouded Yellow		1	1			3						
Pale Clouded Yellow		1	1			3						
Mountain ringlet										1		
Dingy Skipper						1						
Silver-spotted Skipper											1	
Grayling	2	1	1								1	
Wall	2	3	1			1			1		1	
Wood White		1	1			3						
Small Copper						1						
Meadow Brown	2	1	1									
Marbled White	2	3	1			1			1		1	
Glanville Fritillary		1		1	1	2					1	
Heath Fritillary				1	1	1		1			1	
Large Skipper	1	2				1			1			
Speckled Wood	2	2	1									
Silver-studded Blue						1						1
Common Blue		1	1			3						
Hedge Brown	2	3	2	1		1		1			1	
Essex Skipper	1	2				1	1		1			
Small Skipper		1				1			1			

	Increasing	Decreasing
Butterfly host plants	3	19
Number of butterfly species for which host plants changed in abundance	10	23

		Present status			Number of food plants with detected range changes							
					GB		Increases			Decreases		
Bird	**Code**	**Declining**	**Stable**	**Increasing**	**+**	**-**	**a**	**p**	**m**	**a**	**p**	**m**
Tree Sparrow	Ts	✓				4				4	3	
Cirl Bunting	Cib	✓			1		1	1		1	1	1
Grey Partridge	Gp	✓			1	6	1		1	6	5	1
Bullfinch	Bf	✓			3	4	2	4		4	4	
Song thrush	St	✓			2		1	1				
Reed Bunting	Rb	✓				2				2	2	
Skylark	Sk	✓				2				3	1	
Linnet	Li	✓			2	8		2		5	5	
Blackbird	Bb	✓			1		1	2				
Mistle thrush	Mt	✓			1		1	2				
Dunnock	Du	✓				4	2	1	1	6	6	1
Yellowhammer	Yh	✓			2	1	1	2	2	1	1	1
Meadow pipit	Mp		✓			2	1			1	1	1
Greenfinch	Gf		✓		1	5		1		4	4	
Robin	Ro		✓		2		3	2				
House sparrow	Hs			✓		5				3	2	
Goldfinch	Gof			✓	2	4		2		3	3	
Chaffinch	Cf			✓	1	5		1		4	3	
Woodpigeon	Wp			✓		2			1	4	3	
Stock dove	Sd			✓		3				3	2	

Cids 36

	Increasing				Decreasing			
	GB	**a**	**p**	**m**	**GB**	**a**	**p**	**m**
Total	13	8	10	6	17	12	14	3

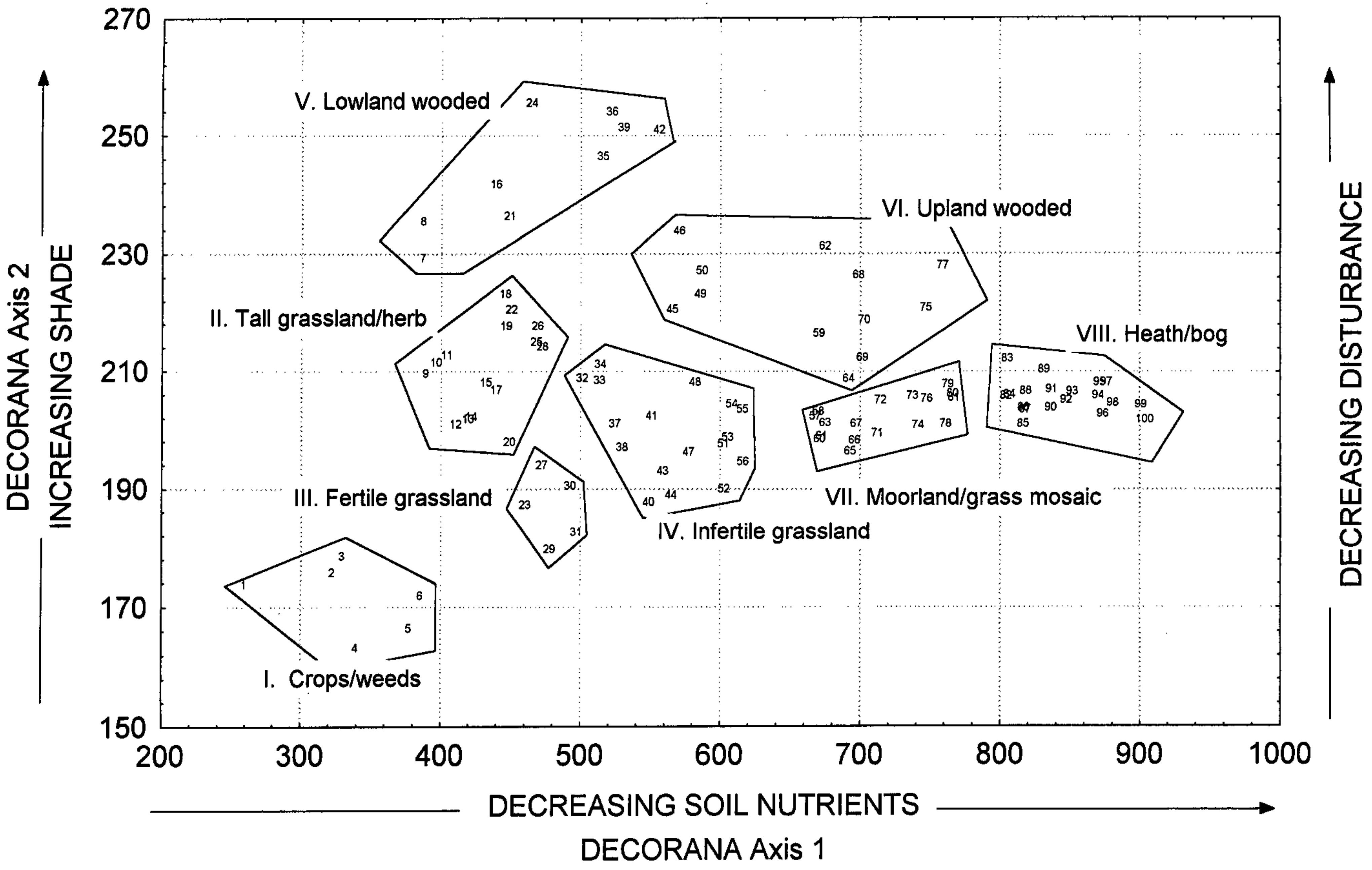
Food plant species	GB		Increases			Decreases		
	+	-	a	p	m	a	p	m
Festuca ovina		✓					✓	✓
Capsella bursa-pastoris		✓						
Cirsium palustre		✓						
Cirsium vulgare		✓						
Rumex acetosella		✓						
Centaurea nigra		✓					✓	
Taraxacum agg.		✓					✓	
Holcus mollis							✓	
Poa annua		✓				✓	✓	✓
Agrostis capillaris		✓	✓				✓	✓
Arrhenatherum elatius		✓				✓	✓	
Cerastium fontanum		✓				✓	✓	
Polygonum aviculare		✓				✓	✓	
Stellaria media		✓				✓	✓	
Trifolium pratense		✓				✓	✓	
Polygonum persicaria		✓				✓		
Poa pratensis		✓	✓					
Rumex obtusifolius	✓					✓	✓	
Trifolium repens	✓				✓	✓	✓	
Holcus lanatus					✓	✓	✓	
Lolium perenne	✓			✓		✓		
Prunus spinosa	✓					✓		
Rumex acetosa		✓		✓				
Sambucus nigra			✓					
Sonchus oleraceus	✓							
Hedera helix	✓		✓	✓				
Potentilla reptans	✓		✓	✓				
Rubus fruticosus	✓		✓	✓				
Agrostis stolonifera	✓		✓	✓	✓			
Festuca rubra	✓		✓	✓	✓			
Festuca vivipara	✓				✓			
Cirsium arvense	✓			✓				
Urtica dioica	✓			✓				
Potentilla erecta					✓			
Crataegus monogyna				✓				

FIGURE CAPTIONS

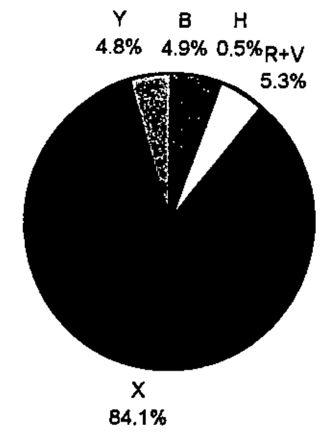
Figure 1	Distribution of the 100 vegetation classes, grouped by aggregate classes, on the first two axes of the DECORANA ordination. Axis 1 is correlated with a gradient from fertile to infertile soils, and axis 2 with a light gradient and indirectly with disturbance (*cf.* Figure 4).
Figure 2	Proportion of the six plot types within each of the eight aggregate classes. X = main plots; B = boundary plots; Y = habitat plots; S = streamside plots; R = verge plots; H = hedge plots.
Figure 3	Relationship between the average DECORANA scores for the first three axes of the 100 vegetation classes, weighted by cover, and the Ellenberg values for fertility, light and wetness.
Figure 4	Average of the Ellenberg value for fertility by aggregate class and plot type. Table 3 provides the sample numbers. X = main plots; B = boundary plots; Y = habitat plots; S = streamside plots; R = verge plots; H = hedge plots.
Figure 5	Functional strategy composition (Grime *et al.*, 1988) of the eight aggregate classes. Figures are for the percentage of species that were present in both 1978 and 1990, regardless of shifts between classes.
Figure 6	Diagrammatic representation of the relationships between classifications represented on two theoretical axes of variations. The numbers 1-7 refer to one classification, and A and B to the range of two classes of another classification.
Figure 7	The total number of plots in the 100 vegetation classes of the Countryside Vegetation System by the four landscape types.
Figure 8(a)	An example of a summary description of one of the 100 vegetation classes of the Countryside Vegetation System.
Figure 8(b)	Key to the summary descriptions of the 100 vegetation classes of the Countryside Vegetation System, giving details of sources and categories involved.
Figure 9	Smoothed distribution of the frequency of five common species in the 100 vegetation classes of the Countryside Vegetation System. Loli per = *Lolium perenne*; Arrh ela = *Arrhenatherum elatius*; Agro cap = *Agrostis capillaris*; Call vul = *Calluna vulgaris*; Erio vag = *Eriophorum vaginatum*.
Figure 10	Average number of vegetation classes within the 1km squares in the four landscape types. A = arable landscape; P = pastural landscape; MU = marginal upland; U = upland; X = main plots; B = boundary plots; Y = habitat plots; S = streamside plots; R = verge plots; H = hedge plots. (a) by landscape type and constituent plot type; (b) by plot type and constituent landscape type.
Figure 11	Average species numbers in the 37 species groups of Table 5 within the eight aggregate classes of the Countryside Vegetation System.

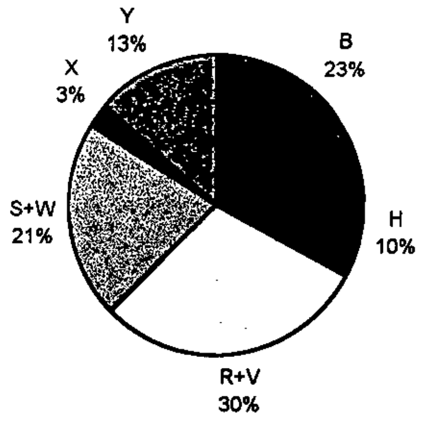
Figure 12 Percentage of plots covering different numbers of unimproved neutral grassland, defined as MG5 within the National Vegetation Classification (Rodwell, 1992), by the six plot types and four landscape types.

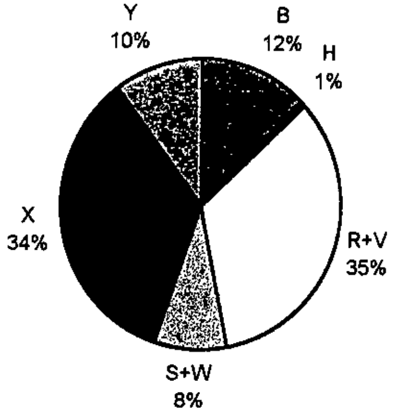
1

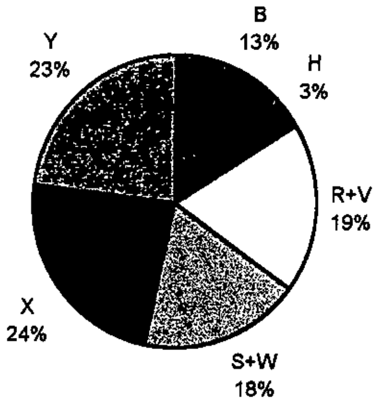

V. Lowland wooded
VI. Upland wooded
II. Tall grassland/herb
VIII. Heath/bog
III. Fertile grassland
VII. Moorland/grass mosaic
IV. Infertile grassland
I. Crops/weeds
270
250
230
210
190
170
150
200
300
400
500
600
700
800
900
1000
DECREASING SOIL NUTRIENTS
DECORANA Axis 1
DECORANA Axis 2
INCREASING SHADE
DECREASING DISTURBANCE

2


Aggregate class I

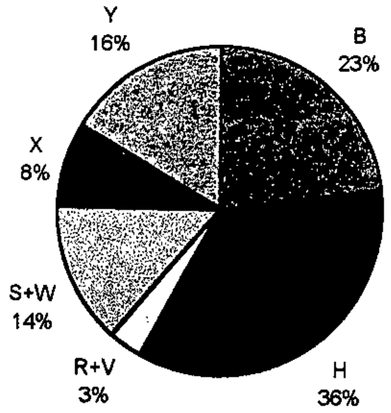

Aggregate class II


Aggregate class III

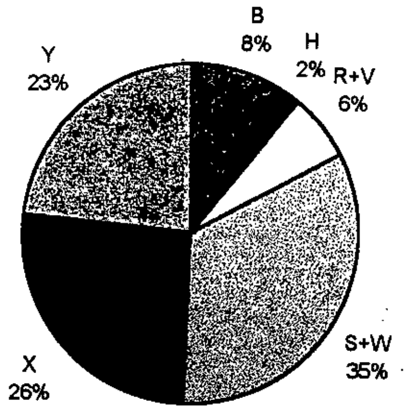

Aggregate class IV

2 contd.

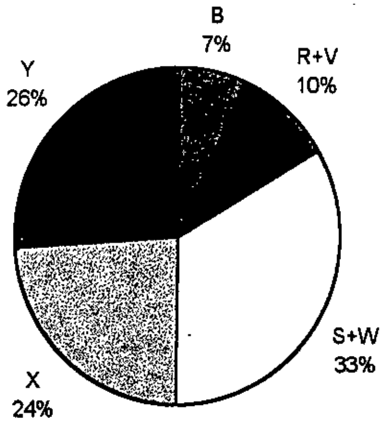
Aggregate class V



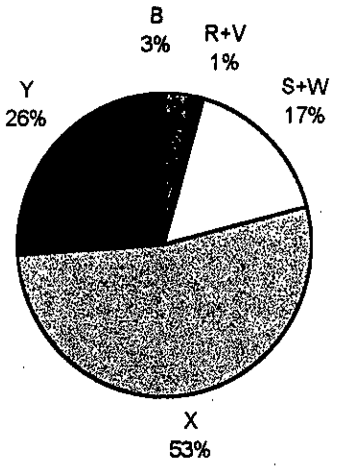
Aggregate class IV



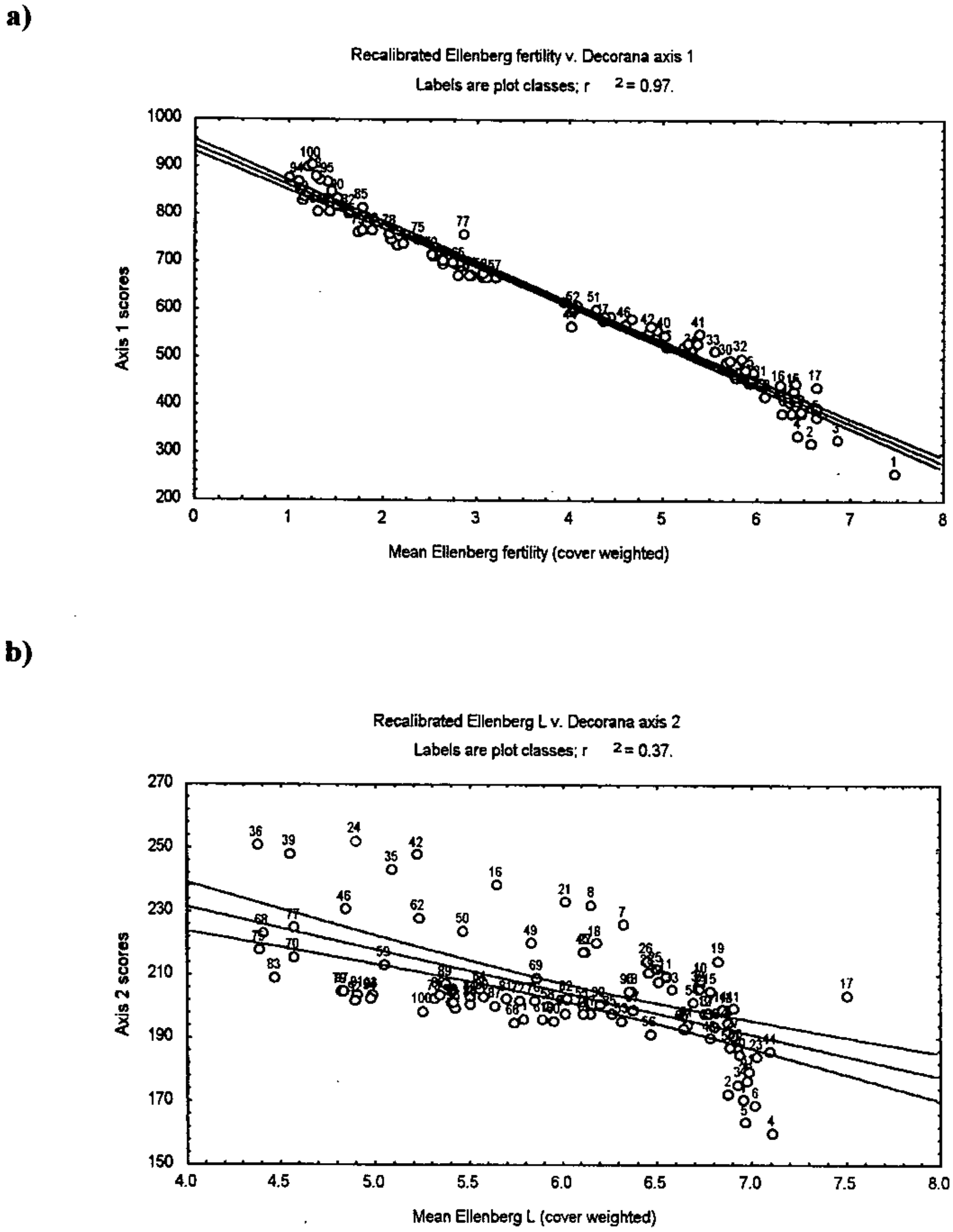
Aggregate class VII



Aggregate class VIII

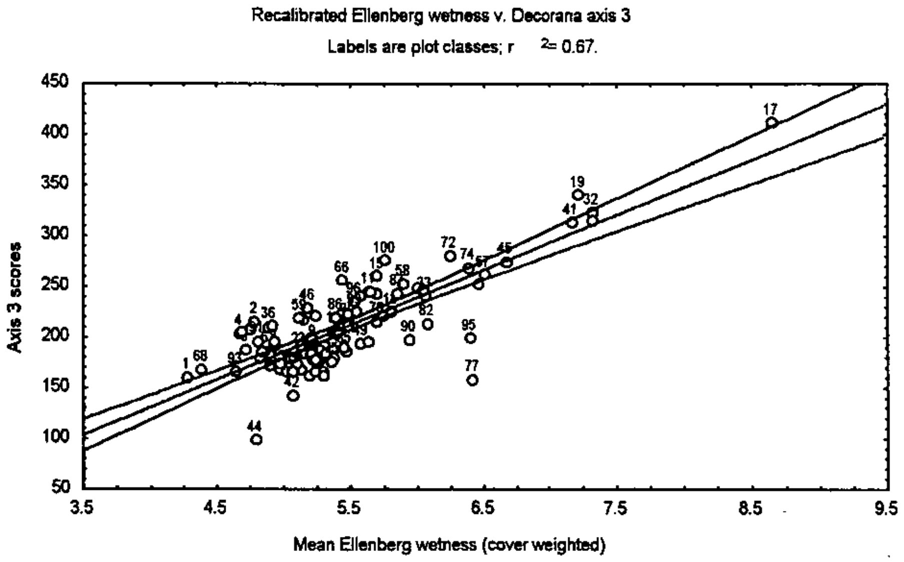


3


a)
Recalibrated Ellenberg fertility v. Decorana axis 1
Labels are plot classes; r 2 = 0.97.
Axis 1 scores
1000
900
800
700
600
500
400
300
200
0
1
2
3
4
5
6
7
8
Mean Ellenberg fertility (cover weighted)
100
95
85
77
75
52
51
41
33
32
17
16
2
3
1
b)
Recalibrated Ellenberg L v. Decorana axis 2
Labels are plot classes; r 2 = 0.37.
Axis 2 scores
270
250
230
210
190
170
150
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
Mean Ellenberg L (cover weighted)
36
39
24
42
35
16
21
8
7
46
62
50
49
18
68
77
83
69
59
19
17
56
2
5
4
6

3 contd.

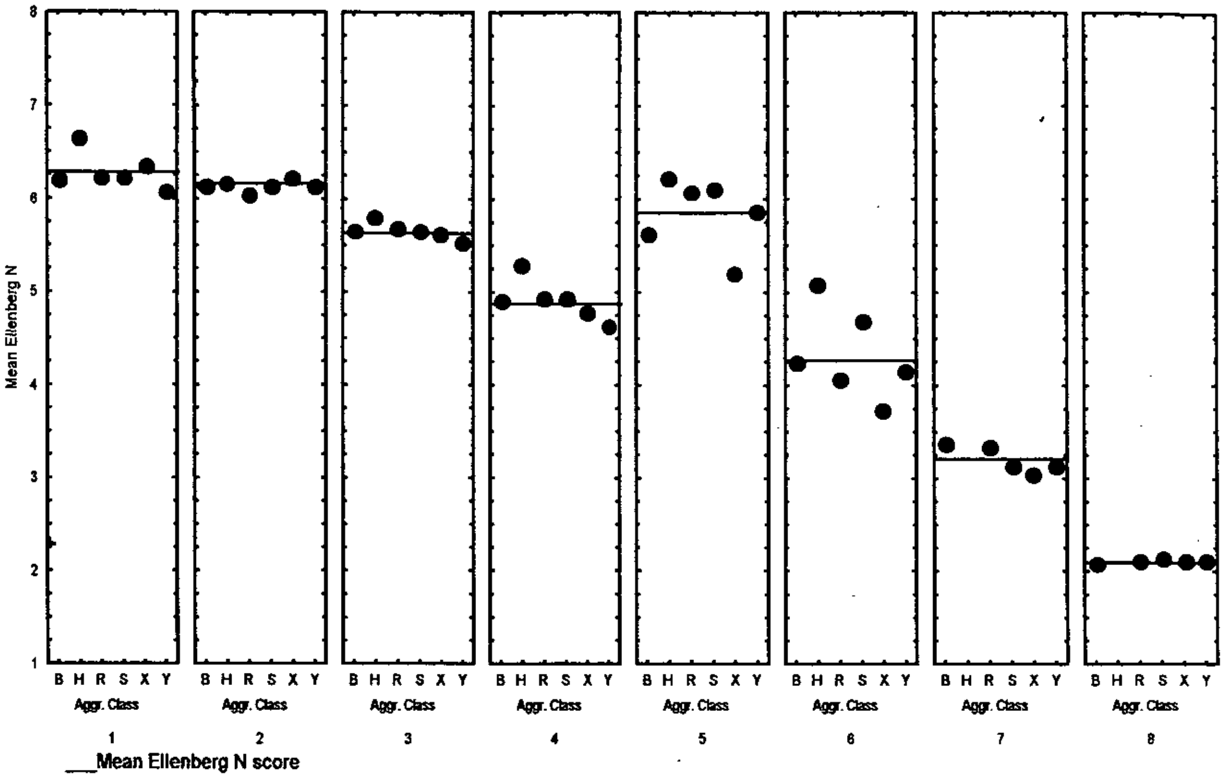
c)



Recalibrated Ellenberg wetness v. Decorana axis 3

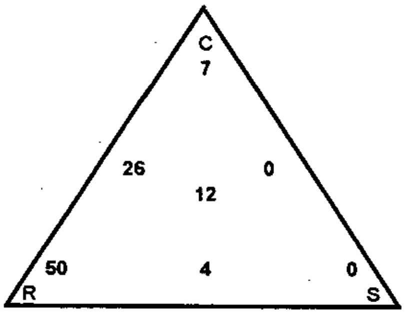
Labels are plot classes; $r^2 = 0.67$.

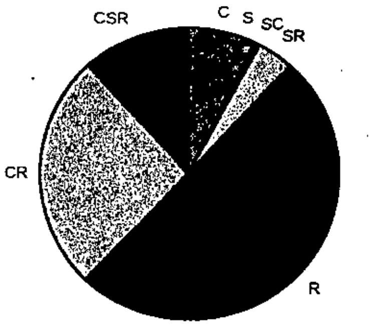
4


Mean Ellenberg N
8
7
6
5
4
3
2
1
B H R S X Y
Aggr. Class
1
2
3
4
5
6
7
8
___Mean Ellenberg N score

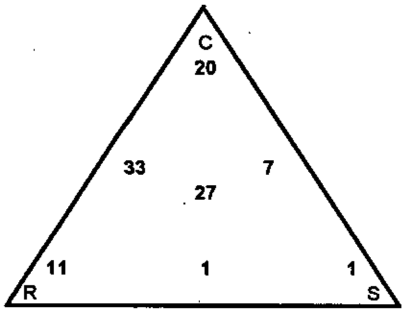
5

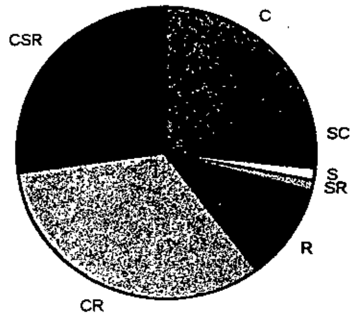
Aggregate class I; Crops/weeds



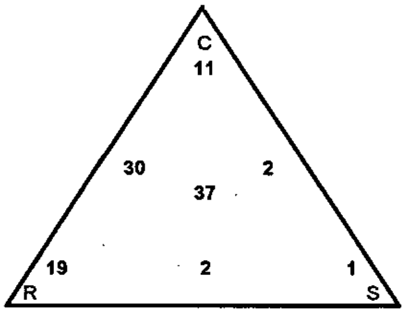


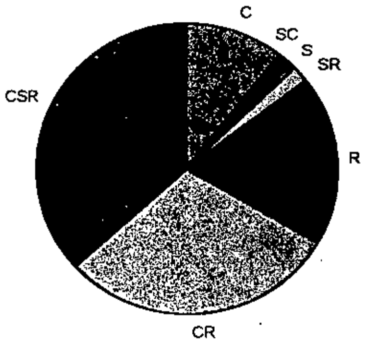
Aggregate class II; Tall grassland/herb



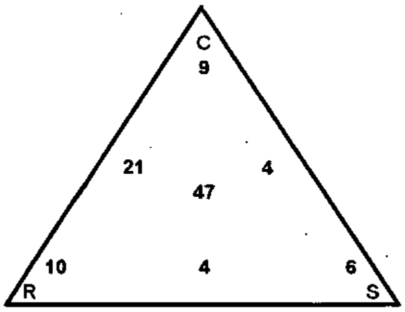


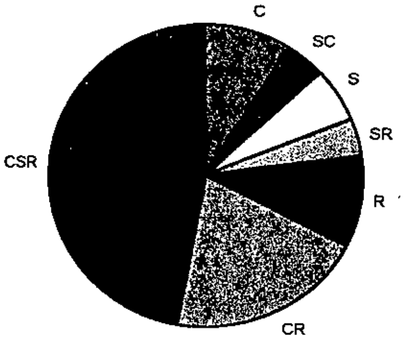
Aggregate class III; Fertile grasslands





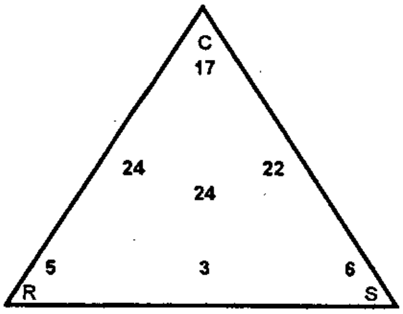
Aggregate class IV; Infertile grassland

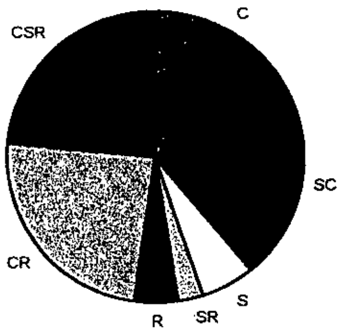




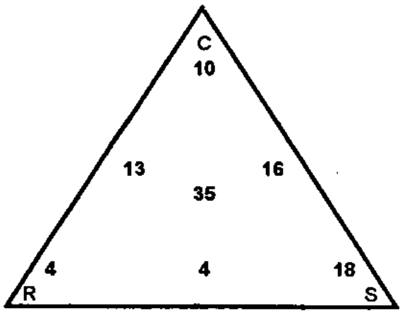
5 contd.

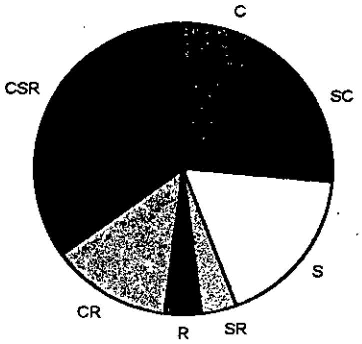
Aggregate class V; Lowland wooded



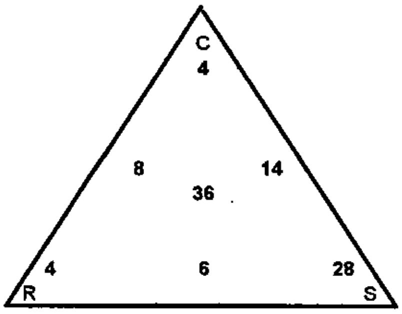


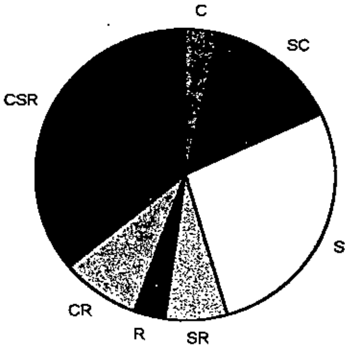
Aggregate class VI; Upland wooded



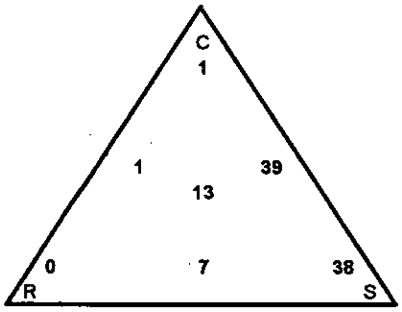


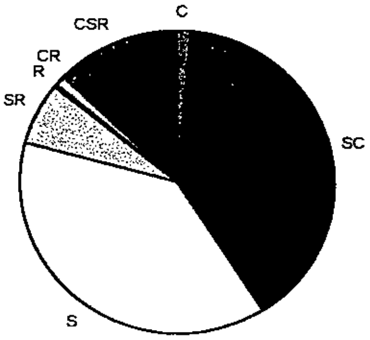
Aggregate class VII; Moorland/grass mosaic



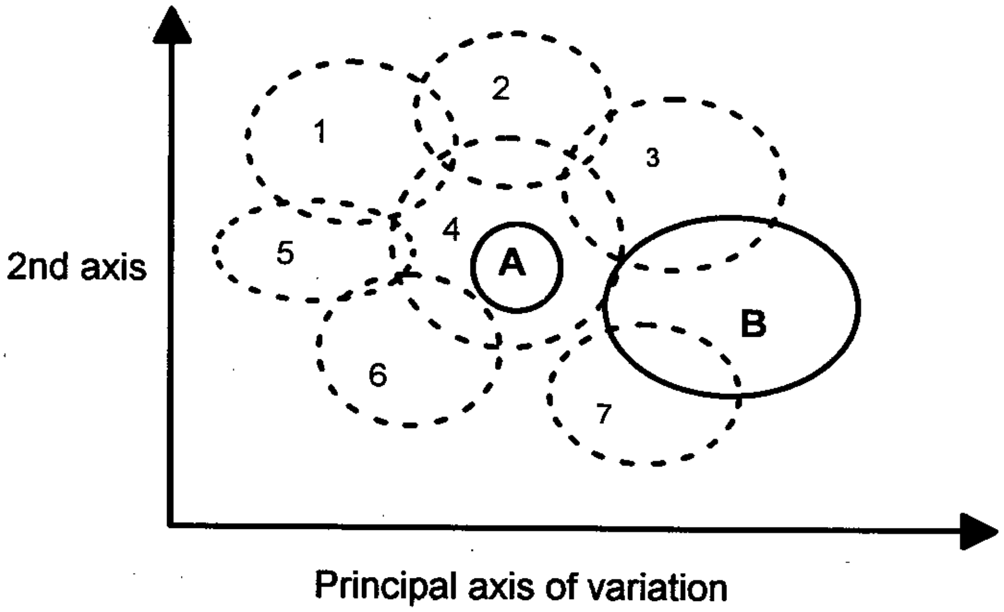


Aggregate class VIII; Heath/bog

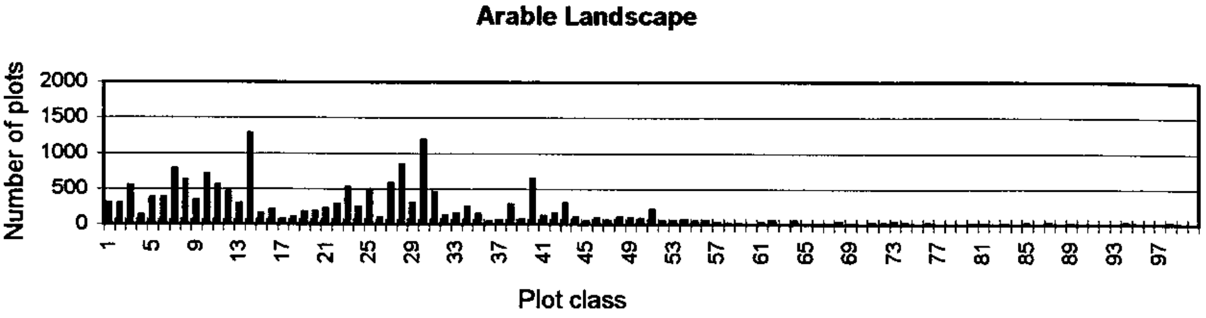


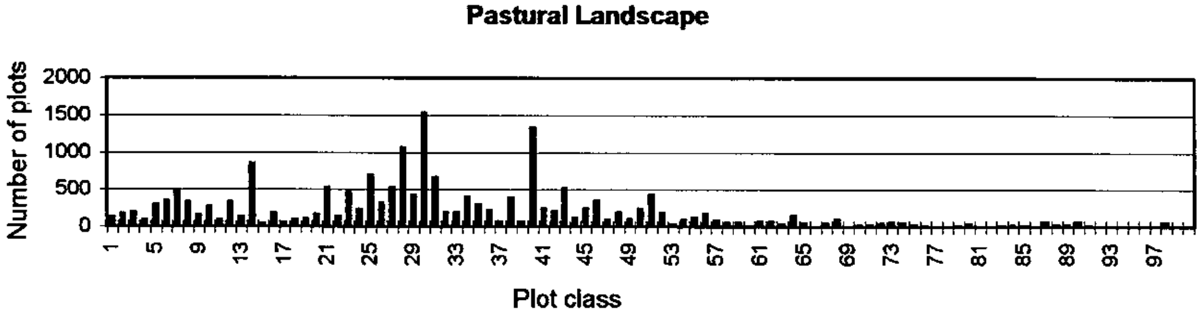


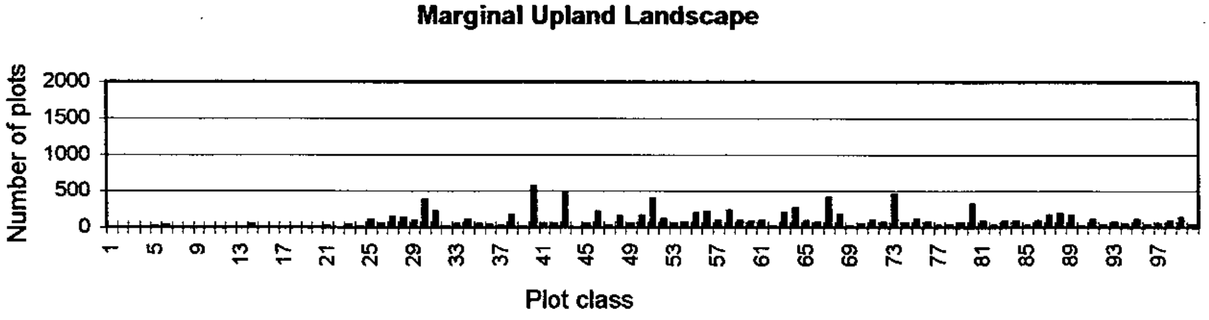
6

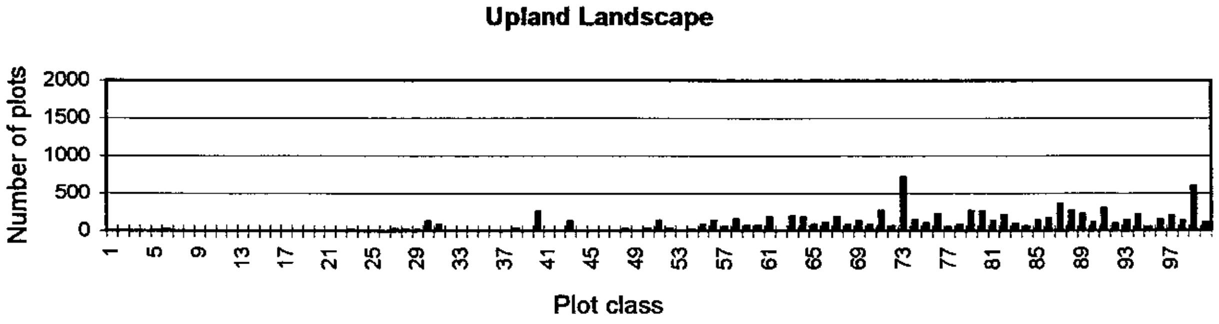


7


Arable Landscape


Pastural Landscape


Marginal Upland Landscape


Upland Landscape

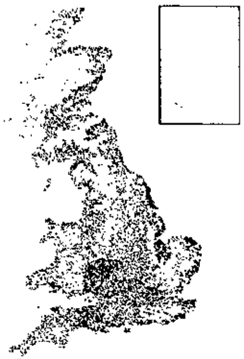
8 a)

Vegetation class 32 **Aggregate Class III : Fertile Grassland**

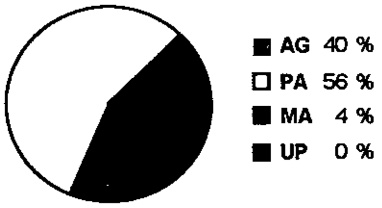
Gravel reedbeds

Total number of plots: 85 **Area:** No estimate **S.e.:** No estimate

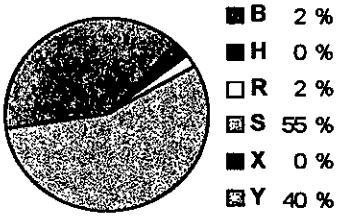
Distribution in G B



Landscape Association



Plottypes



Description:

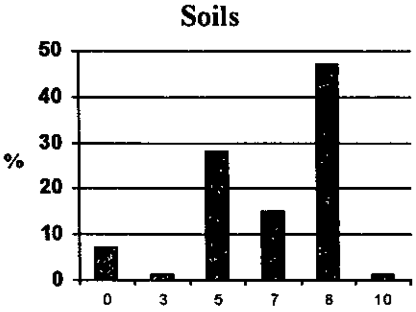
This class occurs by streamsides or in small wet patches. It is quite a common class and has canary grass as the main cover species with soft rush and nettles being often frequent cover species. It is not a diverse class and has characteristic species such as brooklime, marsh bedstraw and hemlock water dropwort. This class is virtually restricted to lowland Britain but can occasionally occur in marginal upland river valleys.

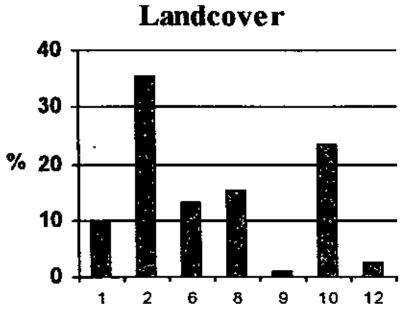
Species number: 201 (high) **Nr. of species groups:** 8 (med.) **Most frequent species group:** 22

Most frequent spp.	**%**	**Spp. with highest cover**	**%**	**Characteristic species**
Urtica dioica	68	*Phalaris arundinacea*	15	*Phalaris arundinacea*
Agrostis stolonifera	67	*Agrostis stolonifera*	9	*Urtica dioica*
Phalaris arundinacea	61	*Urtica dioica*	6	*Myosotis scorpioides*
Ranunculus repens	52	*Juncus effusus*	6	*Rumex obtusifolius*
Juncus effusus	45	*Holcus lanatus*	<5	*Mentha aquatica*

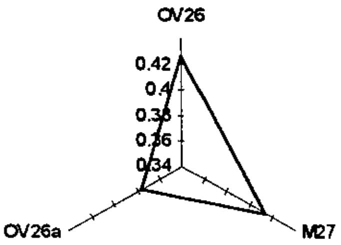
Related habitats

Biodiversity habitat: 13 CORINE biotope: n.e. Phase1 habitat: F3

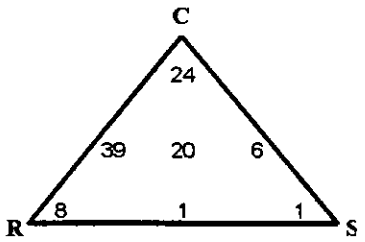




Similarity with NVC types (%):



CSR characterisation (%):



8 b)

Vegetation class 0

Description Sheet

Total number of plots

Aggregate Class 0:

Area and **S.e.** are estimated on X-plot coverage. No estimate can be made for vegetation classes in which no X-plots were located.

Distribution in GB

- ☐ 0.005
- ▨ 0.010
- ▨ 0.025
- ▨ 0.050
- ▨ 0.100
- ▨ 0.200
- ▨ 0.400

Landscape Association

Landscape types of plot locations.

Ag = Arable landscape
Pa = Pastural landscape
Ma = Marginal Uplands
Up = Uplands

Plottypes

Percentage of plottypes in vegetation class.

B = Boundary plots
H = Hedgerow plots
R = Roadside verge plots
S = Streamside plots
X = Random plots
Y = Target plots

Description

Species number:

Nr. of species groups:

Most frequent species group:

Most frequent spp.
Percentage occurrence of most frequently present species.

Spp. with highest cover
Percentage cover of species with highest cover.

Characteristic species
Species characteristic for the Vegetation Class within the Aggregate Class, as indicated by the significant (5%) result of a χ^2 -test.

Related habitats
Biodiversity habitats can be found in **Department of the Environment**. 1995. *Biodiversity: the UK steering group report. Volume 2: Action plans*. London: HMSO.

CORINE biotopes can be found in **Devillers, P., Devillers-Terschuren, J & Ledant, J.-P.** 1991. *Habitats of the European Community. CORINE Biotopes Manual, Volume 2.* Luxembourg: Commission of the European Communities.

Phase 1 habitats can be found in **Wyatt, G.** 1991. *A review of Phase 1 habitat survey in England.* Peterborough: Nature Conservancy Council.

Soils

Percentage occurrence of the major soils groups.

0. *Disturbed soils*
1. *Terrestrial raw soils*
2. *Raw gley soils*
3. *Lithomorphic souls*
4. *Pelosols*
5. *Brown soils*
6. *Podzolic soils*
7. *Surface water gley soils*
8. *Ground water gley soils*
9. *Man-made soils*
10. *Peat soils*

Landcover

Percentage occurrence of the major landcover types.

1. *Crops*
2. *Fertile grassland*
3. *Infertile grassland*
4. *Grass mosaic and bracken*
5. *Moorland grass*
6. *Tall grassland/ herb*
7. *Bog*
8. *Woodland*
9. *Heath and screes*
10. *Water and wetland*
11. *Maritime vegetation*
12. *Communications and urban*

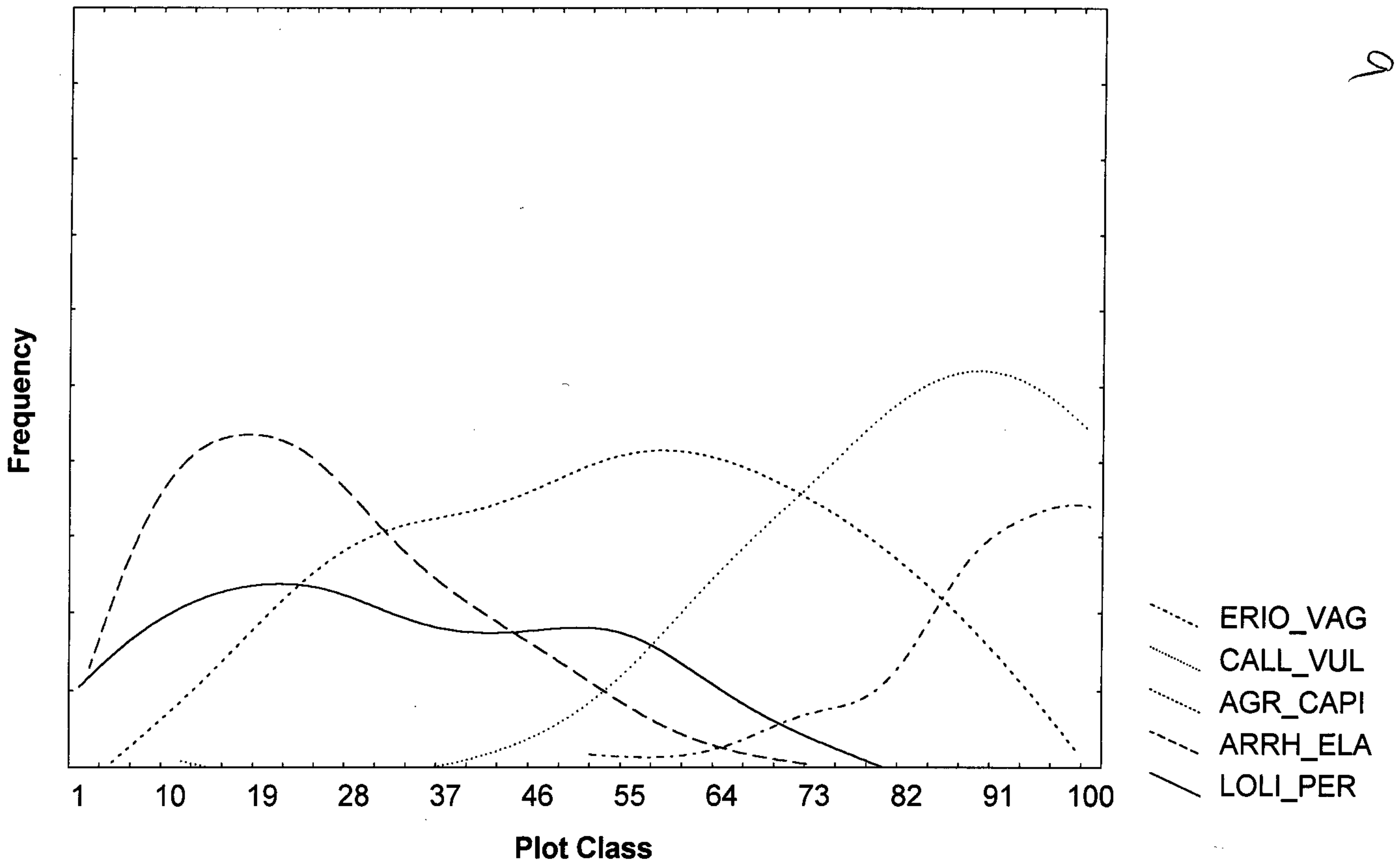
Similarity with NVC types

Percentage similarity scores were computed between the species frequency for each plot class and each NVC unit as provided in electronic form by the Unit of Vegetation, Lancaster University. The matching process was exactly the same as that carried out by MATCH (Malloch, 1991). The top 3 most similar communities or sub-communities are shown.

CSR characterisation

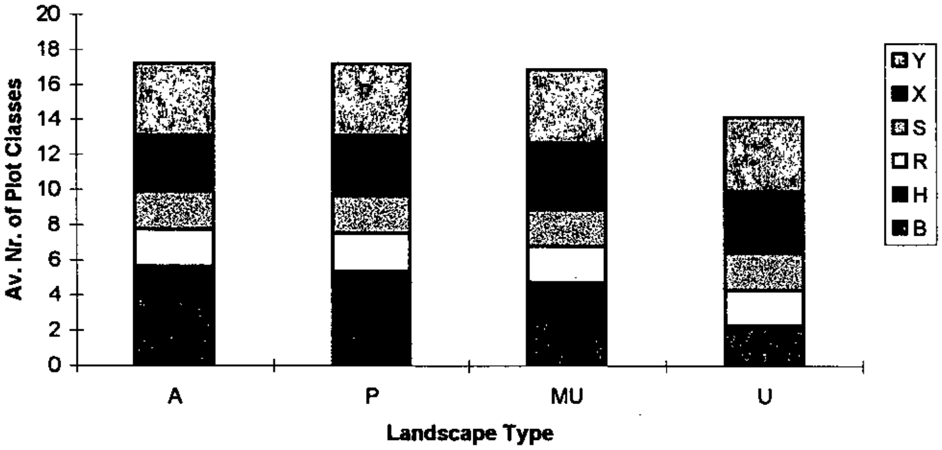
CSR structure of the Vegetation Class as calculated from CSR scores of component species.

9

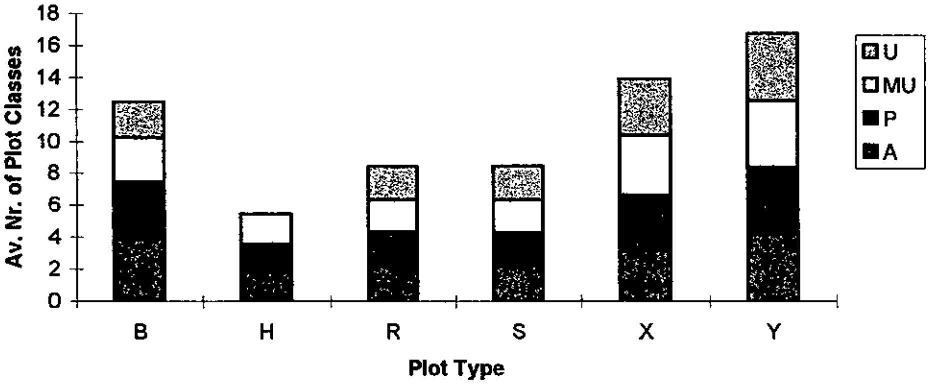

Frequency
1
10
19
28
37
46
55
64
73
82
91
100
Plot Class
ERIO_VAG
CALL_VUL
AGR_CAPI
ARRH_ELA
LOLI_PER

10

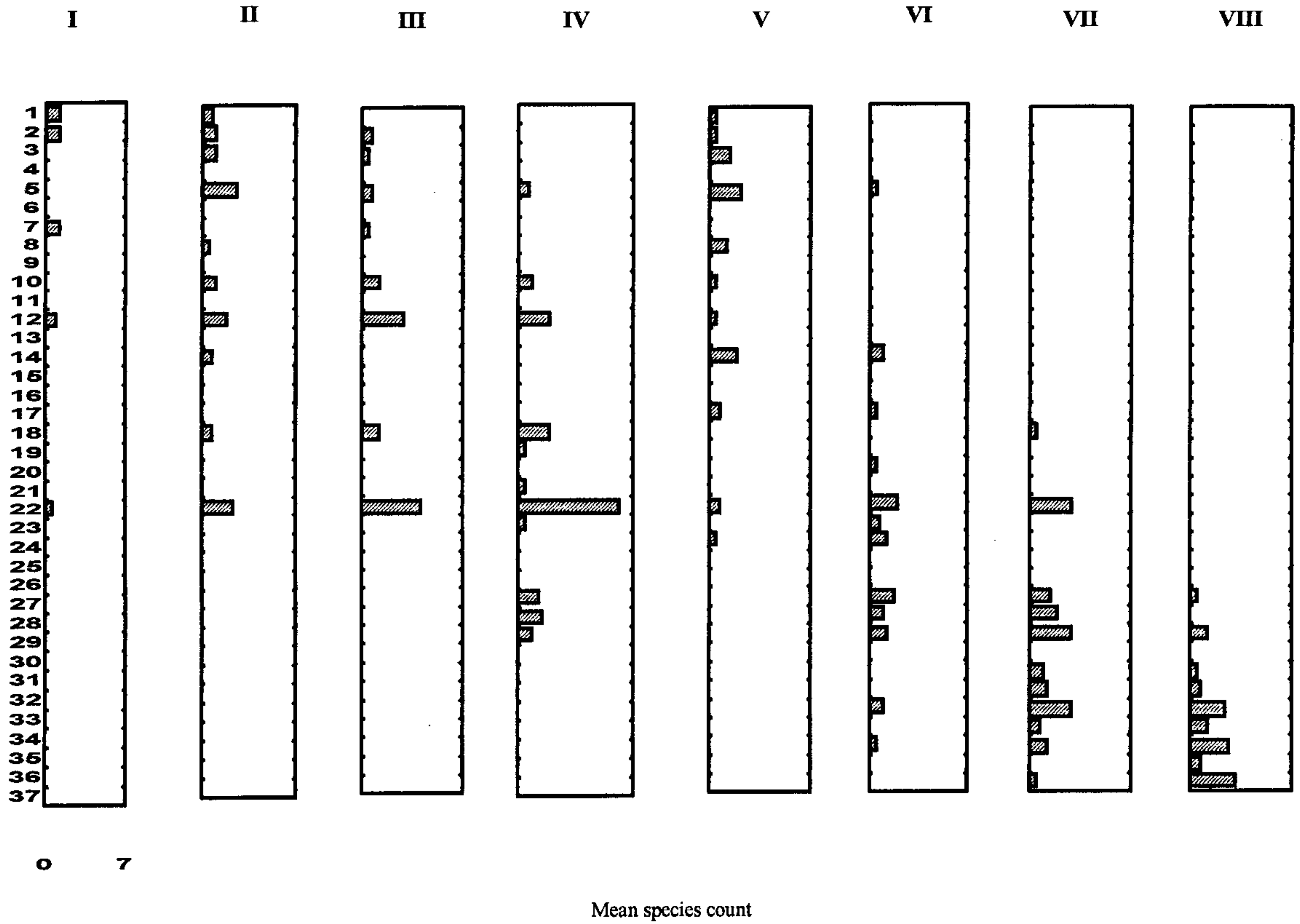
a)


Av. Nr. of Plot Classes
20
18
16
14
12
10
8
6
4
2
0
A
P
MU
U
Landscape Type
Y
X
S
R
H
B

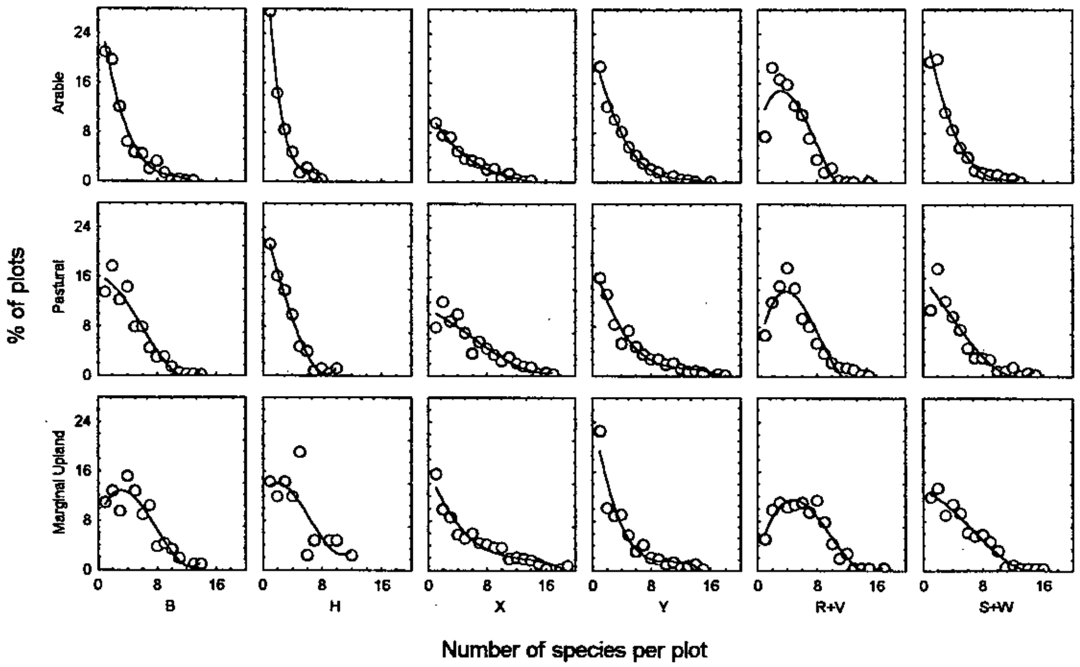
b)


Av. Nr. of Plot Classes
18
16
14
12
10
8
6
4
2
0
B
H
R
S
X
Y
Plot Type
U
MU
P
A

11


I
II
III
IV
V
VI
VII
VIII
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
0
7
Mean species count

12


% of plots
Arable
Pastural
Marginal Upland
24
16
8
0
0
8
16
B
H
X
Y
R+V
S+W
Number of species per plot

ITE has six Research Stations throughout Britain, which allows the efficient use of resources for regional studies and provides an understanding of local ecological and land use characteristics. The Institute's administrative headquarters is at Monks Wood.

ITE sites

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Fax 015395 34705
Email MERLEWOOD@ITE.AC.UK

Edinburgh Research Station
Bush Estate
PENICUIK
Midlothian EH26 0QB
Telephone 0131 445 4343
Fax 0131 445 3943
Email BUSH@ITE.AC.UK

Furzebrook Research Station
WAREHAM
Dorset BH20 5AS
Telephone 01929 551518-9, 551491
Fax 01929 551087
Email FURZEBROOK@ITE.AC.UK

Banchory Research Station
Hill of Brathens
Glassel, BANCHORY
Kincardineshire AB31 4BY
Telephone 01330 823434
Fax 01330 823303
Email BANCHORY@ITE.AC.UK

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Email BANGOR@ITE.AC.UK

Details about the Institute are available on the Internet via the World Wide Web (http:/www.nmw.ac.uk/ite)