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# Botanical Character of the British Countryside and change between 1978 and 1990

**Final Report**

RGH Bunce, SM Smart,
JW Watkins, HM Van de Poll,
WA Scott & P Wilson*

Institute of Terrestrial Ecology
Merlewood Research Station
Grange Over Sands
Cumbria
LA11 6JU

*Unit of Comparative Plant Ecology
Sheffield University

With editorial assitance from NR Webb and LG Firbank

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## GLOSSARY

**Aggregate Class (AC) I-VIII:** The 8 aggregate classes derived from the 100 CVS vegetation classes by cluster analysis and used to stratify data for analyses of change.
**CS1990:** The Countryside Survey which took place in 1990, but also repeating those carried out in 1978 & 1984.
**CSR:** The functional traits (Competitors, Stress tolerators and Ruderals) of the Sheffield University approach to vegetation (see Grime *et al.* 1988).
**CVS Classes:** The 100 classes produced from the classification of all CS1990 vegetation data.
**Countryside Information System (CIS):** A software mapping package developed to deliver rural information using a one kilometre square grid of Great Britain.
**Countryside Vegetation System (CVS):** The integrated system developed during ECOFACT for classifying vegetationof the wider countryside.
**DECORANA (ordination):** The statistical procedure used to derive the principal gradients within vegetation (Hill, 1979a).
**Ellenberg Scores:** Scores attributed to species, which define their ecological range in terms of fertility, pH, light, and moisture (Ellenberg, 1974).
**MAVIS:** Modular Analysis of Vegetation and Interpretation System: a software package being developed to link NVC, CVS, CSR and Ellenberg scores for analysis of vegetation samples.
**National Vegetation Classification (NVC):** The classification system developed at Lancaster University for describing British vegetation.
**Ordination Axis:** The gradient along which vegetation samples are ordered, according to their ecological affinities.
**Plots:** Defined areas of vegetation, usually by quadrats, within which species are recorded.
**Plot Types:** The 6 types of sample vegetation plots placed in different landscape elements in the Countryside Survey (main, streamside, roadside, hedge, boundary and habitat).
**Species Groups:** Groups of species with relatively constant ecological affinities classified by a minimum variance cluster analysis of ordination scores for each species.
**TWINSPAN (classification):** The statistical procedure used for classification of vegetation into classes (Hill, 1979b).
**Land Classification:** A multi-variate classification of all 1 kilometre squares in GB based on geology, climate and topography and thus independent of the biota of the land surface.
**Landscape type:** The 32 ITE Land Classes generated by the land classification were aggregated at a higher level into four landscape types based on joint similarity in shared geological, climatic and topographic attributes. For many of the analyses in this report Countryside Survey data was stratified by these four landscape types.
**CORINE biotopes:** A classification of European habitat types used to identify Special Areas of Conservation (SAC) under the EC Habitats Directive (92/43/EEC). The biotopes were defined by grouping phyto-sociological units themselves based upon the joint occurrence of characteristic plant species.
**LUCID:** Land-use Classification, Information and Documentation. Software that provides a comparison of land cover definitions between different classifications.
**SOAEFD:** Scottish Office Agriculture, Environment and Fisheries Department.
**ECOFACT:** Ecological Factors controlling biodiversity in the British countryside. The title of a research programme of which this report forms part.

# 1. INTRODUCTION

The vegetation and land cover of the British countryside was surveyed in 1990, repeating and extending the baseline established by a similar survey of the countryside and its vegetation in 1978. The outline results of *Countryside Survey 1990* were published by the Department of the Environment in 1993 (Barr *et al.* 1993).

The work described in this report builds upon these analyses by describing the botanical characteristics of the British countryside, presenting them in a manner which is accessible to non-specialists and relevant to the development of countryside policies.

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, including those used in the European Union, Great Britain and Northern Ireland;

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.

Work on the explanation of the causes of change are the subject of ECOFACT Module 6 and will be reported separately.

# 2. APPROACH: THE RECORDING AND ANALYSIS OF COUNTRYSIDE VEGETATION

## 2.1 *Field Recording Programme*

The vegetation of the British countryside was surveyed using a 1 km square as a basic sampling unit. The location of each 1 km 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 1 km squares to be recorded were distributed in a predetermined way among the different land classes to form a stratified sampling programme. In 1978, 256 1 km squares were recorded throughout Britain; the number of squares was increased in 1984 to 384 and to 508 in 1990 (Barr *et al.* 1993). All of the 256 squares recorded in 1978 were re-recorded in 1990. Neither shorelines nor highly urbanised environments were included in the field survey.

Within each of the 508 1 km squares vegetation was recorded in up to 27 plots. These plots were of three types which differed in size and in the way in which they were distributed within each 1 km square (Table 1). There were:

Five **main plots**, which were 200 $m^2$ vegetation plots located at random within five equal-sized sectors of the 1 km square. If they fell on a linear feature they were relocated at random;

Five **habitat plots**, which were 4 $m^2$ vegetation plots placed only within semi-natural habitats not covered by the larger random plots, according to a random allocation procedure;

Up to 17 10 m x 1 m linear plots placed alongside field boundaries (**boundary plots**), hedges (**hedge plots**), watercourses (**streamside plots**), and roads/tracks (**roadside plots).** The five **boundary plots** were placed at the nearest field boundary to each of the Main plots (if within 100 m). 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, 10 m x 1 m plot being recorded on the water side to record any emergent macrophytes; two of the streamside plots were located at random within the square and three more were placed to sample different sizes of watercourses. **Roadside plots** were placed immediately adjacent to the road edge; two of the roadside plots were located at random and three were placed to sample different road types.

For convenience both in this and other documents these plots have been designated as B = boundary plots, H = hedge plots, R = roadside 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 1 km 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 not located at random, but were targeted at semi-natural habitats and, whilst they can be used to give a measure of the relative diversity and abundance of the habitats concerned, they cannot be used in a statistical sense to estimate relative frequency.

In each plot the presence and percentage cover of vascular plants and selected mosses and liverworts (*Bryophytes*) were recorded. The percentage cover was recorded to the nearest five percent. Highly variable and taxonomically-disputed species, such as bramble (*Rubus fruiticosus*), were considered as single species, except for the analysis of changes in species number, from which they were excluded.

In addition, the mapped land cover and landscape features of the entire 1 km square was described using a predetermined list of codes.

## *2.2 Analysis*

*The classification of British vegetation*
The analysis of vegetation change at the national scale would have been very difficult using existing tools, as no vegetation classification is able to cope equally well with the full range variation as found in the wider countryside. Furthermore, classifications split according to habitats and landscape elements run into the problem that similar assemblages of species, such as dandelions (*Taraxacum* spp), daisies (*Bellis perennis*) and ryegrass (*Lolium perenne*) can grow in a range of situations, such as roadsides, along streamsides, or in fields.

It was therefore considered necessary to construct a new, overall classification of British vegetation to provide the basis for the analysis of vegetation change, updating the procedures followed in the statistical analyses of the vegetation data described in the CS 1990 Main Report (Barr *et al.* 1993). This analysis of vegetation in the wider countryside is known as the Countryside Vegetation System (CVS).

In summary the procedure involved two steps. Firstly, the vegetation data for each individual sample plot in both 1978 and 1990 (except for those boundary plots not adjacent to hedgerows, 11,557 in total) were grouped into 100 vegetation classes using a standard statistical method (TWINSPAN, Hill 1979a) (Table 2). In the second step, these classes were arranged statistically using ordination to reveal patterns of similarity among them. The process of ordination involved spreading the classes along an axis which accounts for the greatest degree of variation among them. The classes were then spread out along a second axis which accounted for the greatest degree of remaining variation, and so on (DECORANA, Hill 1979b). Those vegetation classes which are close together on the resulting axis are more similar than those which are not. Eight aggregate vegetation classes were then generated by clustering the individual classes according to their relative positions on the first four DECORANA axes (Fig. 1).

The 100 CVS classes and the eight aggregate classes generated by the TWINSPAN analysis were given names designed to give the reader an understanding of the type of vegetation and a clear impression of the composition of each class. The naming could not be entirely consistent because precise ecological terms are not available with adequate definitions; therefore the style used followed Barr *et al.* 1993, in that distinct combinations of habitats were used where possible, and in other cases species or soil types were included in the names.

The number of plots which make up each of the classes provides an objective measure of their abundance (Barr *et al.* 1993). For main plots the area represented by the five plots in the 1 km square can be used and a statistical procedure was developed to estimate areas of plot classes based upon main plots only. However, because many plots lie along linear features, any estimate of their abundance should be weighted by length of feature rather than area.

*Species groups*
As ecologically similar species can occur in a variety of vegetation classes, a more species-oriented approach is also of value. Therefore, the species recorded from the plots were also classified into groups (species groups) according to their ecological requirements (Bunce, 1977 and Prieto & Sanchez, 1992). The vegetation classes vary in their species complexity. The management practised during crop production creates a narrow, uniform range of ecological conditions suitable for only a few species of a restricted ecological range. 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 species can be grouped in terms of their ecological requirements in order to help interpret the variation within the vegetation classes. For these analyses, the entire 1990 species data set were subject to an ordination and the species were clustered into groups on the basis of their proximity to each other. Each group therefore links species which grow together under similar conditions. The various combinations of the species groups therefore help to provide an ecological explanation of the composition of the aggregate vegetation classes. Furthermore, the analysis of the relative frequencies of species groups provides another tool to help explain differences in the species composition among vegetation classes and shifts in the vegetation at a location over time.

Both the vegetation classes and species groups were then simultaneously arranged (ordered) according to the principal gradient of the vegetation classification (i.e Axis 1 in Fig. 1), so that they were ranked in the same way in the tables describing the classifications.

*Vegetation change*
By including data for the plots sampled in 1978 and 1990, it was possible to determine how the vegetation of individual plots have shifted between classes and to produce, for the first time, the matrix of vegetation change for all landscape elements together. However, some classes were too infrequent to estimate change reliably. Barr *et al.* 1993 solved a similar problem by grouping classes on the basis of expert judgement and combining them with the four landscape types (arable, pastural, marginal upland and upland) taken from the ITE Land Classification of Great Britain. Here, the approach was simply to ensure that all vegetation classes were included in the analyses of change by conducting some analyses at the aggregate class level, and not simply at the level of the individual vegetation class. Separate analyses were carried out for the

different plot types, to ensure that variation in the plot size had not affected the results. The same structure was used to determine changes in species number, individual species and species groups.

### *2.3 Conclusion*

In order to fully comprehend vegetation change in Great Britain, it has been necessary to construct a new, single vegetation classification for all plots surveyed using standard analytical techniques with full quality assurance. The resulting integrated system of classification and its supporting analyses is called the Countryside Vegetation System (CVS). The CVS has 100 vegetation classes representing the botanical variation in the wider countryside. For some analyses and presentation purposes, the 100 classes can be grouped into 8 aggregate classes. A full technical description of the CVS will be 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).

# 3. RESULTS I - THE COUNTRYSIDE VEGETATION SYSTEM

## *3.1 Description of the Classification*

The larger vegetation classes were relatively uniform and clearly defined; for example, vegetation class 10 (tall grass boundaries) consisted of over 800 plots. However, most of the classes contained only 30-50 plots. In order to provide sufficient information for the classification to be used effectively, a one page summary sheet has been developed with a description for each class (Figure 3a & 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). The full set of vegetation class descriptions will be published separately.

Because the CVS has a heirarchical structure each of the 100 vegetation classes contribute to eight groups defined at a higher level of the classification of individual plots. At this level between-group differences in overall species composition are maximised resulting in floristically well defined units whose links to different parts of the GB landscape can be easily understood. Since the eight aggregate classes encompass all recorded plots they also provide larger sample sizes than each of the 100 plot classes and so provide a convenient and meaningful way of stratifying vegetation data for many of the analyses that follow.

The aggregate class series starts with AC I (crops/weeds) encompassing largely lowland vegetation of frequently disturbed ground within arable fields and their boundaries but with a small proportion of road verges. The most characteristic species of the class include annual weeds such as field pansy (*Viola arvensis*), black bindweed (*Fallopia convolvulus*) and shephard's purse (*Capsella bursa-pastoris).* AC II (tall grassland/herb) is also most common in lowland GB. It is predominantly made up of vegetation on linear features, for example on roadverges and streamsides, and is characterised by false oat-grass (*Arrhenatherum elatius*), common *nettle (Urtica dioica*), cleavers (*Galium aparine*) and cow parsley (*Anthriscus sylvestris).* AC III (fertile grassland) is defined by the preferential occurrence of species such as perennial rye-grass (*Lolium perenne*), annual meadow grass (*Poa annua*) and curled dock (*Rumex crispus*). The bulk of intensively managed improved and semi-improved grasslands throughout GB are grouped within this aggregate class. AC IV (infertile grassland) is made up of a varied mix of separate vegetation classes representing some of the most uncommon and recently declined vegetation types such as unimproved neutral and calcareous grassland in both dry and wet situations. Characteristic species include crested dog's-tail (*Cynosurus cristatus*), common mouse-ear chickweed (*Cerastium fontanum*), ribwort plantain (*Plantago lanceolata*) and birdsfoot trefoil (*Lotus corniculatus*). AC V (lowland wooded) encompasses vegetation of both hedgerow and woodland mainly concentrated in lowland GB whilst AC VI (upland wooded) covers upland woodland including conifer plantation. The large areas of usually grazed grassland in the GB uplands are grouped within AC VII (mooralnd grass/mosaic). This aggregate class thus encompasses both relatively species poor, extensive grassland on acidic bedrocks and more species rich but localised upland flushes. The aggregate class is most strongly characterised by species such as matgrass

(*Nardus stricta*), tormentil (*Potentilla erecta*), heath bedstraw (*Galium saxatile*) and star sedge (*Carex echinata*). Vegetation dominated by various heath sub-shrubs, largely in the uplands but including much less common lowland samples, are grouped within AC VIII (heath/bog). The aggregate class is best defined by the wet heathland species cross-leaved heath (*Erica tetralix*) and graminoid dominants such as deer-grass (*Trichophorum cespitosum*), cotton-grass (*Eriophorum vaginatum*) and bog asphodel (*Narthecium ossifragum*).

The DECORANA ordination was designed to show the relationships between the vegetation classes purely in terms of their botanical composition, and without additional environmental data. However, the results of the ordination could be interpreted clearly in terms of environmental gradients. On axis 1 (the x-axis of Fig 1) 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. The vegetation of arable fields is known to consist 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. Axis 1 can therefore be interpreted as a gradient of soil nutrient status. Axis 2 (the y-axis) represents another gradient with the relationship quantified in section 3.2. At the bottom, close to the x-axis, the vegetation classes contain short-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. Although it cannot easily be seen on Figure 1, there is also a third axis arising from a small group of classes which are linked by association with soil moisture.

The three gradients of nutrient level, shade/disturbance and soil moisture appear to dominate the main vegetation analyses, and it is interesting to note their pre-eminence within this random sample of British vegetation: this point is explored further below. It is also of interest that changes in land management can also be easily visualised in terms of movement within the ordination diagram; for example, heathland and bog vegetation is usually maintained by management (disturbance), and where this management is relaxed, succession typically occurs, with the vegetation moving diagonally higher and to the left towards woodland (Figure 1).

The possibility of the plot types introducing bias into the ordination as a whole was tested by correlating the percentage of plot types in the aggregate classes with the first axis DECORANA scores for the constituent plots (mentioned in section 2.2). Three out of ten possible correlations were not significant and all the remainder showed very weak correlations, with <10% of the variation explained, implying that the use of a single classification across all plot types was justified.

The analysis of individual plot types (eg main plots and habitat plots) showed that any relationships with vegetation class could be explained in terms of the distribution of vegetation in the landscape. Thus while Aggregate Classes I and VIII (crops/weeds and heath/bog) were dominated by main plots (Figure 2), this is hardly surprising for vegetation typical of extensive areas of land. In contrast AC II (tall grassland/herb) was usually associated with linear feature plots since such vegetation is usually beside hedges, streams or roads. AC VII (grass mosaic/moorland) consisted mainly of the targeted habitat plots, suggesting that in the uplands these plots were selected in grassland or flushes which were more species-rich than the surrounding species-poor moorland. AC V (lowland wooded) was a mixture of all plot types, since it is found by linear features or in woodlands. AC VI (upland wooded) is mainly a mixture of streamsides and main plots.

If the landscape is divided into the four main landscape types of upland, marginal upland, pastural and arable, further differences in the distribution of different aggregate classes of vegetation are revealed (Table 3). Some combinations of plot type, aggregate class and landscape are absent e.g. AC II (tall grassland/herb) main plots in the upland landscape and while others are present in low numbers. In most analyses only those classes are presented that have more than 10% of the total number of plots in the aggregate class, in order to exclude results based on a small sample size.

At the GB scale, three groups of classes predominate in terms of area: crops/weeds, fertile grassland, and moorland (Table 2). Some common classes may occupy a negligible area, because they occur mainly by linear features. The area estimated for the aggregate classes are in general agreement with those derived from the land cover measurements given by Barr *et al* (1993). For example, all woodland was estimated as 24800 $km^2$ from CVS 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, there are greater discrepancies at the scale of vegetation classes because they are derived in different ways from the earlier estimates using land cover(see Section 5 below). An exception is calcareous grassland (800 $km^2$ from CVS as opposed to 600 $km^2$ from land cover) which shows reasonable correspondence in its overall contribution to British vegetation.

While the CVS divides the British vegetation into classes and aggregate classes, it should be remembered that this is the result of a statistical division of the continuously variable character of the British vegetation. This is illustrated by Figure 4 which shows the changing abundance of 5 ecologically important species through the 100 CVS vegetation classes.

### 3.2 *Relationship of Vegetation Classes and Aggregate Classes to Ellenberg Values*

Interpretation of vegetation axes of ordinations is usually carried out using ecological understanding of the species involved. In the present case, with such a large and diverse data set such interpretation is difficult. However, it is an important objective of this study 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 with respect 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 fertility. Thus, plants growing only in soils very poor in available nitrogen and fertility were scored 1 and those growing in only soils very rich in available 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 heather (*Calluna vulgaris*) when cultivated alone grows well in soil with a higher pH than those in which it grows in the wild, where it is confined to the more acid soils through competition with other species.

The average Ellenberg scores for nitrogen (a measure of soil fertility), light (a measure of disturbance) and moisture were calculated for each of the 100 vegetation classes by weighting the individual species scores according to their cover, so preventing unusual species from biasing the results. These scores were then related to the position of the vegetation class along the first three axes of the DECORANA analysis (Figure 1).

The relationships between the Ellenberg scores and the scores for the first axis of the DECORANA ordination support the interpretation of the axes given earlier (Figure 5). The principal axis identified within the CVS shows a highly significant correlation with the weighted Ellenberg scores for nitrogen; 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. Figure 5 shows that the second axis is correlated with the Ellenberg scores for light, and the third axis is correlated with soil moisture.

This study has demonstrated that the overriding factors which determine the composition of British 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 6). The mean Ellenberg scores decrease from 6.3 in AC I (crops/weeds) to 2.1 in AC 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.

These relationships between vegetation classes and environmental variables can be used to help interpret and predict changes in vegetation at a given location: if a plot changes its vegetation class along a particular gradient, then the change is likely to have resulted from the associated environmental change, such as an increase in soil fertility. Equally, methods of evaluating ecological impacts of environmental change could be developed on the basis of changes from plot class to plot class along the associated gradients.

### *3.3 Plant Strategy Theory and Functional Analysis*

Plant Strategy theory developed by Grime and his co-workers (Grime *et al.* 1988) postulates 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 - precisely the main gradients of the CVS.

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 light, moisture or 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.

The Ellenberg analysis suggests how the vegetation shifts from one aggregate class to another can be interpreted in terms of environmental change. The CSR analysis allows these interpretations to be brought to the level of individual species within the communities. For example, 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. It follows that some vegetation classes should be dominated by plants of particular CSR strategies. The compositions of the eight aggregate vegetation classes in terms of plant strategy (been derived by including all plots, both linear as well as main plots, surveyed in 1978 and 1990) bear this out (Figure 7):

*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 even 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 an undisturbed and unproductive system.

### *3.4 Distribution of Vegetation Classes*

The vegetation classes may be used to define the general patterns of vegetation in the four main landscape types of Britain (Figure 8). The arable landscape is dominated by ACI (crops/weeds), ACII (tall grassland/herb) and AC III (fertile grassland), but it has a small element of AC VII and VIII. The pastural landscape is similar, but is dominated by AC III and has a higher proportion of moorland grass/mosaic. The marginal uplands also have AC III (fertile grassland) as the most abundant aggregate class, but all the other aggregate classes are well represented, indicating the inherent variability of this landscape. The upland landscape is dominated by AC VII (moorland grass/mosaic) and AC VIII (heath/bog).

The diversity of CVS classes provides a measure of botanical diversity complementary to the use of species number. Their relative frequency in the landscape types, as measured by the mean number by plot class and by kilometre squares (Figure 9; note that a given class may occur in several landscape elements in the same square), therefore enables comparisons to be drawn as to the relative vegetation diversity in the different features. The principal conclusions are as follows:

- The diversity of vegetation classes is similar in the arable, pastural and marginal upland landscapes, but less in the uplands.

- Linear plots make a major contribution to diversity in all landscapes, but less in the uplands, even allowing for absence of hedgerows.

- The boundary plots decline in diversity through the series of landscape types from arable to upland.

- The targeted habitat plots contain the highest diversity, closely followed by the random main plots (especially if the mean frequency of vegetation classes restricted to a given plot type are considered).

- Hedges, roadsides and streamsides have similar levels of diversity, but lower than the other plot types.

- The variation in the lowlands is mainly in highly disturbed vegetation, linear features and fragments of semi-natural vegetation (represented by the habitat plots), whereas in the uplands the vegetation is mainly semi-natural and extensive (see Table 2).

### *3.5 Conclusion*

The Countryside Vegetation System provides a statistically valid means of describing vegetation and its diversity across Britain, both over broad landscape types and among the individual landscape elements within them. It also summarises the vegetation in a manner which is directly interpretable with respect to the key environmental drivers of nutrients, disturbance and water availability. The CVS also has the potential to assist in the interpretation and the forecasting of change of the vegetation as a whole and to the level of individual species through the CSR strategy model. The patterns of distribution of botanical diversity vary according to the ecological character of the region concerned. There is a continuum characterised by two extremes: In the lowlands of the south and south east of Britain, vegetation diversity is highest in linear features and scattered, small patches. In the upland landscapes of the north and west diversity is distributed more evenly accross the whole landscape.

# 4. RESULTS II - LINKS BETWEEN VEGETATION CLASSIFICATIONS

## 4.1 *Introduction*

A variety of other classifications of British vegetation and land cover exist for different purposes and in this section comparisons will be drawn between the classes of the CVS and these existing classifications. Full tabulation of the comparisons are provided in the technical annexes.

Vegetation data are continuously variable (Dale 1988) with no easily recognisable grouping of individuals. It is therefore to be expected that because boundaries between groups (classes) are arbitrary, the divisions will not be identical.

While the CVS considers 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. Such differences 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 10 illustrates some of the difficulties in reconciling two imaginary classifications. A series of classes on two axes of an ordination (such as Figure 1) are illustrated diagrammatically, with two classes from a second 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, and so it would be possible to express the results of the second class in terms of the first. This would not be possible for Class B, however, as it overlaps several different classes and therefore is not mutually exclusive to any one class.

## 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 individuals or groups of experts. 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 such 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 (which are considered as units of land with a recognisable ecological character) 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 these units. The CORINE Biotope manual (Moss et al, 1991) 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 National Vegetation Classification, concentrates on semi-natural vegetation. In contrast, CS1990, which is an impartial, random sample of the countryside only rarely captures scarce and localised assemblages, especially if they cover a small area. In the CVS, such small areas will be incorporated within 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 biotopes (Technical Annex 1). 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 with CVS classes, compared with some of the classifications that contain cartographically defined limits.

### *4.4 Phase 1 Habitats Classification*

The Nature Conservancy Council (NCC) developed a classification of habitats for Britain which is widely used by the conservation agencies. This recognises eight major categories of semi-natural vegetation, some of which contain a cartographic element (eg coast lands). 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 is presented in Technical Annex 1. 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 of Broad Habitats*

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 initially recognised 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.

Expert judgement comparisons were made between the CVS and the 37 broad habitat types of the Steering Group Report (Technical Annex 1). There is a poor agreement between the two classifications, with only the calcareous grassland and coniferous woodlands showing any direct agreement. It is not possible to compare over one third of the categories since these are defined in geographical terms rather than vegetation eg islands and archipelagos.

Some CVS classes occur in several of the broad habitat types. Predominantly, these are semi-natural habitats of conservation interest which are difficult to place in the CVS scheme since they are composed of vegetation complexes. For example, 'lowland wood pasture' and parkland' could contain CVS vegetation classes 42 (woodland on heavy soils), 47 (diverse mesotrophic pasture) and 52 (mesotrophic grasslands).

Other CVS classes are not clearly identifiable among the broad habitat definitions and are probably spread between several classes eg CVS classes 51 (wet rushy grasslands), 55 (rushy mesotrophic/acid grasslands) and 65 (acidic herb-rich grass/heath). The marine broad habitats lie outside the scope of the CVS.

The broad habitat classification is currently being revised and it is evident that by definition 'broad' habitats will embrace a range of vegetation. However, as the broad habitats will now be mutually exclusive and cover all the land of GB, it will be possible to assess the composition of each broad habitat in terms of vegetation plots, thus providing the basis for cross-comparison.

## *4.6 Comparison Between the CS 1990 Land Cover Reporting Categories and the CVS Vegetation Classification*

Land cover was mapped as part of CS1990 (Barr *et al.* 1993), and 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. The full comparisons are presented in Technical Annex 2. 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 crops and 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 in the land cover classification were ordered to reflect management intensity. The mixture of CVS vegetation classes present within them reflect this gradient, as demonstrated by the Ellenberg scores of Figure 5.

- There is reasonable correspondence between the CVS vegetation classes and the upland land cover categories of bracken, upland grass, moorland and bog, but overlaps between them do exist.

- Heath land cover categories 32 and 33 are not differentiated in their vegetation class composition, nor are bog categories 35 and 36. The distinction between these categories has been made on criteria other than the species composition, such as topographic position.

### *4.7 The National Vegetation Classification (NVC)*

The programme SIMIL was used to assign the average composition of the CVS classes to the National Vegetation Classification (NVC) communities eg Rodwell (1992). A summary of these comparisons with the aggregate classes and community groups is given in Table 4. At this level, there is broad agreement with each of the aggregate classes being dominated by one community grouping. In detail, however, comparisons are more difficult to make between the CVS classes and NVC associations as shown in Technical Annex 3 and in the summary descriptions where almost all the similarity coefficients are below 60%, which is the level generally set as acceptable for good comparisons. This is because the plots in the CVS were placed at random within the 1 km squares (except the habitat plots), whereas NVC plots are selectively placed in homogeneous vegetation. NVC is also primarily concerned with semi-natural vegetation, whereas many of the CVS plots, and hence the classes, are in highly disturbed situations. Nevertheless, some direct comparisons can be made eg with NVC calcicolous grassland association (CG 2) and CVS class 44 calcareous grasslands. Other comparisons can also be usefully drawn eg CVS class 40 rye-grass/Yorkshire fog grassland and MG7 rye-grass (*Lolium perenne*) leys, CVS class 26 tall grassland scrub and MG1 false oat-grass (*Arrhenatherum elatius*) grassland and CVS class 65 acidic herb-rich grassland and CG10 sheep's fescue (*Festuca ovina*), bent grass (*Agrostis capillaris*) and wild thyme (*Thymus praecox*) grassland. Annex 3 will enable users experienced in the use of the NVC to identify comparable assemblages in the CVS classes, further supported by the summaries available for each class. Rare associations and those occupying small patches of vegetation may be of conservation importance and considered separately within the NVC, but they will not correspond to individual CVS classes.

### 4.8 *Construction of a Statistical Procedure to Assign New Vegetation Plots to Classes Within the CVS*

A part of the work programme of Module 2 was to provide an automated procedure for allocating any vegetation plots recorded to the CVS. 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 high (50% - 60%), although misclassifications generally fell into neighbouring classes. It, therefore, appears that the hierarchical nature of the classifications themselves necessitates a hierarchical method for allocation of vegetation units to classes. Indeed, it is logical to use a method of allocation which is related to the methodology originally used to create the classification.

In order to allocate vegetation units to an existing hierarchical classification a binary decision tree was 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.

The decision tree structure for allocating vegetation units to the CVS has been implemented as a software package running under Microsoft Windows$^{TM}$. So far this package has been made available on request for several applications to test its efficiency, where it has performed well. It has also been incorporated into MAVIS (Modular Analysis of Vegetation and Interpretation System), which is currently being tested and is designed to provide ready access to the vegetation analysis procedures of CVS, NVC, CSR and Ellenberg values. 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 determine 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 Land Cover and Lowland Grasslands in Great Britain and Northern Ireland*

Countryside Surveys in Northern Ireland (NI) have followed a similar approach to those in Great Britain, but with different land cover and vegetation classifications. The purpose of this element of the work programme was to compare these different classifications.

The first stage was to compare details of the definitions for land cover, and these were computed and entered into LUCID, the software package which compares a range of different land cover classifications and which is held in the CIS. 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, even although the two regions are close geographically, the Antrim coast being only 15 km from western Scotland. However, the management of grasslands appears less intense and the extensive drift deposits may be different from western Scotland. 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 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 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 $m^2$ plots (Cooper and McCann 1994). The vegetation data were classified using similar analytical procedures as for the CVS. Further details of the comparisons are given in Annex 4.

The results confirmed the anecdotal observations of botanists. The NI fertile 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 may be attributed to management, but these would require further study.

This comparison between the vegetation of NI and GB has also highlighted the desirability that programmes use 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.

### *4.10 Conclusion*

A variety of comparisons were made between the CVS and other classifications to aid interpretation of the results. A computer software package was developed to enable ready access to the classification and to allow vegetation plots to be analysed in a variety of ways, but this should be used with care, as different classifications make different assumptions about data collection and interpretation.

# 5. RESULTS III - SPECIES DIVERSITY, SPECIES GROUPS AND SPECIES

## *5.1 Description of the Species Groups*

The clustering of the 1990 species data generated 37 species groups (Table 5), the principles of which are described in section 2.2. The different combinations of species groups help explain ecological differences between vegetation classes and aggregate classes (Table 6) and reveal differences in the inherent diversity of the vegetation. Shifts in the balance in species groups as vegetation changes from one class to another through time can provide insights into the causes of change, and its possible future direction.

The principal ecological characteristics of the aggregate classes is revealed by which species groups they contain, and they may be summarised as follows:

AC I (crops/weeds): mainly crop and crop edge plants.

AC II and III (tall grassland/herb and fertile grassland): comparable with some crop and crop edge plants, but with more frequent grassland, wood edge and tall grassland plants usually on brown soils.

AC IV (infertile grassland): dominated by grassland plants on variable soils, but with some plants from wetter conditions.

AC V (lowland wooded): dominated by woodland and wood edge plants, but with some crop edge plants on nutrient rich, calcareous or neutral soils.

AC VI (upland wooded): woodland or woodland edge plants but with a strong element of moorland species of acidic soils.

AC VI (upland wooded): although an element of grassland plants from brown soils is present most species or moorland or heath plants from acidic soils.

AC VII and VIII (grass mosaic/moorland and heaths/bogs): almost entirely confined to a restricted range of moorland heath or bog plants of podzolic or peaty soils.

It is also useful to examine the occurrence of the species groups in the different plot types and in the different landscape types (Table 7). It transpires that there are widespread species groups which are found generally within the principal vegetation classes, while there are scarcer groups which are found in particular situations resulting from local variations in habitat. For example, streamside vegetation is likely to have widespread plants such as stinging nettle (*Urtica dioica*) from species group 5, but may also have specialist water-loving species such as water cress (*Nasturtium officinale*).

The principal features of the distribution patterns of the species groups may be summarised as follows.

- The most ubiquitous species groups, 18, 22 and 27, mainly consist of grassland species, and they occur through all plot types and landscapes.
- Some species groups, eg 6, 20 and 21, are restricted to particular plot types, usually of limited frequency. They contain specialised species, particularly water loving plants or calcicoles.
- Some species groups, such as 36, occur only in one landscape type and in the uplands; bog plants are especially restricted.
- In all landscapes the streamside plots are most diverse in their species group composition, reflecting the complexity of conditions at the edge of water.
- Arable and upland landscapes have the fewest species groups, as the variation is polarised into crop and grassland species groups on the one hand and moorland and bog species groups on the other. The other two landscapes contain mixtures because they are more intermediate.
- Although the habitat plots have the smallest number of species groups, they contain more vegetation classes and individual species than the other plot types confirming that they were located in areas of relatively diverse vegetation, not covered by other plots. They are also in small patches of vegetation, often outside the main management of the landscape.

### *5.2 Conclusion*

The various measures of diversity show that botanical capital is unevenly distributed through the countryside. Different measures identify different reservoirs of diversity, but in general linear features, especially streamsides, are particularly diverse. However, the main plots still have a surprising amount of variation even in the lowlands, although this may not be of semi-natural vegetation. The habitat plots, usually representing often small fragments of vegetation, were consistently high in diversity, emphasising the conservation importance of such patches.

# 6. RESULTS IV - CHANGES IN BOTANICAL CHARACTER 1978 - 1990

## *6.1 Change: Introduction*

The data for botanical change were those collected at the same locations, the sample plots (main, hedgerow, streamside and roadside) recorded in both 1978 and 1990 (Barr *et al.* 1993). Statistical tests of such changes are far more sensitive than those relying on separate sets of samples randomly located on each occasion. The sample size of the comparison remains important, in that larger samples can reveal smaller degrees of change, and samples which are too small may give misleading results. Therefore, in the tables presented below change data were omitted if the category contained fewer than 10 % of all plots in the respective landscape type (Table 8).

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 (Barr *et al.* 1993). AC I is directly comparable with the crops group of CS 1990. AC II is not represented in the open landscapes which were included in the comparable table in the CS 1990 main report. AC III is comparable to the improved grassland, AC IV to the semi-improved grassland, AC VII to the upland grass mosaics and AC 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) in the CVS. It must also be borne in mind that in the current analysis, using the CVS, all plots can be considered together, regardless of their position in the landscape.

One of the objectives of the CVS was to enable integrated assessment of the changes in species number, group and vegetation classes across the whole landscape, regardless of plot-type. Therefore in the table below, plots were combined regardless of size, but these were also treated separately, so that trends within landscape elements can be separated from those taking place across the whole landscape. Results for all plots irrespective of plot type are presented in Table 9. Results for the different plot types are presented in Tables 10 to 13.

The plots were classified in the tables according to the vegetation present in 1978. Therefore, they include plots which may have moved between aggregate classes and represent the overall change that has taken place. An overall summary of the number of tests and the directions of change are presented in table 14.

## *6.2 Change in species numbers*

Here, we report total species number in 1990 and its change since 1978 for all plots within different combinations of plot and landscape type. Note that these analyses excluded aggregate species.

### *6.2.1 Main plots*

In the intensively managed farmland containing AC I (crops/weeds) and AC III (fertile grassland), species richness was greater in pastural than arable landscape types. AC IV (infertile grassland) was most species-rich in marginal uplands. Upland vegetation, AC VII (moorland/grass mosaic) and AC VIII (heath/bog) was more species-rich in the true uplands than in the marginal uplands.

Overall there was a significant decline in species number between 1978 and 1990 in AC I (crops/weeds) of -26%, in AC II (infertile grassland) of -16% and in AC VI (upland wooded) of -21%.

### 6.2.2 *Roadside plots*

Species number per plot was greater in small (10 m) linear verge plots than in the large (200 m) main plots.

For GB as a whole there was a significant increase in species number (+17%) in AC II (tall grass/herb) on roadsides between 1978 and 1990. This increase was most marked in pastural landscapes. There were no significant changes in other aggregate classes at the GB level.

In the pastural landscape AC III (fertile grassland) on roadsides increased in species number (+14%) whereas AC IV (infertile grassland) on roadsides became slightly poorer in species (-6%).

### 6.2.3 *Hedge plots*

Hedge plots contained fewer species than roadside verges and streamside plots.

For GB as a whole there was a significant loss of species number (-14%) in AC II (tall grass/herb) in hedges. Similar losses also occurred in both arable and pastural landscapes, but were not significant.

### 6.2.4 *Streamside plots*

Streamside plots had similar species numbers to roadsides but were more diverse than hedges, and in most cases were more species rich than main plots, even though these were larger.

For GB as a whole, significant loss of species number occurred between 1978 and 1990 in AC III (infertile grassland) (-17%), AC VI (upland wooded) (-21%) and AC VIII (grass mosaic/moorland) (-13%). The declines were most marked in arable and upland landscapes.

In contrast, AC II (tall grass/herb) streamsides in arable landscapes increased in species diversity, a trend which also occurred by roadsides, but not in hedges.

### 6.2.5 *All Plots*

Considering all plots together, for GB as a whole, there were significant decreases in species number in AC II (crops/weeds) (-22%), AC IV (infertile grassland) (-14%) and AC VI (upland wooded) (-21%) vegetation types. That is the equivalent of on average two fewer species per plot in AC II (crops/weeds), three fewer in AC IV (infertile grassland) and four fewer in AC VI (upland wooded). The loss of species richness in these vegetation types was experienced across most of the major elements of the landscape, and was concentrated in the lowlands.

There was a small (+6%) but significant increase in species number in heath/bog vegetation types, equivalent to on average one extra species per plot. However, the main plots did not show a significant increase, and this figure may have been influenced by the 12% increase by streamsides in the uplands.

### *6.2.6 Conclusion*

These figures portray a substantial decline in the diversity of common plants across much of lowland Britain between 1978 and 1990. The widespread vegetation of fields, woods, hedges and streamsides became simpler in composition and thus more uniform in character. The heath/bog aggregate class in the 'true' uplands showed a small increase in diversity, but this may have been influenced by streamsides.

The analyses that follow look in more detail at the changes in species composition which underly the changes in species numbers. Changes in species composition can help to assess the implications for biodiversity in the wider countryside and can help to indicate the processes operating.

## *6.3 Change in Individual Species Frequency and Cover*

Changes in cover and frequency of individual species are implicated in the changes observed in species groups but have ecological significance in their own right. Full tabulations of the changes are given in Annexes 5 and 6.

Change analyses are presented in the same way as the changes in species number. The principal changes are as follows:

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

- In the arable landscape, tall grasslands (AC II) in hedgerows and on roadsides, there has been an expansion in weeds and 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 (AC III) in main plots, white clover (*Trifolium repens)* and rye grass (*Lolium perenne)* have declined in cover in the arable landscape whilst creeping thistle (*Cirsium arvense)* has increased at the GB scale and in the pastural landscape.

- Other species increasing in cover in the fertile grasslands (AC III) include bramble (*Rubus fruticosus)*, red fescue *(Festuca rubra)* and creeping bent *(Agrostis stolonifera).* The same trends occur on roadsides and main plots.

- The increasing species across all landscapes were stinging nettle (*Urtica dioica),* cleavers (*Galium aparine)*, rye grass *(Lolium perenne),* creeping bent (*Agrostis stolonifera*) and red fescue (*Festuca rubra).* There was also an increase in cover in red fescue (*Festuca rubra),* creeping bent (*Agrostis stolonifera)* and Yorkshire fog (*Holcus lanatus).*

- Stinging nettle (*Urtica dioica)* has also increased by streamsides, as well as cleavers (*Galium aparine),* great hairy willowherb (*Epilobium hirsutum)* and creeping bent (*Agrostis stolonifera*).

- In hedgerows there was an increase in weeds such as 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)* have increased in cover.

- Changes in shrub abundance in hedges, 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 overall, because removed hedges were included in this analysis. In the pastural landscape hazel (*Corylus avellana)* declined but hawthorn (*Crataegus monogyna)* and ivy *(Hedera helix)* increased.

- In the upland landscapes Sitka spruce (*Picea sitchensis)* increased in the grass/ moorland mosaic and heath/bog (AC VII and VIII respectively).

- Change in the heath/bog (AC VIII) show few changes, but species such as bent grass (*Agrostis capillaris),* Yorkshire fog (*Holcus lanatus)* and heath bedstraw *Galium saxatile* showed a significant increase.

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

The interpretation of the ecological significance of these changes led to hypothesis formulation regarding underlying causes of ecological change in the British countryside, the results of which are presented elsewhere (ECOFACT Module 6).

### *6.4 Change in Species Groups*

The analyses of changes in cover for species groups did not include 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, was therefore on changes in cover within plots rather than changes in frequency between plots. The change in species groups complement the figures on changes in species number, but enable the ecological properties of those species which have increased or decreased in their mean cover. The following are the principal changes. The full tabulation is given in Annex 7 and the names of the species groups in Table 5.

*AC I (crops/weeds)*: Plants associated with crops have decreased whereas grassland plants have increased, reflecting a shift towards graminaceous weeds.

*AC II (tall grassland/herb):* Some grassland species have been lost and all significant changes in species groups have been negative.

*AC II & III (tall grassland/herb and fertile grassland):* Significant increases in the cover were in three species groups, associated with grassland on fertile soils and in the latter on woodland plants associated with humus-rich or fertile soils.

*AC III (fertile grassland):* The largest decline is in grassland species and there is also an increase in species of plants associated with crops, indicating a change in balance of species within fields.

*AC IV (infertile grassland):* This class shows the largest change in species groups over all the combinations examined and confirms the decline of species groups representing plants of neutral grasslands. Six groups of grassland plants have declined overall and there is also a small increase in plants associated with crops.

*AC IV (infertile grassland):* There is 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 associated with wood edge and woodlands.

*AC V (lowland wooded):* A striking decline of woodland and wood edge species, with a corresponding increase in plants associated with crops on fertile soils.

*AC VI (upland wooded):* A significant decline of four species groups all involving woodland species.

*AC VII (grass mosaic/moorland):* Three significant losses affecting mainly grassland species groups.

*AC VII (grass mosaic/moorland):* A balance between losses and gains with grassland plants generally declining but heath and bog plants increasing.

*AC VIII (heaths/bogs):* The main changes involve a loss of moorland plants and a gain in grassland plants reflecting the shift away from ericaceous species to more general grassland plants.

### *6.5 Changes between aggregate classes*

The net flows of plots between the aggregate classes between 1978 and 1990 are shown in Figure 11. Complete matrices of change between aggregate classes within the four landscape types are given in Annex 8. 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 were losses from ACs III and IV (fertile and infertile grasslands) mainly into AC II (tall grassland/herb). The other major loss was from AC VIII (heath/bog) to AC VII (grass mosaic and moorland), which in turn has shown shifts into AC VI (upland wooded), reflecting the planting of new coniferous plantations. There was a small loss from AC I (crops/weeds), but this may have been a temporary change in cropping systems, perhaps associated with the five year set-aside programme introduced in 1988.

Within arable landscapes, the major shift was from AC III (fertile grassland) into AC II (tall grassland/herb) perhaps indicating that roadsides, streamsides and hedgerows have become more overgrown. Within pastural landscapes, the major shift was from AC IV (infertile grassland) into AC II (tall grassland/herb), but this masks a considerable movement between AC IV (infertile grassland) and AC III (fertile grassland). Within marginal upland landscapes AC V (lowland wooded) and AC VI (upland wooded) increased at the expense of AC IV (infertile grassland) and there have also been losses in AC VII (grass mosaic/moorland) and VIII (heaths/bogs) mainly into the upland wooded class. Within the uplands, the situation was relatively stable, apart from a loss of AC VIII (heaths/bogs) into AC VII (grass mosaic/ moorland) perhaps corresponding to the losses of ericaceous species.

These shifts in aggregate classes reflect major changes, masking smaller movements between individual CVS classes. Thus, within AC IV (infertile grassland) there was a major shift towards CVS 30 (mixed eutrophic) from CVS 40 (rye grass/Yorkshire fog grassland) and CVS 31 (ryegrass/clover grassland), implying a loss of diversity. The small shift towards AC IV (infertile grassland) from AC III (fertile grassland) is likely therefore to reflect a reduction in short term grassland, that does not correspond with the shift inside the AC IV (infertile grasslands). CVS class 75 (upland coniferous plantations on moorland/upland garssland) increased at the expense of other CVS classes in AC VII and VIII. There was also a shift from CVS 75 to 77 (Sitka Spruce plantation) owing to canopy closure between 1978 and 1990. 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, implying increased uniformity accross the vegetation.

## 6.6 *Conclusion*

The decline of individual species in frequency and cover complement the losses detailed in the CS1990 main report (Barr et al, 1993), and emphasise the trend towards simplification. The species that have increased are generally already widespread, abundant plants.

# 7. RESULTS V - BOTANICAL QUALITY EVALUATION OF BRITISH VEGETATION AND CHANGE 1978 - 1990

## *7.1 Introduction*

The botanical analyses presented so far are designed to be objective and value-free. However, ecosystems, vegetation and species differ in the values attached to them by the conservation agencies, policy makers and the public, and therefore a procedure is required to evaluate the quality of botanical variation in order to inform policy. This is not a new idea; indeed a set of principles for the evaluation of sites using botanical quality was proposed by Usher (1986) over a decade ago and similar approaches have been developed for application with the NVC (Rodwell, 1992).

We consider that the quality of vegetation depends upon an anthropocentric assessment of its value according to its abundance, its contribution to the perception of high environmental character, or its importance to other elements of biodiversity which are regarded as of value in their own right.

There can therefore be no simple or single measure of quality, and so our approach uses a range of different approaches to quality assessment which relate to different aspects of vegetation. For example, the creeping thistle (*Cirsium arvense*) is normally regarded as of low quality within vegetation as it is widespread, visually apparent and an aggressive weed. However, its flowers and seeds provide important food sources for moths, butterflies and birds, and so this species would therefore be considered a high quality plant for the conservation of these taxa.

The quality measures used 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 a high quality vegetation of importance for nature conservation 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 plots and field plots) 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 indicator species within each plot type were analysed. Where possible, analysis of change in abundance between 1978 and 1990 was also carried out, but using only the smaller number of replicate plots recorded in both years.

Results are expressed as differences between plot types within the four landscape types (arable, pastural, marginal upland and upland) but including an overlapping coastal zone comprising all sampled 1 km-squares containing maritime fringe features such as sea, estuary, sea cliff, salt marsh and dunes.

## 7.2 *Habitat Indicator Species for Unimproved Grasslands*

### 7.2.1 *Approach*

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 can be used as a basis for interrogating the CS1990 database in order to determine the representation of these species in the wider 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 approach is generic, however, in that a variety of different lists could be used to generate alternative assessments of landscape elements and vegetation types in terms of botanical quality of different habitats.

Three categories of high quality species were considered; which were those regarded as indicators of unimproved calcareous grasslands in England and Wales, acidophilous grassland species and mesotrophic grassland species in GB respectively.

### 7.2.2 *Distribution of the indicator species in the landscape*

Calcareous grassland indicators occurred in a significantly greater number of roadside 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 (Table 15 a). 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 acidic and mesotrophic grassland indicator species were recorded from a significantly greater proportion of streamside plots than any other plot type (Table 15 b and c). 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.

### 7.2.3 *Changes between 1978 and 1990*

Tests for the significance of changes in presence of indicator species between 1978 and 1990 were undertaken (see Table 16). 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 acid 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 grassland indicators was detected for the whole of GB (-8%) and for the pastural landscape (-11%).

Some indicator species are less strictly confined to unimproved mesotrophic grasslands; these 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 17, 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%.

### *7.3 Rarity Indicator Species*

#### *7.3.1 Approach*

Nationally scarce and Red Data Book (RDB) species were recorded in 66 plots in 1990; 22 in the arable landscape, 20 in the upland landscape, 18 in pastural landscape and 6 in the marginal uplands (Table 18 ). 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.

#### *7.3.2 Distribution of rare and scarce species*

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 common in main and streamside plots.

#### *7.3.3. Changes between 1978 and 1990*

No change in number of records was detected for either species rarity groups, indicating that it is the more common species which are changing. However, the records of rare species are by their nature small in number, unusual and therefore difficult to generalise from. In this respect CS1990 provides a less appropriate dataset than those available from targetted, smaller scale studies.

### *7.4 NVC Diagnostic Species*

#### *7.4.1 Approach*

The National Vegetation Classification was developed by the assignation of whole swards to particular semi-natural vegetation types, which have been defined by Rodwell (1992) in terms of their characteristic species, and which are considered to represent a range of levels of conservation importance.

One method of interpreting Countryside Survey data in terms of the presence of a valued NVC community is therefore to identify a core assemblage of species which is typical of it, even though it is likely to be accompanied by species perhaps typical of other community types. This is especially because field sampling for NVC targets "homogenous" vegetation, while CS protocols will often encompass gradations of vegetation types. 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?

Within the NVC, there are combinations of widespread species which characterise the less common plant communities, and so it is possible to detect the presence and changes in these communities in a robust statistical manner by analysing those situations where such widespread species occur together. As an example, the plot type and landscape preferences of species that characterise the NVC unimproved grassland community MG5 (Rodwell, 1992) were analysed.

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 even be used to 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 the floristic table for MG5 published in Rodwell (1992). Species were then excluded if they were also common in other habitat types, as evaluated using Biological Records Centre (BRC) grades, resulting in a list of 21 species (Table 19), here termed MG5 faithful species.

Two subsets of plots recorded in 1990 were then defined for analysis using the list of faithful species. Firstly, 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, 1992) 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)*. 73 out of 13,587 plots (0.6%) were selected because they contained all 4 species. 84% (62) of these were in AC IV, the remainder in AC VII. When these plots were grouped by plot type no significant differences in total count of the remaining 19 faithful species was detected, implying that these plots could be regarded as homogeneous within the landscape. The small size of the data set indicates how uncommon the assemblage is in the countryside as a whole. Secondly, joint occurrence patterns of all MG5 faithful species were examined for between plot-type and between landscape type differences. For this analysis any plot that contained at least one or more of the faithful species was included.

### *7.4.2 Frequency distribution of MG5 species among plots*

The distribution of MG5 faithful species across the entire CS1990 data set covers extremes which at one end contains many plots that has only one of these species, while at the other extreme there exist a small number of plots which 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, omitting the upland landscape which is outside the expected distribution range of the community.

The degree of the rarity of the community depends upon how many of the MG5 faithful species are judged to be required before the community can be assigned to MG5. Where only one species is present, the community cannot be regarded as MG5, but as number of faithful species in each plot increases, the greater is the confidence that the plot is best placed in MG5.

In Figure 12, the greater the percentage of plots occupied by high numbers of MG5 species, the more the distribution is skewed to the right of each graph. In practice, there are few plots in the different combinations of landscape and plot type which show more than 6 MG5 species, and only 25 plots in total have 14 MG5 species or more (Table 20). Main plots in the arable landscape have the lowest representation of MG5 species; they are more abundant in roadsides in all landscapes and in boundary plots in the marginal uplands. The greatest concentration of MG5 plots was in the roadside verges in the marginal uplands, although even here only 2.8% of plots had 12 MG5 species growing together.

### 7.4.3 *Changes between 1978 and 1990*

For the analysis of change between 1978 and 1990, the variable of interest was the median number of 'faithful' species in each plot which is considered to be MG5, ie. having pre-selected a group of plots possessing a minimum floristic element of MG5 we go on to test whether, between years, there has been any differences in median richness of the remaining MG5 indicators in Table 19, and therefore any increase or decrease in similarity to MG5, and therefore any change in conservation quality.

Only 17 plots had all 4 species recorded together in 1978. Between 1978 and 1990 there was a significant increase in richness of MG5 faithful species in these plots. Their environmental and ecological situations were examined by reference to the original survey records. These highlighted the probable 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.

## 7.5 *Abundance of Preferential Species*

### 7.5.1 *Approach*

Preferential species are those most strongly associated with each of the eight CVS aggregate classes. These were identified by a chi-square analysis and then divided into three groups; abundant, intermediate and rare, based upon their frequency. It turns out that most of the significant differences in mean count between plot types are shown by the set of abundant species, not least because of the larger number of these species in the dataset (Table 21).

While the abundant species strongly characterise the vegetation, they may not reflect the conservation quality of the vegetation. Each abundance category can be interpreted in terms of botanical quality in ways which vary between aggregate classes. For example, all categories of the infertile grasslands are indicative of higher quality, since the class itself represents unimproved diverse 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. By analysing plots in terms of species richness of the appropriate combination of abundant, intermediate and rare preferential species for each aggregate class, it is possible to make statements about the distribution of high quality examples of these vegetation types across the landscape.

### *7.5.2 Distribution of high quality plots*

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

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

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

In general, therefore, the marginal uplands encompass the richest infertile grassland vegetation. Hedges and roadsides 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.

### *7.5.3 Changes between 1978 and 1990*

It is possible to provide a measure of changing ecological quality between 1978 and 1990 by analysing changes that occurred have occurred in numbers of preferential species for each aggregate vegetation class divided into the 3 abundance groups; abundant, intermediate or rare (Table 22). Major findings are:

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 detected shifts in aggregate class membership probably indicating more weed-free crops, since the average cover of weeds was also shown to have declined.

An increase in the commonest characteristic tall grassland species occurred in the arable and pastural landscapes, the ecological significance of which is reported in ECOFACT module 6.

The mean counts of the most characteristic infertile grassland species have fallen across the whole dataset with reductions in the most frequent character species 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 more diverse grassland vegetation in GB has experienced the most marked decline in botanical character between 1978 and 1990, and that the vegetation of Britain is becoming more homogenous with abundant species of more common and species poor vegetation becoming even more widespread.

These changes accord with trends detected in functional analyses of change by the Unit of Comparative Plant Ecology (UCPE) (ECOFACT Module 6) and with analyses of change in species diversity by landscape type and aggregate class.

## *7.6 Butterfly Larval Food Plants*

### *7.6.1 Approach*

Vegetation only forms part of a functioning ecosystem, and so the consideration of quality should include the contribution it makes to other valued elements of biodiversity. One way to do this is to use known dependencies between individual plant species and faunal groups; if the plant species has increased, then that is an indication that the habitat for the animal species concerned has also improved. It is only an indication, since other factors can also be important; for example, the presence of seeds as a food resource can depend upon a cutting regime as well as on the mere presence of the appropriate species of plants, and for butterflies, there needs to be nectar resources for adults as well as larval host plants.

Lists of butterfly species and their larval host plants were obtained from the database of the Biological Records Centre (BRC). For each landscape type and aggregate class combination, the mean counts of butterfly host plants per plot were generated from 1990 data only. In total 145 butterfly host plants were recorded in CS data.

### *7.6.2 Distribution of host plant species*

The results (Table 23) again emphasise the importance of AC IV (infertile grasslands). 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 AC I (crops/weeds) in the arable, pastural and upland landscapes and for AC V (lowland wooded) in the marginal uplands.

### *7.6.3 Changes between 1978 and 1990*

Butterfly host plants for which significant changes in frequency between 1978 and 1990 were detected are listed in Table 24. Table 25 lists the butterfly species for which host plants either increased or decreased. Stratification was by aggregate class and landscape type.

Nineteen butterfly host plants (13%) decreased in frequency between 1978 and 1990 whilst three species (2%) increased (Table 26). Of the remaining 123, no change was detected for fifteen (10%) and 108 (75%) were too infrequent for analysis. 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.

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, because increases under sheep grazing are unlikely to result in the greater availability of the preferred larger and leafier individuals of the food-plant typical of 'boggy meadows' (Heath et al, 1984; Thomas, 1991).

The largest number of declining species was recorded from AC IV (infertile grasslands) in the pastural landscape including the prostrate herb of unimproved grasslands bird's-foot trefoil *(Lotus corniculatus)*; the food-plant for seven 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.*

## 7.7 *Food Plants of Lowland Farmland Birds*

### 7.7.1 *Approach*

The same approach as for butterfly host plants was used. 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 of 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. 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).

### 7.7.2 *Distribution of bird food plants*

The analysis of distribution of bird food plants is 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 bird food plants in the species records of plots in the lowland aggregate classes and landscapes.

Crop and ruderal species such as chickweed *(Stellaria media)*, annual meadow grass (*Poa annua)* and especially *Polygonum* spp. feature prominently in the list of food plants, and it is, therefore, not surprising that the highest figures refer to AC I (crops/weeds) 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 of the severely declining farmland 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 plots with a high cover of food plants were all found in AC I (crops/weeds) in both lowland landscapes, with the second highest figures picking out AC III (fertile grasslands).

Table 28 also shows that the highest mean cover values of food plants were associated with plots in the pastural landscape.

The greatest abundance of food plants for the bullfinch was found in AC V (lowland wooded) 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.

### 7.7.3 *Changes between 1978 and 1990*

For each bird species listed in Table 29 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. Eight species increased and 10 species showed both an increase and a decrease in different strata (Table 30). 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 31).

Changing patterns of food plant abundance however, fail to separate the three groups of stable, increasing and decreasing species. 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.

### *7.8 Conclusion*

With the exception of the rare species, almost all the plants identified by the different approaches as indicative of quality have declined. These analyses therefore demonstrate that the losses of species reported in section 6 are accompanied by a loss of quality, within the assemblages of species that make up the wider countryside.

# 8.0 GENERAL CONCLUSION

The present report provides details of the botanical analyses carried out largely in response to the comments received following publication of the CS1990 main report (Barr et al, 1993).

The supporting documentation provides descriptive material in support of the statistically complex analyses carried out and data on the links between the CVS and other classification systems. The CVS has been developed as a classification of the wider countryside. It provides a statistically sound framework for the assessment of stock and change of botanical diversity.

The results from the application of this framework largely confirm the widespread losses reported in CS1990 but go further showing that these also involve a loss of botanical quality.

The principal gradients in the vegetation of the wider GB countryside have also been correlated with surrogate measures of controlling environmental factors enabling hypotheses to be developed on the causes of change.

All analyses can be repeated when data is available from CS2000. Communication of the results in an easily digestible form will be favoured by applying the same approaches to stock and change underpinned by the CVS classification of Countryside Survey botanical data.

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**FIGURE CAPTIONS**

<u>Figure 1</u> Distribution of the 100 vegetation classes, grouped by aggregate classes, on the first two axes of the CVS 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).

<u>Figure 2</u> Proportion of the six plot types within each of the eight aggregate classes. X = main plots; R = verge plots; B = boundary plots; H = hedge plots; S = streamside plots, Y = habitat plots.

<u>Figure 3(a)</u> An example of a summary description of one of the 100 vegetation classes of the Countryside Vegetation System.

<u>Figure 3(b)</u> Key to the summary descriptions of the 100 vegetation classes of the Countryside Vegetation System, giving details of sources and categories involved.

<u>Figure 4</u> 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*.

<u>Figure 5</u> 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.

<u>Figure 6</u> Average of the Ellenberg value for fertility by aggregate class and plot type. Table 3 provides the sample numbers. X = main plots; R = verge plots; B = boundary plots; H = hedge plots; S = streamside plots, Y = habitat plots.

<u>Figure 7</u> 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.

<u>Figure 8</u> The total number of plots in the 100 vegetation classes of the Countryside Vegetation System by the four landscape types.

<u>Figure 9</u> Average number of vegetation classes within the 1km squares in the four landscape types. A = arable landscape; P = pastural landscape; M = marginal upland; U = upland; X = main plots; R = verge plots; B = boundary plots; H = hedge plots; S = streamside plots, Y = habitat plots.

(a) by landscape type and constituent plot type;
(b) by plot type and constituent landscape type.

<u>Figure 10</u> 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.

<u>Figure 11</u> Net movement of plots between 1978 and 1990 between aggregate vegetation

classes. + = net gain, - = net loss.

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.

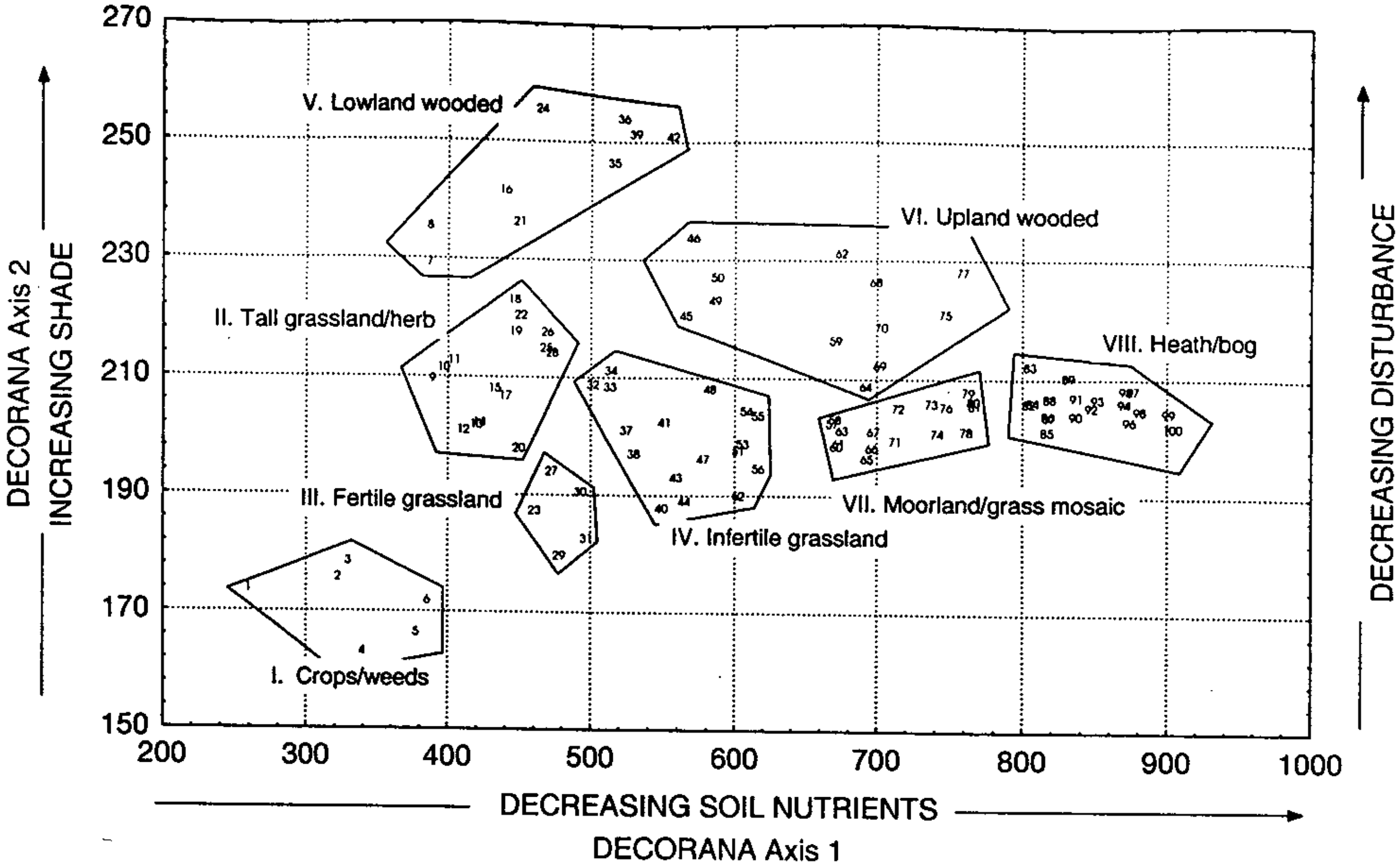

V. Lowland wooded
VI. Upland wooded
II. Tall grassland/herb
VIII. Heath/bog
III. Fertile grassland
VII. Moorland/grass mosaic
IV. Infertile grassland
I. Crops/weeds
DECORANA Axis 2
INCREASING SHADE
DECREASING DISTURBANCE
DECREASING SOIL NUTRIENTS
DECORANA Axis 1

Figure 1

Figure 2. Proportion of plot types represented in each aggregate vegetation class.

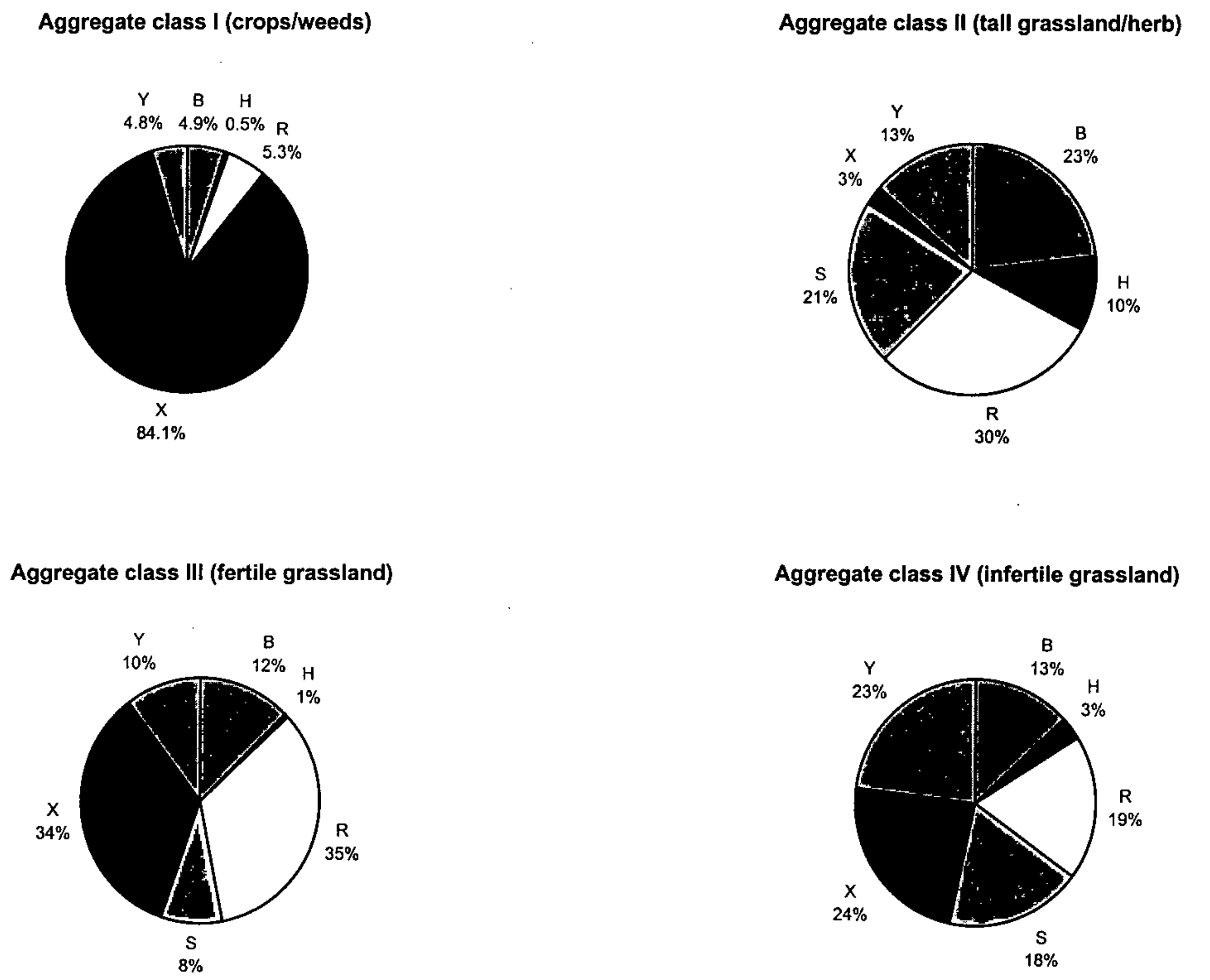


Figure 2. Continued.

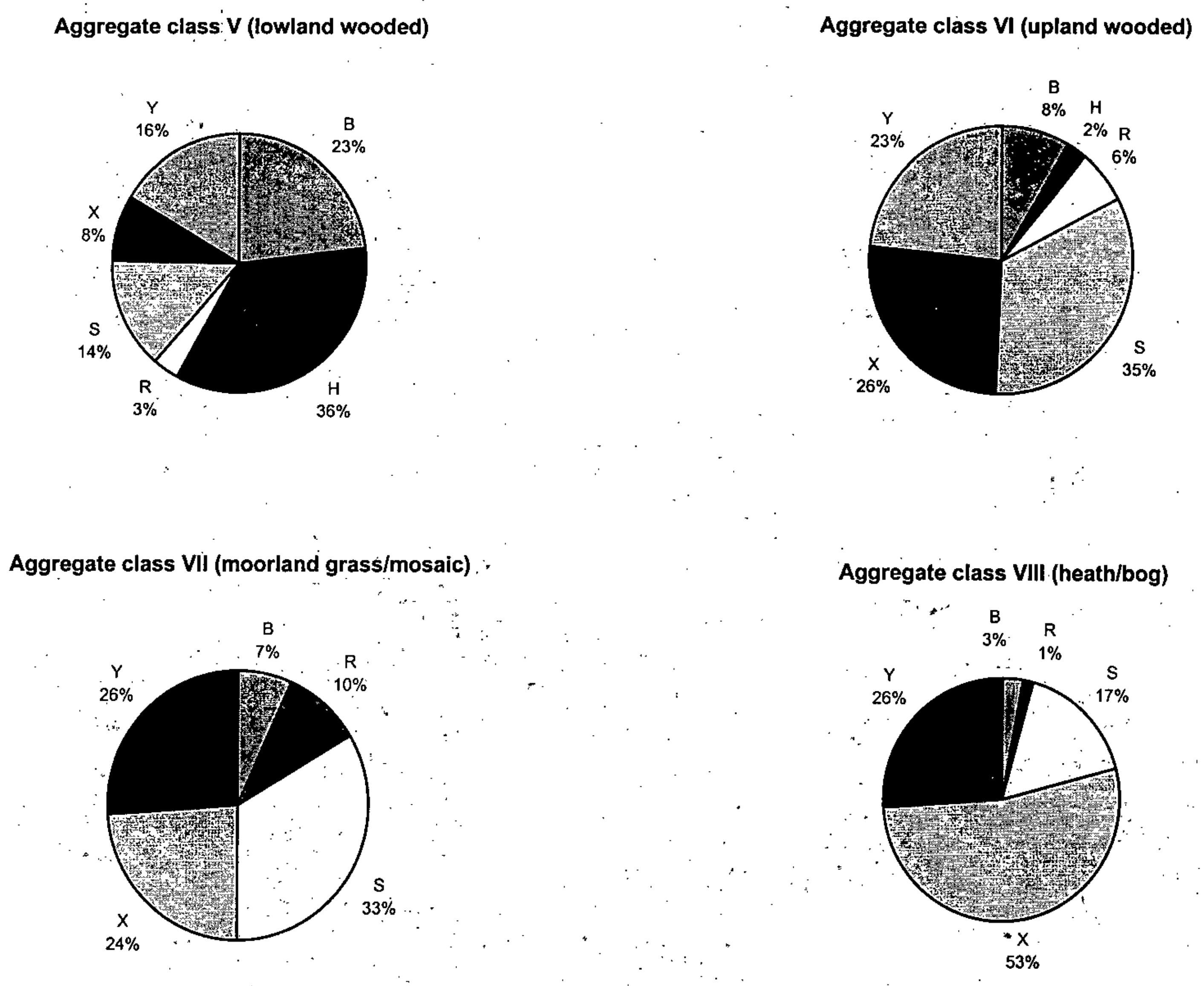


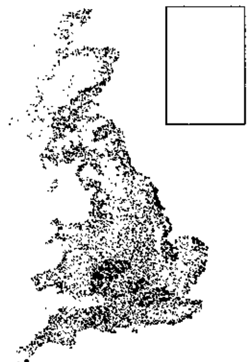
Figure 3a)

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

# Gravel reedbeds

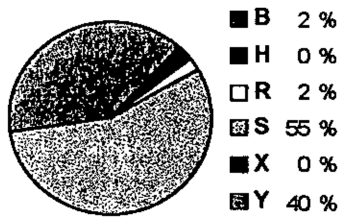
**Total number of plots:** 85 **Area:** No estimate **S.e.:** No estimate

**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.

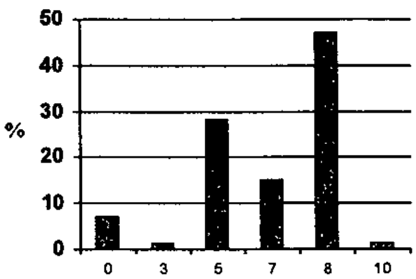
**Species number:** 201 (high) **Nr. of species groups:** 8 (med.) **Most frequent species group:** 22

| **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* |

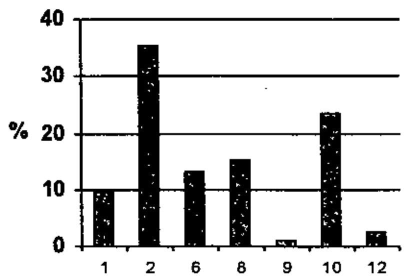
**Related habitats**

Broad habitat: 13 CORINE biotope: n.e. PhaseI habitat: F3

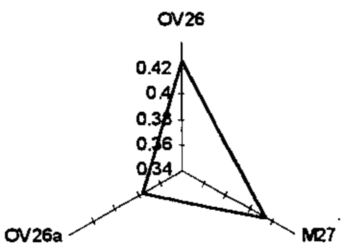
**Soils**




**Landcover**




**Similarity with NVC types (%):**




**CSR characterisation (%):**

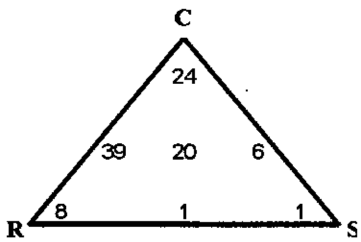


Figure 3 b)

**Vegetation class 0** **Aggregate Class 0:**

## Description Sheet

**Total number of plots**

**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.

*A = Arable landscape*
*P = Pastural landscape*
*M = Marginal Uplands*
*U = 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 $\chi^2$ -test.

**Related habitats**
Broad 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.

Figure 4.

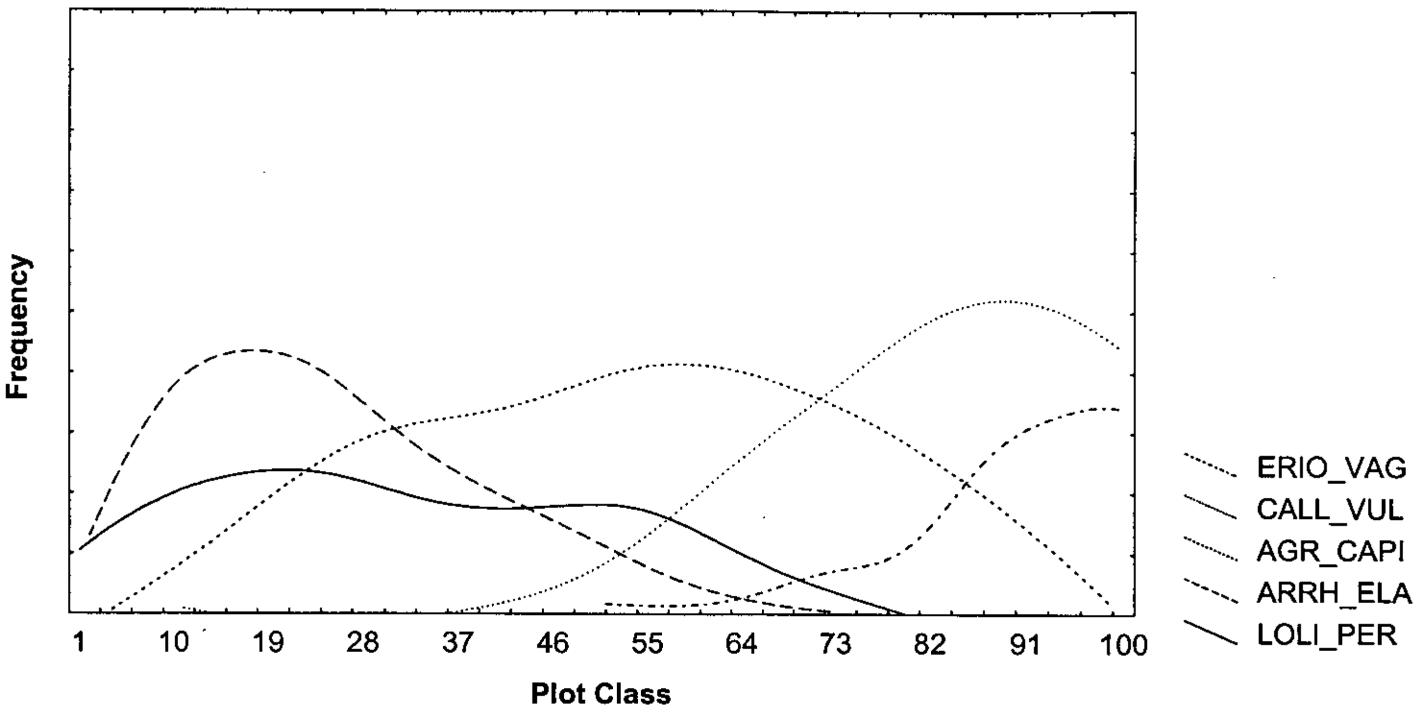
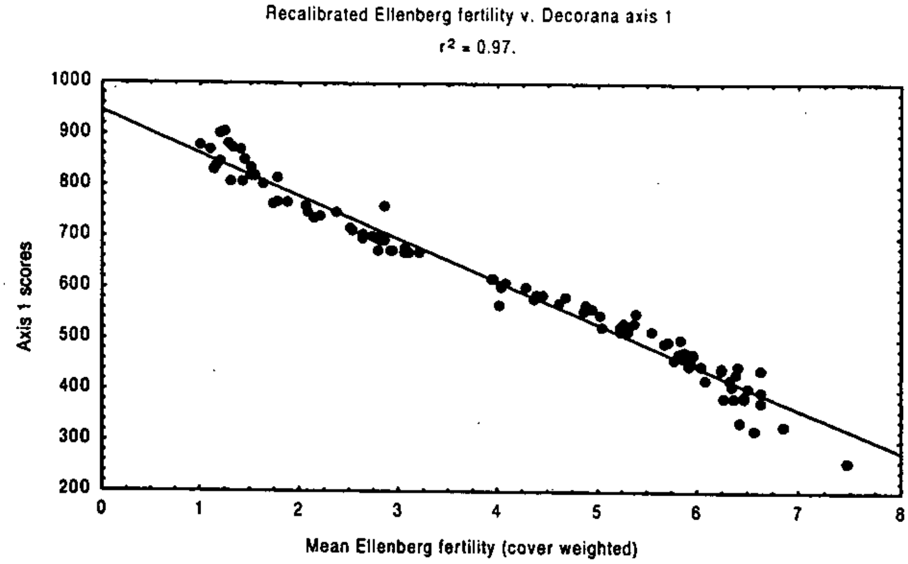

Frequency
1
10
19
28
37
46
55
64
73
82
91
100
Plot Class
ERIO_VAG
CALL_VUL
AGR_CAPI
ARRH_ELA
LOLI_PER

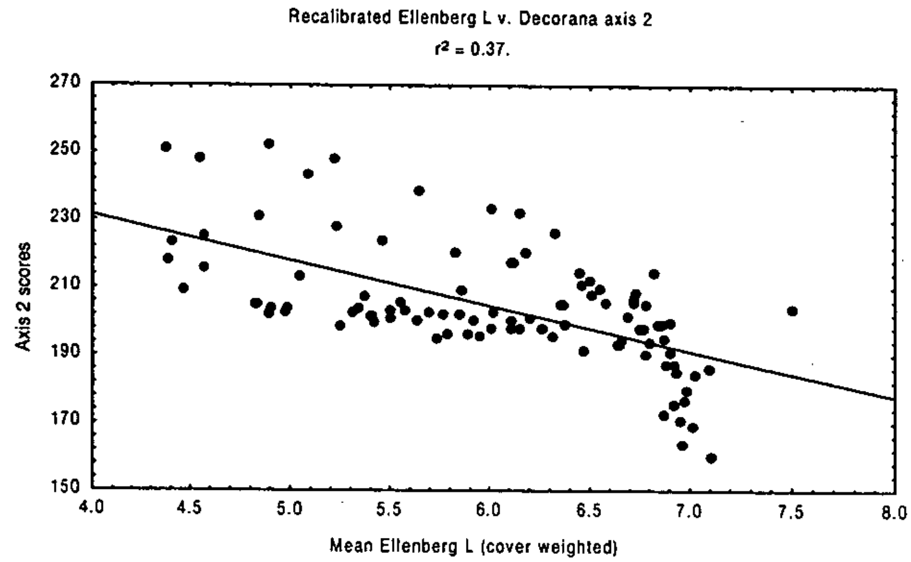
Fig 5

a)



Recalibrated Ellenberg fertility v. Decorana axis 1
r² = 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)

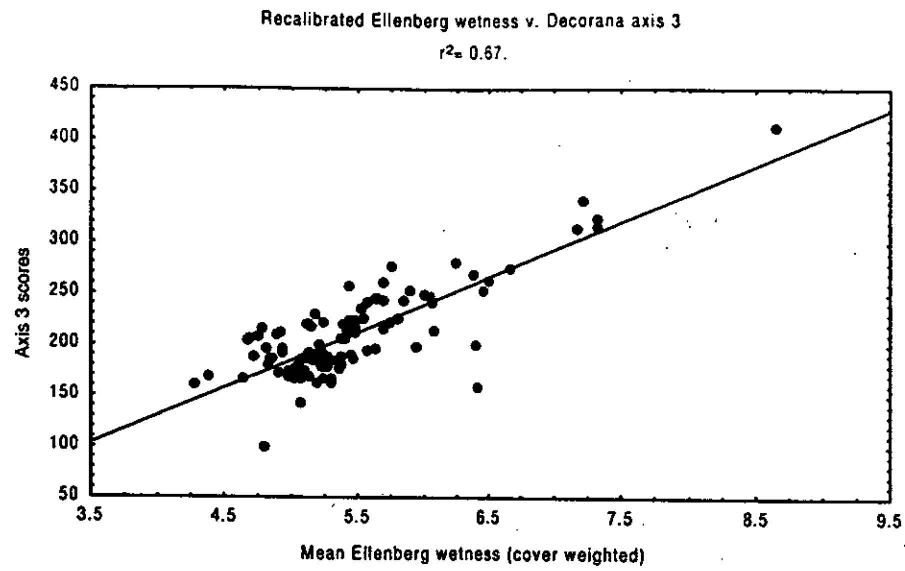

b)



Recalibrated Ellenberg L v. Decorana axis 2
r² = 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)

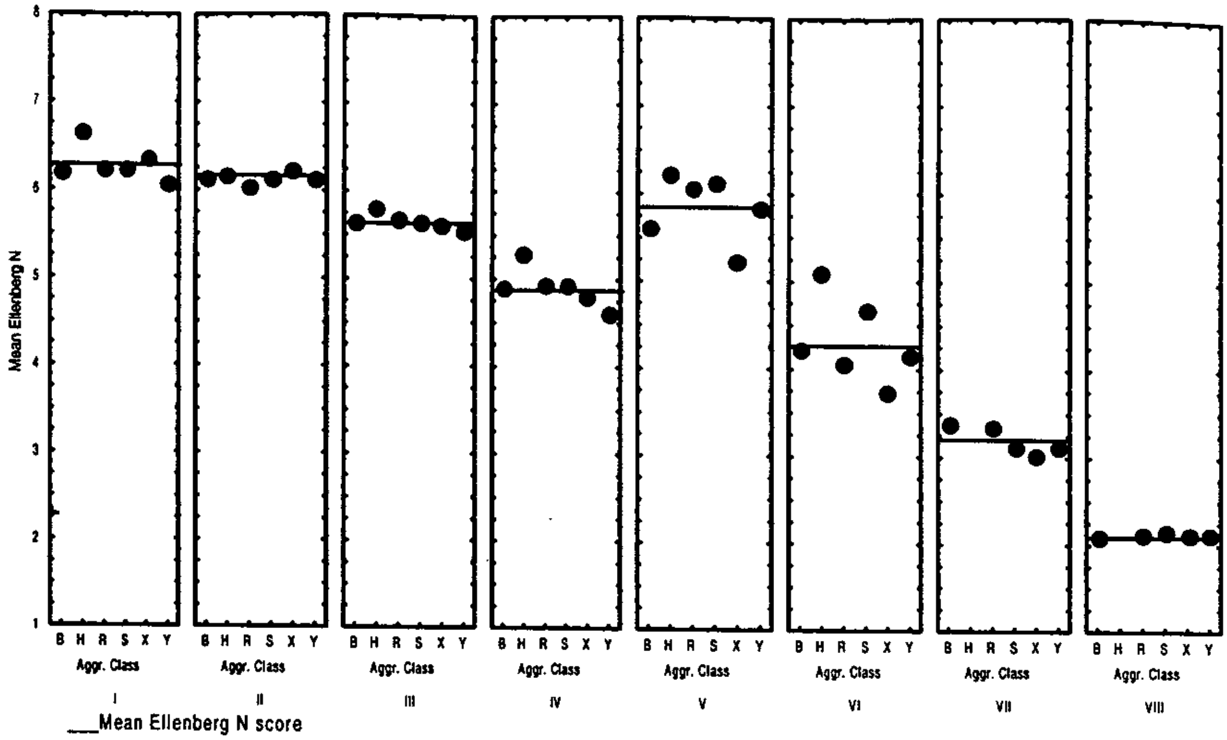
Fig 5 contd.

c)



Recalibrated Ellenberg wetness v. Decorana axis 3
r²= 0.67.
Axis 3 scores
450
400
350
300
250
200
150
100
50
3.5
4.5
5.5
6.5
7.5
8.5
9.5
Mean Ellenberg wetness (cover weighted)

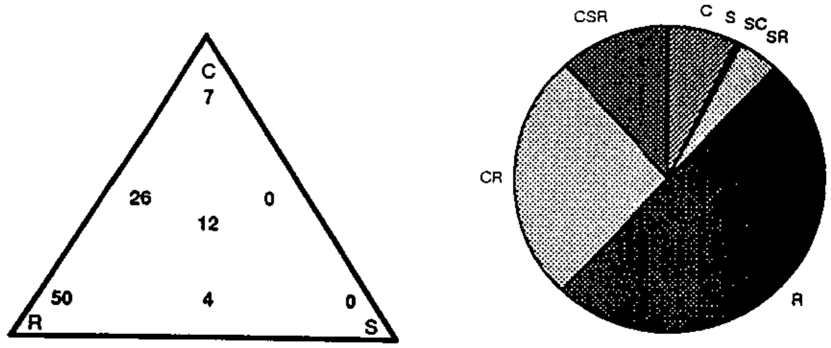
Figure 6



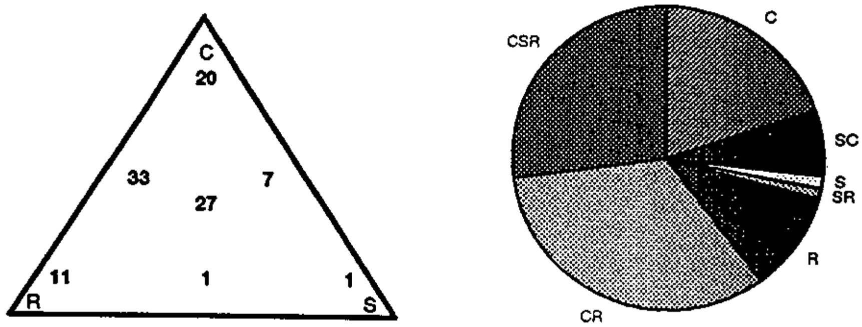
Mean Ellenberg N
8
7
6
5
4
3
2
1
B H R S X Y
Aggr. Class
I
II
III
IV
V
VI
VII
VIII
___Mean Ellenberg N score

Fig 7

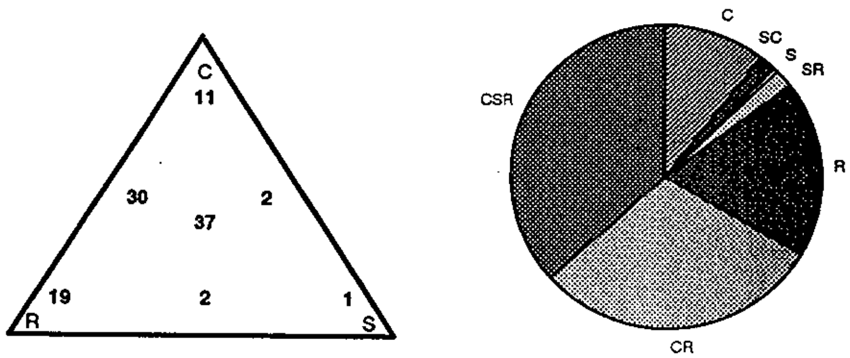
Aggregate class I; Crops/weeds




Aggregate class II; Tall grassland/herb




Aggregate class III; Fertile grasslands




Aggregate class IV; Infertile grassland

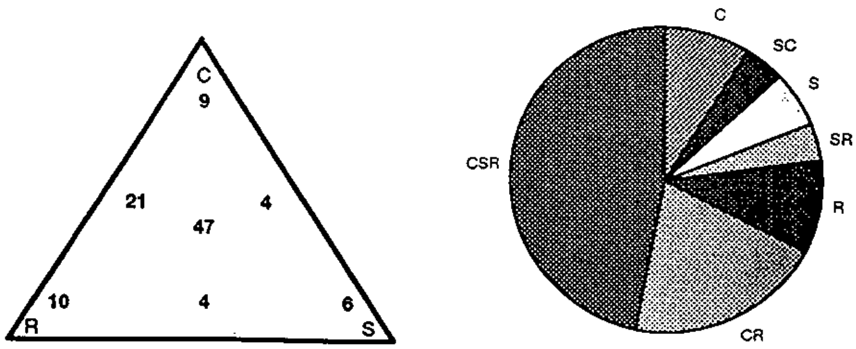
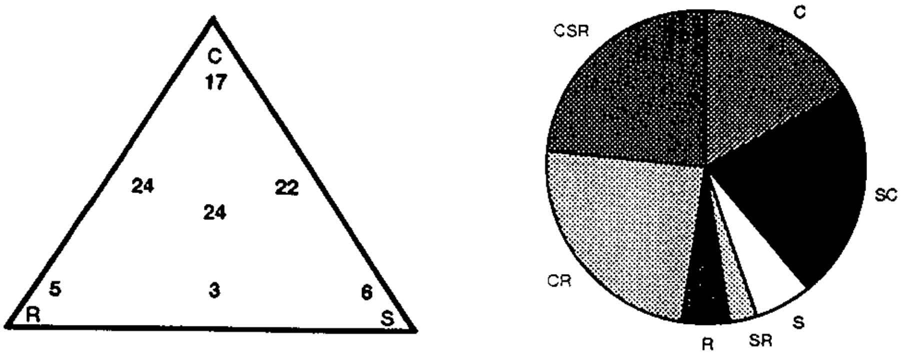
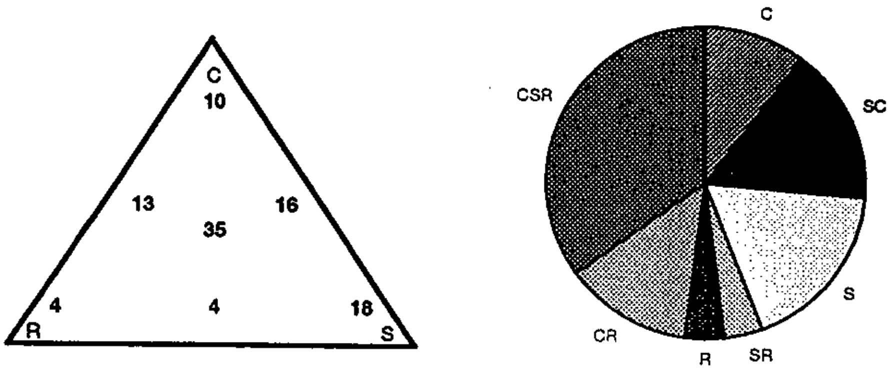


Fig 7 contd.

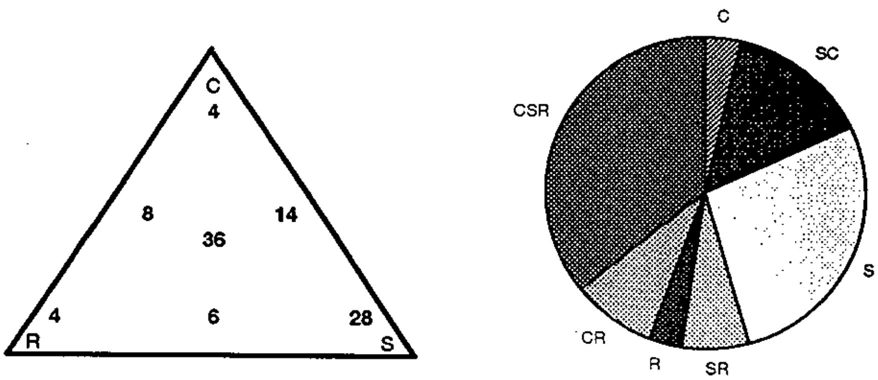
**Aggregate class V; Lowland wooded**




**Aggregate class VI; Upland wooded**




**Aggregate class VII; Moorland/grass mosaic**




**Aggregate class VIII; Heath/bog**

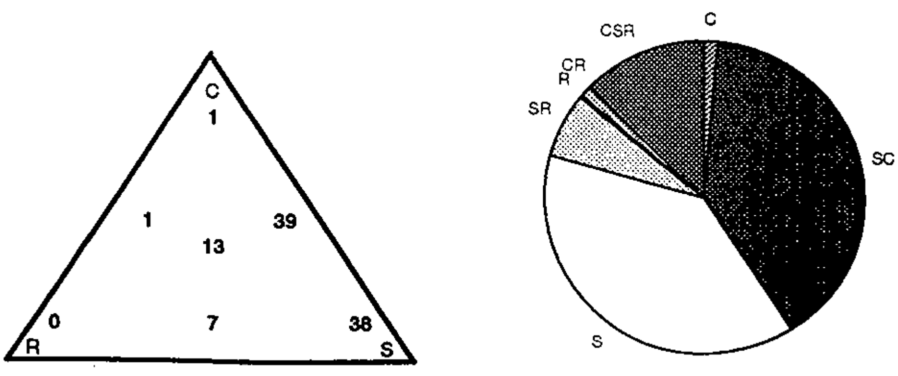
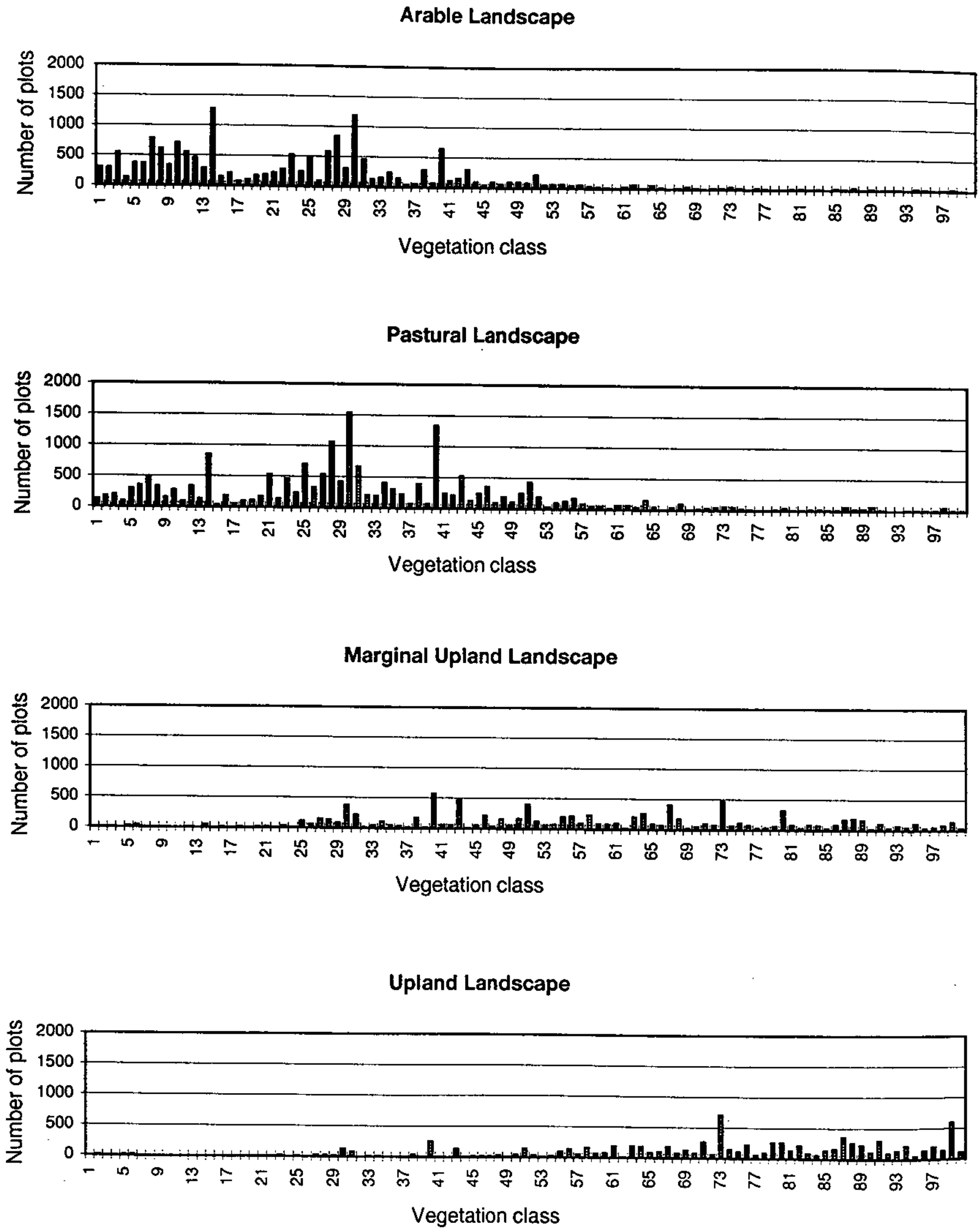


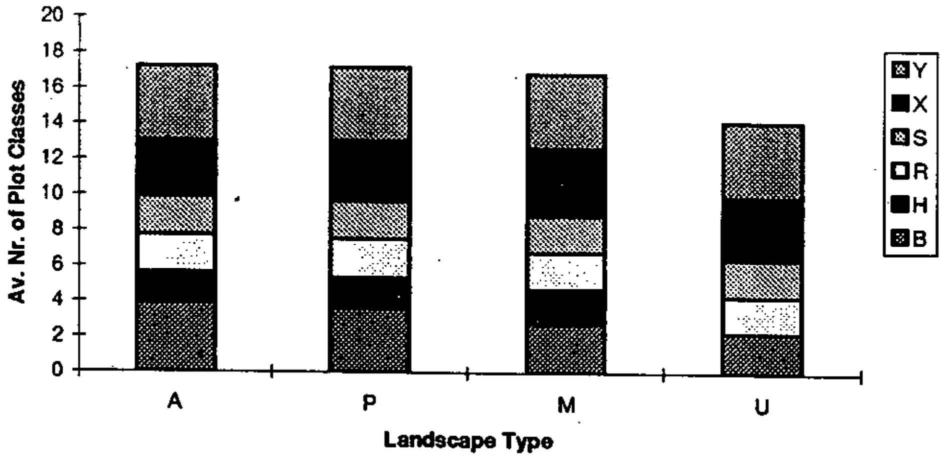
Figure 8



Arable Landscape
Number of plots
2000
1500
1000
500
0
Vegetation class
Pastural Landscape
Number of plots
Vegetation class
Marginal Upland Landscape
Number of plots
Vegetation class
Upland Landscape
Number of plots
Vegetation class
1 5 9 13 17 21 25 29 33 37 41 45 49 53 57 61 65 69 73 77 81 85 89 93 97

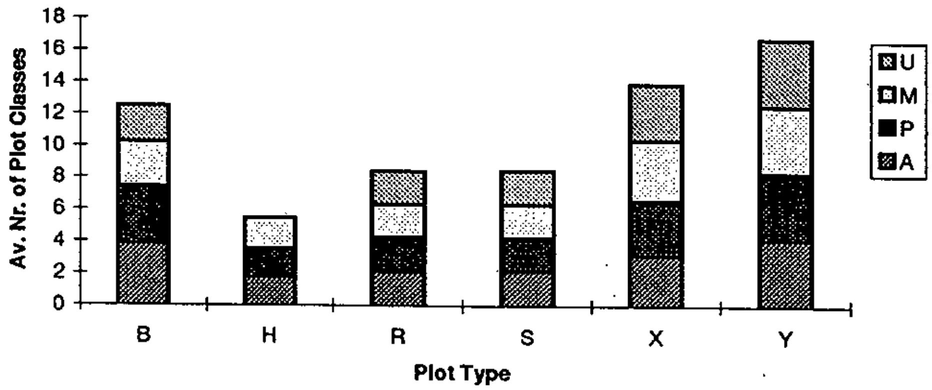
Figure 9

a)



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


b)



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

Figure 10

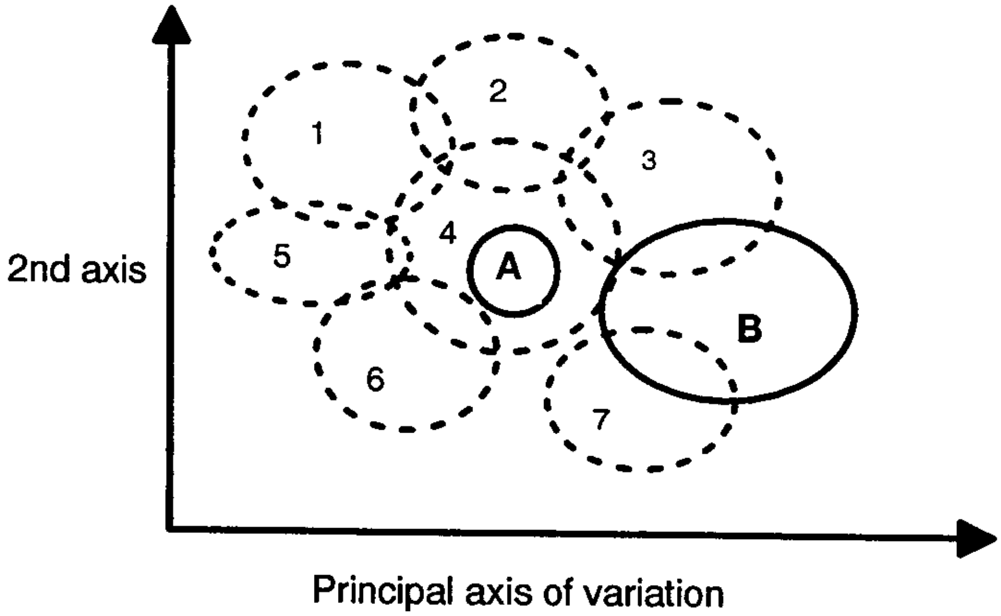
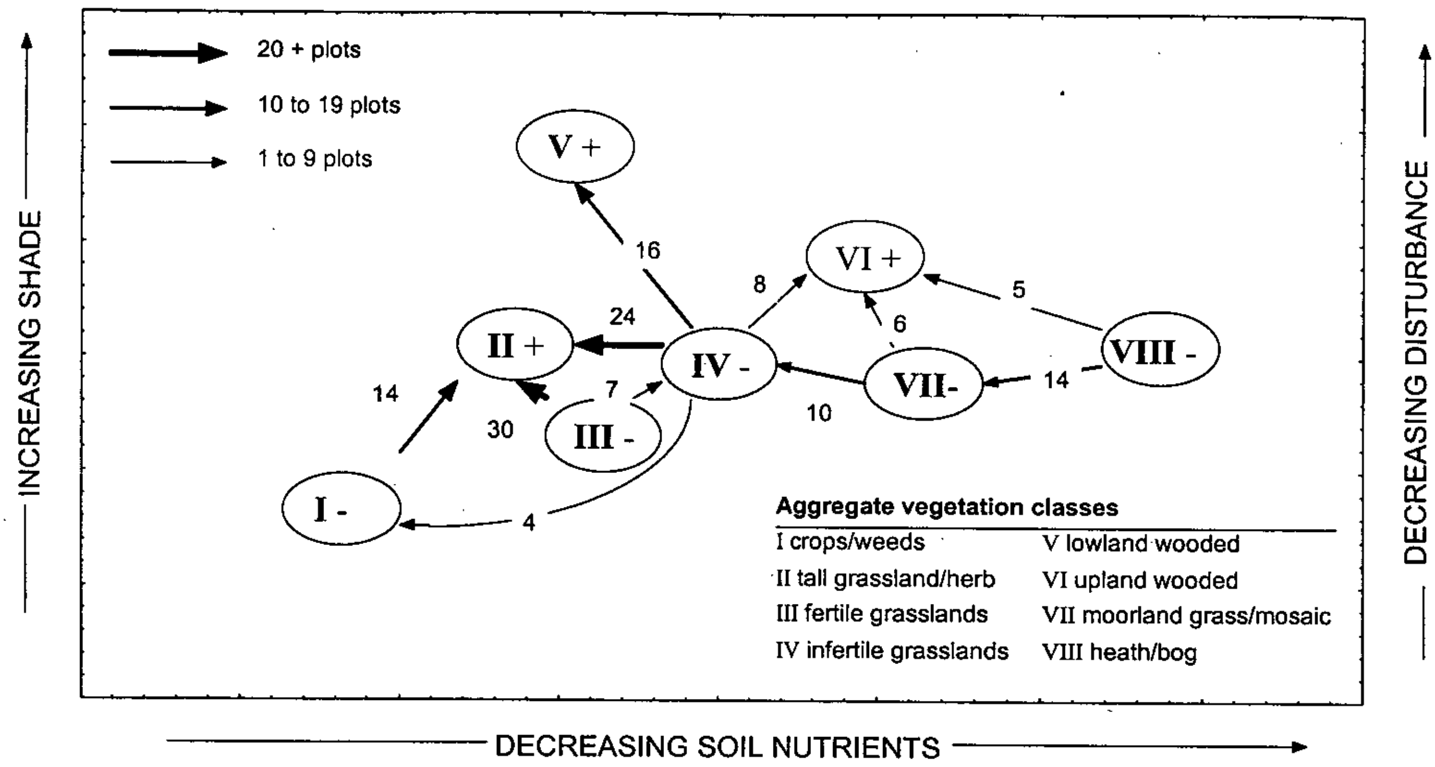
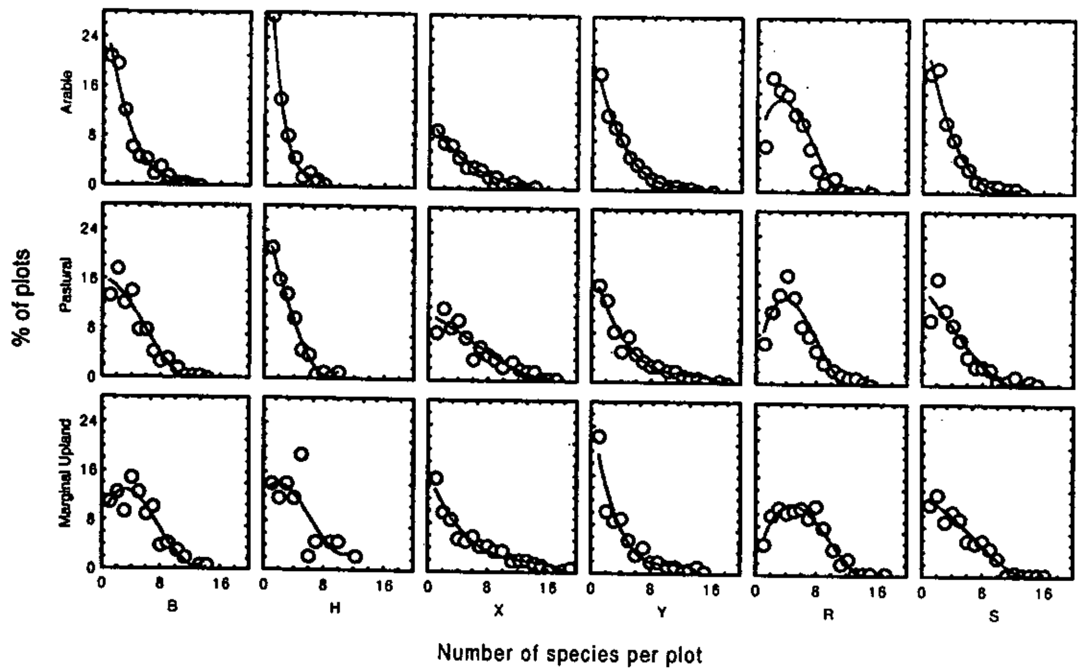


Figure 11.



20 + plots
10 to 19 plots
1 to 9 plots
V +
VI +
II +
IV -
VII-
VIII -
III -
I -
16
8
5
24
6
14
7
14
30
10
4
Aggregate vegetation classes
I crops/weeds
II tall grassland/herb
III fertile grasslands
IV infertile grasslands
V lowland wooded
VI upland wooded
VII moorland grass/mosaic
VIII heath/bog
INCREASING SHADE
DECREASING DISTURBANCE
DECREASING SOIL NUTRIENTS

Figure 12



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

## TABLE CAPTIONS

Table 1 Types and numbers of the vegetation plots surveyed in the 508 1km squares in the Countryside Survey 1990.

Table 2 2a. The eight aggregate vegetation classes (AC) derived from cluster analysis of the 100 vegetation classes, together with estimated area and standard errors derived from the relative coverage of vegetated land by the main plots in the 1km squares.

2b. List of the CVS vegetation classes with estimated area and standard errors.

Table 3 Numbers of plots recorded in the Countryside Survey 1990 summarised by the four landscape types, aggregate class and plot type.

Table 4 Comparison of aggregate vegetation classes with communities of the National Vegetation Classification. Figures give the percentage of all the similarity coefficients (three for each of the 100 vegetation classes) over each aggregate class that refer to each broad grouping of NVC communities.

Table 5 Names of the 37 species groups determined by Ward's minimal variance clustering of the first four axes of the species scores from DECORANA of the entire CVS data set. The top most characteristic species for each species group are given.

Table 6 Average number of species per plot in each of the 37 species groups of Table 5 within the eight aggregate vegetation classes. Codes in body of table are as follows; number=rounded mean count; + =mean count >=0.25; . = mean count <0.25.

Table 7 Average number of species per plot in each of the 37 species groups of Table 5 within the four landscape types and six plot types. Codes in body of table are as follows; number= rounded mean count; + =mean count >=0.25; . = mean count <0.25.

Table 8 Numbers of replicate plots recorded in both 1978 and 1990 within the combination of four landscape types and the eight aggregate classes of the Countryside Vegetation System. Emboldened figures indicate that the stratum contains over 10% of the plots in the respective landscape type.

Table 9 Changes in average species numbers per plot for all plots by the eight aggregate classes of the Countryside Vegetation System and by the four landscape types. A = arable; P = pastural; M = marginal upland; U = upland; GB = all Great Britain. Emboldened rows indicate combinations comprising more than 10% of plots in each landscape type. * $p < 0.05$; ** $p = < 0.01$.

Table 10 Change in average species number per plot by main plots within the eight aggregate classes of the Countryside Vegetation System. A = arable; P = pastoral; M = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $p < 0.05$; ** $p = < 0.01$

Table 11 Change in average species number per plot by verge plots within the eight aggregate classes of the Countryside Vegetation System. A = arable; P = pastoral; M = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $p < 0.05$; ** $p = < 0.01$.

Table 12 Change in average species number per plot by hedge plots within the eight aggregate classes of the Countryside Vegetation System. A = arable; P = pastoral; M = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $p < 0.05$; ** $p = < 0.01$.

Table 13 Change in average species number per plot by streamside plots within the eight aggregate classes of the Countryside Vegetation System. A = arable; P = pastoral; M = marginal upland; U = upland. Emboldened rows indicate combinations comprising more than 10% of all plots. * $p < 0.05$; ** $p = < 0.01$

Table 14 Summary of tests of change in species richness between 1978 and 1990 based upon combinations available in Table 10.

Table 15 Analysis of occurrence of EN indicator species by plot type, using Countryside Survey data for 1990 only; a) calcareous grassland, b) acidic grassland, c) mesotrophic grassland. $\chi^2$ calculated for plot types and indicator species. * $p < 0.05$; ** $p < 0.01$. Data in italics indicates plot types with the highest preference values. The data for habitat plots are presented in the table but were not analysed because they were not randomly located. X = main plots; R = verge plots; B = boundary plots; H = hedge plots; S = streamside plots, Y = habitat plots.

Table 16 Change in numbers of plots between 1978 and 1990 that have at least one of the EN indicators of unimproved grassland.

Table 17 Change in numbers of plots that have at least one EN indicator for unimproved mesotrophic grassland between 1978 and 1990. Includes only taxa strictly confined to unimproved mesotrophic grasslands.

Table 18 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. The data for habitat plots are presented in the table but were not analysed because they were not randomly located. X = main plots; R = verge plots; B = boundary plots; H = hedge plots; S = streamside plots, Y = habitat plots.

Table 19 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 in bold.

Table 20 Number of plots in the Countryside Survey 1990 database that contained over 14 of the faithful species of MG5 within the National Vegetation Classification

(Rodwell, 1992).

Table 31 Bird food plant species that have changed in frequency between 1978 and 1990. A = arable; P = pastural; M = marginal upland. + = gain in species frequency; - = decline in species frequency.

Table 1.

| Plot type | Code letter | Dimensions | Sampling strategy | Max no. per square | Total recorded in 1990 |
|---|---|---|---|---|---|
| Main plots (200m2) | X | $200m^2$ | random | 5 | 2317 |
| Habitat plots (4m2) | Y | $4m^2$ | targetted | 5 | 2464 |
| Hedgerow plots (1m x 10m) | H | 10x1m | random | 2 | 565 |
| Boundary plots (1m x 10m) | B | 10x1m | random | 5 | 1797 |
| Roadside verge plots (1m x 10m) | R | 10x1m | random | 2 | 783 |
| Additional verge plots (1m x 10m) | V | 10x1m | random | 3 | 1164 |
| Streamside plots (1m x 10m | S | 10x1m | random | 2 | 879 |
| Additional streamside plots (1m x 10m) | W | 10x1m | random | 3 | 1277 |
| Total | | | | 27 | 11246 |

Table 2

(a)

| Aggregate vegetation class | | Area ($km^2$) | Standard Error ($km^2$) |
|---|---|---|---|
| I | Crops/weeds | 35980 | 1794 |
| II | Tall grassland/herb | 4779 | 533 |
| III | Fertile grassland | 34434 | 1625 |
| IV | Infertile grassland | 29068 | 1496 |
| V | Lowland wooded | 7166 | 798 |
| VI | Upland wooded | 14395 | 1287 |
| VII | Moorland grass/mosaic | 19530 | 1299 |
| VIII | Heath/bog | 39218 | 1777 |

(b)

| Aggregate vegetation class | Vegetation Class No. | Vegetation class | Area ($km^2$) | Standard Error ($km^2$) |
|---|---|---|---|---|
| I | 1 | Almost weed free wheat/other crops | 7361 | 852 |
| I | 2 | Scattered weeds in various crops | 5731 | 790 |
| I | 3 | Grassy weeds in cereal crops | 9532 | 1062 |
| I | 4 | Broadleaved weeds in mixed crops | 3579 | 658 |
| I | 5 | Mixed weeds in cereal groups | 3507 | 604 |
| I | 6 | Weedy leys/undersown cereal crops | 6269 | 789 |
| II | 9 | Boundaries/open crop hedges | 250 | 147 |
| II | 10 | Tall grass boundaries | 275 | 150 |
| II | 11 | Streamside banks within crops | 433 | 214 |
| II | 12 | Lowland eutrophic roadsides | 842 | 264 |
| II | 13 | Lowland mesotrophic roadsides | 112 | 109 |
| II | 14 | Lowland roadsides/crop boundaries | 1059 | 282 |
| II | 15 | Lowland river banks | 104 | 74 |
| II | 17 | Lowland wetlands/water edges | 55 | 48 |
| II | 18 | Eutrophic shaded ditches | 160 | 111 |
| II | 19 | Eutrophic riverside/wetland tall herb | 81 | 77 |
| II | 20 | Grassy roadside verges | 200 | 139 |
| II | 22 | Nutrient rich riverbanks | NA | NA |
| II | 25 | Shaded grassland/hedges | 607 | 235 |
| II | 26 | Tall grassland/scrub | NA | NA |
| II | 28 | Eutrophic tall herb/grassland | 600 | 224 |
| III | 23 | Eutrophic mixed grassland | 801 | 240 |
| III | 27 | Rye grass roadsides | 502 | 194 |
| III | 29 | Rye grass swards | 9739 | 895 |
| III | 30 | Mixed eutrophic grassland | 14573 | 1000 |
| III | 31 | Rye grass/clover grassland | 8819 | 823 |
| III | 32 | Gravel reedbeds | NA | NA |
| IV | 33 | Marshy grassland | 140 | 89 |
| IV | 34 | Mixed grassland scrub | 214 | 111 |
| IV | 37 | Diverse mesotrophic grassland/scrub | NA | NA |
| IV | 38 | Enriched mesotrophic grassland | 556 | 194 |
| IV | 40 | Ryegrass/Yorkshire fog grassland | 14000 | 1005 |
| IV | 41 | Riverside silts/wetlands | NA | NA |
| IV | 43 | Rye grass/bent grass swards | 5462 | 588 |
| IV | 44 | Calcareous grassland | 804 | 368 |
| IV | 47 | Diverse mesotrophic pasture | 344 | 143 |
| IV | 48 | Marshy riversides | 92 | 69 |
| IV | 51 | Wet rushy grasslands | 2046 | 410 |
| IV | 52 | Mesotrophic grasslands | 1483 | 318 |
| IV | 53 | Diverse mesotrophic/acid grasslands | 242 | 132 |
| IV | 54 | Marshes/wet tall herb | 124 | 73 |
| IV | 55 | Rushy mesotrophic/acid grasslands | 1143 | 275 |
| IV | 56 | Mesotrophic diverse moist grasslands | 2417 | 538 |
| V | 7 | Crop hedges/boundaries | 89 | 87 |
| V | 8 | Eutrophic hedges/boundaries | NA | NA |
| V | 16 | Shady eutrophic streamsides | 276 | 135 |
| V | 21 | Diverse lowland hedgerows | 154 | 107 |
| V | 24 | Dry base rich woodland | 1157 | 304 |
| V | 35 | Diverse base rich woodland/hedgerows | 3105 | 592 |
| V | 36 | Shaded moist stream banks | 182 | 121 |
| V | 39 | Eutrophic streamsides/woodlands | NA | NA |
| V | 42 | Woodland on heavy soils | 2204 | 537 |
| VI | 45 | Shaded grassy streamsides | 95 | 93 |
| VI | 46 | Shaded nutrient rich streamsides | 420 | 182 |
| VI | 49 | Acidic woodland fragments | 672 | 247 |
| VI | 50 | Acidic woodlands | 1585 | 424 |
| VI | 59 | Upland semi shaded acidic streamsides | 503 | 229 |
| VII | 57 | Enriched moorland flushes | 606 | 256 |
| VII | 58 | Rushy diverse streamside/flushes | 969 | 273 |
| VII | 60 | Streamsides/flushes within acidic grasslands | 140 | 102 |

Table 2 contd.

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

Table 3

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

Table 4

| Community groups of the NVC | CVS Aggregate vegetation classes | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | VI | VII | VIII |
| Other Vegetation (OV) | 100 | 22 | 20 | | | | | |
| Mesotrophic Grassland (MG) | | 61 | 60 | 55 | 19 | 7 | | |
| Swamp and tall-herb fen (S) | | 2 | | | | | | |
| Woodland and scrub (W) | | 14 | 13 | 11 | 48 | 63 | | |
| Calcicolous Grassland (CG) | | | | 8 | | 22 | 33 | |
| Upland and calcifugous grassland (U) | | | | 14 | 26 | 7 | 26 | 7 |
| Mire (M) | | | 6 | 11 | 7 | | 37 | 79 |
| Heath (H) | | | | | | | 4 | 13 |

Table 5.

| Species group | Species group name | Characteristic species |
|---|---|---|
| 1 | Crop or crop edge plants on fertile soils | *Bromus sterilis, Convolvulus arvensis, Lamium album* |
| 2 | Crops, crop edge or grassland on eutrophic soils | *Elymus repens, Rumex crispus, Sonchus oleraceus* |
| 3 | Woods, tall grasslands or wood edge plants on brown earth soils | *Heracleum sphondylium, Anthriscus sylvestris, Hedera helix* |
| 4 | Tall grassland plants on calcareous brown earths | *Tragopogon pratensis, Silene latifolia, Carduus nutans* |
| 5 | Wood edge, tall grassland or grassland plants on brown earths, often humus rich | *Urtica dioica, Arrhenatherum elatius, Galium aparine* |
| 6 | Water edge plants on wet alluvial soils | *Epilobium hirsutum, Polygonum persicaria, Phalaris arundinacea* |
| 7 | Crops or crop edge plants on brown earth soils | *Stellaria media, Polygonum aviculare, Veronica arvensis* |
| 8 | Woodland edge or scrub plants on brown earth soils | *Crataegus monogyna, Prunus spinosa, Tamus communis* |
| 9 | Grassland, tall grassland plants on wood edges on variable soils | *Cirsium arvense, Poa trivialis, Rumex obtusifolius* |
| 10 | Maritime saline or fresh water edge plants on gleyed brown earths | *Oenanthe crocata, Phragmites australis, Hordeum secalinum* |
| 11 | Water edge plants on saturated gleyed alluvial soils | *Sparganium erectum, Glyceria maxima, Lemna minor* |
| 12 | Grassland or tall grassland plants on brown earth soils | *Dactylis glomerata, Lolium perenne, Poa annua* |
| 13 | Grassland plants on brown earths, often skeletal and calcareous | *Medicago lupulina, Daucus carota, Leucanthemum vulgare* |
| 14 | Wood or wood edge plants on calcareous or neutral brown earths | *Rubus fruticosus, Fraxinus excelsior, Geranium robertianum* |
| 15 | Tall grassland plants on damp gleyed brown earths | *Potentilla anserina, Carex hirta, Juncus inflexus* |
| 16 | River edge or aquatic plants on wet alluvial soils | *Apium nodiflorum, Nasturtium officinale, Polygonum amphibium* |
| 17 | Woodland or wood edge plants on brown earth soils | *Stellaria holostea, Corylus avellana, Hyacinthoides non-scripta* |
| 18 | Grassland plants on semi-fertile, sometimes rocky, brown earths | *Taraxacum agg., Poa pratensis, Achillea millefolium* |
| 19 | Grassland plants on calcareous brown earths | *Campanula rotundifolia, Galium verum, Heiracium pilosella* |
| 20 | Wood or wood edge plants on damp fertile brown earths | *Filipendula ulmaria, Angelica sylvestris, Epilobium montanum* |
| 21 | Water edge or aquatic plants on hydromorphic soils | *Glyceria fluitans, Veronic beccabunga, Alopecurus geniculatus* |
| 22 | Grassland wood edge or scrub plants on brown earths | *Holcus lanatus, Agrostis stolonifera, Ranunculus repens* |
| 23 | Marsh, wood edge or woodland plants on wet gleyed brown earths | *Cardamine pratensis, Stellaria alsine, Lotus uliginosus* |
| 24 | Marsh or water edge plants on soil water gleys | *Galium palustre, Juncus bufonius, Caltha palustris* |
| 25 | Woodland or woodland edge plants on acid brown earths | *Primula vulgaris, Digitalis purpurea, Oxalis acetosella* |
| 26 | Plants of maritime habitats on variable soils | *Plantago maritima, Plantago coronopus, Armeria maritima* |
| 27 | Wood, wood edge, scrub, grassland or heath plants on acid or neutral brown earths | *Agrostis capillaris, Pteridium aquilinum, Lotus corniculatus* |
| 28 | Grassland marsh or water edge plants on moist brown earth or gleyed soils | *Juncus effusus, Ranunculus acris, Deschampsia cespitosa* |
| 29 | Grassland or wood edge plants on acid or brown podzolic soils | *Anthoxanthum odoratum, Galium saxatile, Festuca ovina* |
| 30 | Water edge or aquatic plants on wet humic soils | *Potamogeton polygonifolius, Carex rostrata, Potentilla palustris* |
| 31 | Flush, moorland or water edge plants on soil water gleys | *Juncus articulatus/acutiflorus, J.bulbosus, Ranunculus flammula* |
| 32 | Moorland plants on peaty gley soils | *Carex nigra, C.echinata, Viola palustris* |
| 33 | Moorland or grassland plants on gley or peaty podzolic soils | *Potentilla erecta, Nardus stricta, Deschampsia flexuosa* |
| 34 | Moorland plants on wet peaty gley soils | *Molinia caerulea, Carex panicea, Dactylorhiza maculata agg.* |
| 35 | Heath or moorland plants on podzols or brown podzolic soils | *Calluna vulgaris, Juncus squarrosus, Vaccinium myrtillus* |
| 36 | Bog, water edge or aquatic plant on peaty soils | *Pedicularis sylvatica, Pinguicula vulgaris, Myrica gale* |
| 37 | Bog or heath plants on deep, raw peat soils | *Erica tetralix, Eriophorum angustifolium, Trichophorum cespitosum* |

Table 6

| Code | Species group name | Aggregate vegetation class | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | I | II | III | IV | V | VI | VII | VIII |
| 1 | Crop or crop edge plants on fertile soils | 1 | + | + | . | + | . | . | . |
| 2 | Crops, crop edge or grassland on eutrophic soils | 1 | + | + | + | + | . | . | |
| 3 | Woods, tall grasslands or wood edge plants on brown earth soils | . | 1 | + | + | 2 | . | . | . |
| 4 | Tall grassland plants on calcareous brown earths | . | . | . | . | . | . | | |
| 5 | Wood edge, tall grassland or grassland plants on brown earths, often humus rich | + | 2 | + | + | 2 | + | . | . |
| 6 | Water edge plants on wet alluvial soils | . | + | . | . | . | . | . | . |
| 7 | Crops or crop edge plants on brown earth soils | 1 | + | + | . | . | . | . | . |
| 8 | Woodland edge or scrub plants on brown earth soils | . | + | . | . | 1 | . | . | . |
| 9 | Maritime saline or fresh water edge plants on gleyed brown earths | . | . | . | . | . | . | . | . |
| 10 | Grassland, tall grassland plants on wood edges on variable soils | + | 1 | 1 | + | + | . | . | . |
| 11 | Water edge plants on saturated gleyed alluvial soils | . | . | . | . | . | . | . | |
| 12 | Grassland or tall grassland plants on brown earth soils | + | 2 | 3 | 2 | + | + | . | . |
| 13 | Grassland plants on brown earths, often skeletal and calcareous | . | . | . | . | . | . | . | |
| 14 | Wood or wood edge plants on calcareous or neutral brown earths | . | + | . | + | 2 | + | . | . |
| 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 | . | + | 1 | 2 | . | + | + | . |
| 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 | + | 2 | 4 | 6 | + | 2 | 3 | . |
| 23 | Marsh, wood edge or woodland plants on wet gleyed brown earths | . | . | . | + | . | + | + | . |
| 24 | Woodland or woodland edge plants on acid brown earths | . | . | . | . | + | 1 | + | . |
| 25 | Marsh or water edge plants on soil water gleys | | . | . | + | . | . | + | . |
| 26 | Plants of maritime habitats on variable soils | | . | . | . | | . | . | . |
| 27 | Wood, wood edge, scrub, grassland or heath plants on acid or neutral brown earths | . | . | + | 1 | + | 2 | 1 | + |
| 28 | Grassland marsh or water edge plants on moist brown earth or gleyed soils | . | . | + | 1 | . | 1 | 2 | + |
| 29 | Grassland or wood edge plants on acid or brown podzolic soils | . | . | . | + | . | 1 | 3 | 1 |
| 30 | Water edge or aquatic plants on wet humic soils | | . | . | . | | . | . | . |
| 31 | Flush, moorland or water edge plants on soil water gleys | . | . | . | + | . | . | 1 | + |
| 32 | Moorland plants on peaty gley soils | . | . | . | . | . | . | 1 | + |
| 33 | Moorland or grassland plants on gley or peaty podzolic soils | | . | . | . | . | 1 | 3 | 2 |
| 34 | Moorland plants on wet peaty gley soils | | . | . | . | . | . | + | 1 |
| 35 | Heath or moorland plants on podzols or brown podzolic soils | | . | | . | . | + | 1 | 3 |
| 36 | Bog, water edge or aquatic plant on peaty soils | | | . | . | | . | . | + |
| 37 | Bog or heath plants on deep, raw peat soils | | . | | . | . | . | + | 3 |

Table 7

| | 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 |
| 1 | Crop or crop edge plants on fertile soils | + | + | + | . | + | . | + | + | + | + | + | + | + | + | + | . | + | . | . | . | . | . | . | . | | . | . | . | . |
| 2 | Crops, crop edge or grassland on eutrophic soils | + | + | + | + | + | + | + | + | 1 | + | + | + | + | + | + | + | + | + | . | . | + | . | . | . | . | . | . | . | . |
| 3 | Woods, tall grasslands or wood edge plants on brown earth soils | + | 1 | 1 | + | . | + | + | 2 | 1 | + | . | + | + | 1 | 1 | + | . | + | . | + | + | . | . | . | . | . | . | . | . |
| 4 | Tall grassland plants on calcareous brown earths | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | | . | . | | | | . | | | |
| 5 | 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 | + | + | . | . | . | . | . | . | . |
| 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 | + | 2 | . | . | . | . | + | 2 | . | . | . | . | + | 2 | + | . | . | . | . | 1 | . | . | . | . | | | . | . | . |
| 9 | Maritime saline or fresh water edge plants on gleyed brown earths | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | + | . | . | | | . | . | . | . | | . | . | . | . |
| 10 | Grassland, tall grassland plants on wood edges on variable soils | + | + | + | + | + | + | + | + | + | 1 | + | + | + | + | + | + | + | + | + | + | + | + | + | . | + | + | . | . | . |
| 11 | Water edge plants on saturated gleyed alluvial soils | . | . | | . | . | . | . | . | | . | . | . | . | | | . | . | . | . | | | | | . | | | . | . | . |
| 12 | 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 | . | . | . |
| 13 | Grassland plants on brown earths, often skeletal and calcareous | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | . | . | . | . | . | | . | . | . | . |
| 14 | Wood or wood edge plants on calcareous or neutral brown earths | + | 1 | + | + | . | + | + | + | + | + | + | + | + | 1 | + | 1 | . | + | . | 1 | + | + | . | . | . | . | . | . | . |
| 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 | . | + | . | . | . | . | . | + | . | . | . | . | . | + | . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . |
| 18 | Grassland plants on semi-fertile, sometimes rocky, brown earths | + | + | 2 | + | + | + | + | + | 2 | + | + | + | + | + | 2 | + | 1 | + | + | 1 | 2 | + | + | + | + | 1 | + | + | + |
| 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 | 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 |
| 23 | Marsh, wood edge or woodland plants on wet gleyed brown earths | . | . | . | + | . | . | . | . | . | + | . | . | . | . | . | + | . | + | . | . | . | + | . | + | . | . | + | . | . |
| 24 | Woodland or woodland edge plants on acid brown earths | . | . | . | + | . | . | . | . | . | . | . | . | . | + | . | + | . | . | . | + | + | + | + | . | + | + | + | + | . |
| 25 | Marsh or water edge plants on soil water gleys | . | . | . | + | . | . | . | . | . | . | . | . | . | . | . | + | . | . | . | . | . | + | . | + | . | . | + | . | . |
| 26 | Plants of maritime habitats on variable soils | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | . | . | . | . | . | . | . | . | . |
| 27 | Wood, wood edge, scrub, grassland or heath plants on acid or neutral brown earth | + | + | + | + | + | + | + | . | + | + | + | + | + | + | + | + | + | + | 1 | 1 | 1 | 1 | 1 | + | + | 2 | 1 | + | + |
| 28 | Grassland marsh or water edge plants on moist brown earth or gleyed soils | + | . | + | 1 | + | + | . | . | . | + | + | + | + | . | + | 1 | + | + | + | + | + | 2 | 1 | + | 1 | 2 | 2 | + | + |
| 29 | Grassland or wood edge plants on acid or brown podzolic soils | + | . | + | 1 | + | + | . | . | . | . | + | + | + | . | + | + | + | + | 1 | + | 1 | 2 | 2 | 1 | 2 | 2 | 3 | 2 | 2 |
| 30 | Water edge or aquatic plants on wet humic soils | . | | . | . | . | . | . | . | . | . | . | . | . | | . | . | . | . | . | | | . | . | . | . | . | . | . | . |
| 31 | Flush, moorland or water edge plants on soil water gleys | . | . | . | + | . | + | . | . | . | . | . | . | . | | . | + | . | + | . | | . | 1 | + | + | + | + | 1 | + | + |
| 32 | Moorland plants on peaty gley soils | . | . | . | + | + | + | . | | . | . | . | . | . | . | . | . | . | . | . | | . | + | + | + | + | + | 2 | + | + |
| 33 | Moorland or grassland plants on gley or peaty podzolic soils | + | . | + | 1 | + | + | . | . | . | . | . | . | . | . | . | + | + | + | + | . | + | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 2 |
| 34 | Moorland plants on wet peaty gley soils | . | . | . | + | + | + | . | | . | . | . | . | . | . | . | . | . | . | . | | . | + | + | + | + | + | + | 1 | + |
| 35 | Heath or moorland plants on podzols or brown podzolic soils | . | . | . | + | + | + | . | | . | . | . | . | . | . | . | . | . | . | + | . | + | + | 1 | + | + | + | 2 | 3 | 1 |
| 36 | Bog, water edge or aquatic plant on peaty soils | . | | . | . | . | . | . | | . | . | . | . | . | | . | . | . | . | . | | . | . | . | . | . | . | + | + | + |
| 37 | 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 |

Table 8

| Landscape | Aggregate class | H | R | S | X | Total no. of plots |
|---|---|---|---|---|---|---|
| | | **Plot type** | | | | |
| **ARABLE** | I | 1 | 6 | 0 | **190** | **197** |
| | II | **47** | **53** | **37** | 7 | **144** |
| | III | 2 | **67** | **15** | **85** | **169** |
| | IV | 8 | 13 | **23** | **64** | **108** |
| | V | **72** | 4 | **12** | 13 | **101** |
| | VI | 0 | 0 | 7 | 7 | 14 |
| | VII | 0 | 0 | 0 | 6 | 6 |
| | VIII | 0 | 0 | 0 | 8 | 8 |
| **Total** | | 130 | 143 | 94 | 380 | 747 |
| **MARGINAL UPLAND** | I | 0 | 0 | 0 | 5 | 5 |
| | II | **7** | 1 | 2 | 0 | 10 |
| | III | 2 | **17** | 1 | **18** | **38** |
| | IV | **10** | **25** | **16** | **59** | **110** |
| | V | **2** | 0 | 1 | 1 | 4 |
| | VI | 3 | 3 | **12** | 13 | **31** |
| | VII | 0 | 5 | **19** | **45** | **69** |
| | VIII | 0 | 0 | **6** | **34** | **40** |
| **Total** | | 24 | 51 | 57 | 175 | 307 |
| **PASTURAL** | I | 0 | 3 | 2 | **84** | **89** |
| | II | **42** | **45** | **25** | 9 | **121** |
| | III | 3 | **40** | **12** | **111** | **166** |
| | IV | **18** | **31** | **32** | **112** | **193** |
| | V | **58** | 8 | **18** | 10 | **94** |
| | VI | 3 | 3 | **22** | 24 | 52 |
| | VII | 0 | 3 | 7 | 17 | 27 |
| | VIII | 0 | 0 | 2 | 18 | 20 |
| **Total** | | 124 | 133 | 120 | 385 | 762 |
| **UPLAND** | I | 0 | 0 | 0 | 2 | 2 |
| | III | 0 | 3 | 0 | 9 | 12 |
| | VI | 0 | 9 | 9 | 5 | 23 |
| | V | 0 | 0 | 1 | 0 | 1 |
| | VI | 0 | 1 | 10 | **33** | **44** |
| | VII | 0 | 16 | **56** | **57** | **129** |
| | VIII | 0 | 1 | **25** | **203** | **229** |
| **Total** | | 0 | 30 | 101 | 309 | 440 |
| **GB** | I | 1 | 9 | 2 | **281** | 293 |
| | II | **96** | **99** | **64** | 16 | 275 |
| | III | 7 | **127** | 28 | **223** | 385 |
| | IV | **36** | **78** | **80** | **240** | 434 |
| | V | **132** | 12 | 32 | 24 | 200 |
| | VI | 6 | 7 | **51** | 77 | 141 |
| | VII | 0 | 24 | **82** | **125** | 231 |
| | VIII | 0 | 1 | 33 | **263** | 297 |
| **GB Total** | | 278 | 357 | 372 | 1249 | 2256 |

Table 9

| *Land scape type* | *Aggr class* | *No. of plots* | *No. of species 1978* | *No. of species 1990* | *Change in mean number* | *Change in %* | *t value* |
|---|---|---|---|---|---|---|---|
| **A** | **I** | **173** | **6.5** | **4.2** | **-2.3** | **-36.1** | **-5.1**** |
| | **II** | **118** | **12.1** | **12.7** | **0.6** | **5.0** | **1.1** |
| | **III** | **139** | **13.2** | **10.7** | **-2.3** | **-17.4** | **-3.8**** |
| | **IV** | **91** | **20.1** | **16.7** | **-3.4** | **-17.0** | **-4.2**** |
| | **V** | **77** | **10.8** | **12.9** | **2.1** | **19.1** | **2.4*** |
| **P** | **I** | **75** | **7.6** | **7.4** | **-0.2** | **-2.5** | **-0.3** |
| | **II** | **100** | **14.4** | **15.0** | **0.7** | **4.5** | **0.8** |
| | **III** | **152** | **11.9** | **12.3** | **0.4** | **3.6** | **0.7** |
| | **IV** | **169** | **21.1** | **17.2** | **-4.0** | **-18.7** | **-5.6**** |
| | **V** | **71** | **14.3** | **12.5** | **-1.9** | **-13.2** | **-2.3*** |
| | **VI** | **47** | **16.3** | **12.4** | **-3.9** | **-23.9** | **-3.4**** |
| | **VII** | **27** | **24.3** | **20.0** | **-4.3** | **-17.7** | **-2.7*** |
| **M** | **III** | **32** | **13.1** | **15.3** | **2.2** | **16.9** | **1.5** |
| | **IV** | **96** | **22.1** | **21.1** | **-1.0** | **-4.5** | **-1.1** |
| | **VI** | **25** | **20.8** | **13.8** | **-7.0** | **-33.5** | **-3.6**** |
| | **VII** | **65** | **17.8** | **20.8** | **2.6** | **14.6** | **2.3*** |
| | **VIII** | **35** | **12.1** | **14.3** | **2.2** | **18.5** | **2.0** |
| **U** | **VI** | **41** | **23.4** | **20.4** | **-3.0** | **-12.9** | **-1.5** |
| | **VII** | **113** | **23.7** | **21.0** | **-2.7** | **-11.4** | **-2.5*** |
| | **VIII** | **209** | **18.9** | **20.0** | **1.1** | **5.7** | **1.9** |
| **GB** | **I** | **254** | **6.8** | **5.3** | **-1.5** | **-22.4** | **-3.9**** |
| | **II** | **227** | **13.3** | **13.8** | **0.5** | **3.8** | **1.1** |
| | **III** | **333** | **12.5** | **12.0** | **-0.5** | **-4.0** | **-1.2** |
| | **IV** | **375** | **21.2** | **18.3** | **-2.9** | **-13.8** | **-6.4**** |
| | **V** | **151** | **12.5** | **12.8** | **0.2** | **1.8** | **0.4** |
| | **VI** | **125** | **20.4** | **16.1** | **-4.3** | **-21.0** | **-4.3**** |
| | **VII** | **210** | **22.1** | **20.7** | **-1.4** | **-6.2** | **-1.9** |
| | **VIII** | **270** | **17.6** | **18.7** | **1.0** | **5.8** | **2.1*** |

Table 10

*X-PLOTS*

| *Land scape type* | *Aggr class* | *No. of plots* | *No. of species 1978* | *No. of species 1990* | *Change in mean number* | *Change in %* | *t value* |
|---|---|---|---|---|---|---|---|
| **A** | **I** | **167** | **6.5** | **3.8** | **-2.6** | **-2.6** | **-5.6**** |
| | **III** | **63** | **10.3** | **7.5** | **-2.8** | **-2.8** | **-3.4**** |
| | **IV** | **52** | **20.7** | **17.2** | **-3.5** | **-3.5** | **-2.9**** |
| **P** | **I** | **72** | **7.6** | **7.2** | **-0.4** | **-4.8** | **-0.5** |
| | **III** | **103** | **10.9** | **10.9** | **0.02** | **0.2** | **0.0** |
| | **IV** | **105** | **21.8** | **16.8** | **-5.0** | **-22.9** | **-5.3**** |
| | **VI** | **24** | **14.8** | **10.5** | **-4.3** | **-28.7** | **-4.4**** |
| **M** | **VI** | **54** | **22.2** | **21.6** | **-0.6** | **-2.8** | **-0.5** |
| | **VII** | **43** | **17.6** | **20.4** | **2.7** | **15.6** | **1.9** |
| | **VIII** | **31** | **12.2** | **14.6** | **2.4** | **19.6** | **1.9** |
| **U** | **VI** | **31** | **23.0** | **20.4** | **-2.6** | **-11.4** | **-1.2** |
| | **VII** | **49** | **23.9** | **22.4** | **-1.5** | **-1.5** | **-0.8** |
| | **VIII** | **186** | **18.7** | **19.5** | **0.8** | **0.8** | **1.4** |
| **GB** | **I** | **245** | **6.8** | **5.0** | **-1.8** | **-26.1** | **-4.5**** |
| | **III** | **190** | **10.7** | **10.0** | **-0.8** | **-7.3** | **-1.5** |
| | **IV** | **215** | **21.7** | **18.3** | **-3.4** | **-15.6** | **-5.3**** |
| | **V** | **22** | **13.5** | **16.9** | **3.4** | **25.3** | **1.6** |
| | **VI** | **74** | **19.6** | **15.5** | **-4.1** | **-20.7** | **-3.1**** |
| | **VII** | **114** | **22.1** | **21.7** | **-0.4** | **-1.8** | **-0.4** |
| | **VIII** | **241** | **17.4** | **18.2** | **0.9** | **4.9** | **1.7** |

Table 11

***R-PLOTS***

| *Land scape type* | *Aggr class* | *No. of plots* | *No. of species 1978* | *No. of species 1990* | *Change in mean number* | *Change in %* | *t value* |
|---|---|---|---|---|---|---|---|
| **A** | **II** | **43** | **13.2** | **14.6** | **1.4** | **10.6** | **1.7** |
| | **III** | **60** | **15.3** | **13.9** | **-1.5** | **-9.5** | **-1.4** |
| **P** | **II** | **40** | **13.9** | **17.1** | **3.2** | **22.7** | **2.8**** |
| | **III** | **36** | **13.6** | **15.5** | **1.9** | **13.9** | **1.8** |
| | **VI** | **24** | **20.9** | **19.6** | **-1.3** | **-5.6** | **-0.8** |
| **GB** | **II** | **84** | **13.5** | **15.7** | **2.3** | **16.8** | **3.2**** |
| | **III** | **112** | **14.6** | **14.9** | **0.3** | **1.7** | **0.4** |
| | **IV** | **65** | **19.5** | **18.9** | **-0.6** | **-3.2** | **-0.7** |
| | **V** | **7** | **15.0** | **18.4** | **3.4** | **22.9** | **0.9** |
| | **VI** | **5** | **20.8** | **16.8** | **-4.0** | **-9.2** | **-1.4** |
| | **VII** | **23** | **21.0** | **20.0** | **-1.0** | **-4.6** | **-0.5** |
| | **VIII** | **1** | **21.0** | **24.0** | **3.0** | **14.3** | **0.0** |

Table 12

***H-PLOTS***

| *Land scape type* | *Aggr class* | *No. of plots* | *No. of species 1978* | *No. of species 1990* | *Change in mean number* | *Change in %* | *t value* |
|---|---|---|---|---|---|---|---|
| **A** | **II** | **38** | **11.6** | **10.0** | **-1.6** | **-14.1** | **-1.6** |
| | **V** | **52** | **9.9** | **10.7** | **0.8** | **8.4** | **1.1** |
| **P** | **II** | **31** | **14.2** | **12.2** | **-1.9** | **-13.7** | **-1.9** |
| | **V** | **43** | **13.4** | **12.0** | **-1.5** | **-11.1** | **-1.4** |
| **GB** | **II** | **76** | **13.3** | **11.5** | **-1.9** | **-14.1** | **-2.9**** |
| | **IV** | **24** | **16.6** | **14.4** | **-2.2** | **-13.1** | **-1.5** |
| | **V** | **97** | **11.5** | **11.4** | **-0.1** | **-1.2** | **-0.2** |

Table 13

S-PLOTS

| Land scape type | Aggr class | No. of plots | No. of species 1978 | No. of species 1990 | Change in mean number | Change in % | t value |
|---|---|---|---|---|---|---|---|
| A | II | 33 | 10.6 | 13.3 | 2.7 | 25.1 | 2.5* |
| | IV | 21 | 20.9 | 17.8 | -3.1 | -15.0 | -2.6* |
| P | IV | 29 | 20.5 | 17.4 | -3.1 | -15.0 | -1.7 |
| U | VII | 48 | 24.3 | 19.5 | -4.8 | -19.7 | -3.5** |
| | VIII | 22 | 20.8 | 24.0 | 3.2 | 15.5 | 1.4 |
| GB | II | 54 | 13.4 | 14.1 | 0.6 | 4.6 | 0.7 |
| | III | 25 | 16.3 | 15.4 | -0.9 | -5.6 | -0.5 |
| | IV | 71 | 23.0 | 19.0 | -4.0 | -17.3 | -3.7** |
| | V | 25 | 15.0 | 13.0 | -2.1 | -13.8 | -1.5 |
| | VI | 44 | 21.3 | 16.9 | -4.4 | -20.5 | -2.4* |
| | VII | 73 | 22.5 | 19.5 | -3.0 | -13.3 | -2.6* |
| | VIII | 28 | 19.6 | 22.0 | 2.4 | 12.2 | 1.3 |

Table 14

| | Number of comparisons | Increasing diversity | Decreasing diversity | ns |
|---|---|---|---|---|
| All plots | 28 | 3 | 13 | 12 |
| Main plots | 20 | 0 | 8 | 12 |
| Hedge plots | 7 | 0 | 1 | 6 |
| Verge plots | 12 | 2 | 0 | 10 |
| Streamside plots | 12 | 1 | 5 | 6 |

Table 15

## a) CALCAREOUS GRASSLAND INDICATORS

| | X | R | B | H | S | Sig | Y |
|---|---|---|---|---|---|---|---|
| **Arable** | | | | | | | |
| 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 |

## b) ACID GRASSLAND INDICATORS

| | X | R | B | H | S | Sig | Y |
|---|---|---|---|---|---|---|---|
| **Arable** | | | | | | | |
| 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 |

Table 15 contd.

## c) MESOTROPHIC GRASSLAND INDICATORS

| Arable | X | R | B | H | S | 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 |

Table 16

| Calcicoles | Sig | No. of plots in 1978 | No. of plots in 1990 | % change | Chi-square |
|---|---|---|---|---|---|
| GB | ns | 255 | 276 | - | 1.4 |
| Arable | ns | 54 | 40 | - | 3.4 |
| Pastural | ns | 56 | 61 | - | 0.2 |
| Coastal | ** | 55 | 87 | 58.2 | 14.6 |
| Mesotrophic species | | | | | |
| GB | ** | 1156 | 1068 | -7.6 | 16.4 |
| Arable | ns | 226 | 195 | - | 1.4 |
| Pastural | ** | 333 | 296 | -11.1 | 7.0 |
| Marginal upland | ns | 219 | 214 | - | 0.3 |
| Upland | ns | 378 | 363 | - | 3.4 |
| Coastal | ns | 166 | 171 | - | 0.4 |
| Acidophiles | | | | | |
| GB | ** | 1243 | 1189 | -4.3 | 6.9 |
| Arable | ns | 201 | 180 | - | 2.7 |
| Pastural | ns | 370 | 352 | - | 1.5 |
| Marginal upland | ns | 264 | 258 | - | 0.6 |
| Upland | * | 408 | 399 | -2.2 | 4.3 |
| Coastal | ns | 173 | 178 | - | 0.3 |

Table 17

| | Sig | Total 78 | No. of plots in 1978 | No. of plots in 1990 | Chi-sqr |
|---|---|---|---|---|---|
| GB | ** | 685 | 624 | -8.9 | 9.5 |
| Arable | * | 86 | 67 | -22.1 | 3.9 |
| Pastural | * | 153 | 130 | -15 | 4.1 |
| Marginal Upland | ns | 128 | 122 | - | 0.4 |

Table 18

## LANDSCAPE TYPE 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** | **B** | **H** | **S** | **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 |

Table 19

| Species | NVC constancy value |
|---|---|
| *Cynosurus cristatus* | 5 |
| *Festuca rubra agg.* | 5 |
| ***Lotus corniculatus*** | 5 |
| *Plantago lanceolata* | 5 |
| ***Agrostis capillaris*** | 4 |
| ***Anthoxanthum odoratum*** | 4 |
| *Dactylis glomerata* | 4 |
| *Holcus lanatus* | 4 |
| ***Trifolium pratense*** | 4 |
| *Trifolium repens* | 4 |
| *Centaurea nigra* | 4 |
| *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 |

Table 20

**Landscape type**

| Plot type | Arable | Pastural | Marginal upland | Total |
|---|---|---|---|---|
| Y | 1 | 6 | - | 7 |
| R | - | - | 2 | 2 |
| S | - | - | 1 | 1 |
| X | - | 7 | 8 | 15 |
| Total | 1 | 13 | 11 | 25 |

Table 21

**Arable landscape**

| Aggregate class | Abundance | B | H | R | S | X | Sig |
|---|---|---|---|---|---|---|---|
| I | A | 1.6 | ***1.3*** | 1.5 | 1.3 | ***2.1*** | *** |
| II | A | 4.3 | ***4.9*** | 4.8 | 4.6 | ***2.0*** | *** |
| III | A | 2.2 | ***1.7*** | ***3.4*** | 2.0 | 2.5 | *** |
| IV | A | 3.5 | ***2.4*** | 4.5 | 4.4 | ***4.5*** | *** |
| IV | R | 1.5 | 1.2 | 1.4 | ***1.1*** | ***2.3*** | ** |
| V | A | 2.5 | 2.9 | ***1.9*** | 2.3 | ***3.2*** | *** |
| V | I | 1.3 | 1.2 | ***1.2*** | 1.3 | ***1.8*** | * |

**Marginal upland landscape**

| Aggregate class | Abundance | B | H | R | S | X | Sig |
|---|---|---|---|---|---|---|---|
| III | A | 2.2 | 2.1 | ***3.1*** | ***1.7*** | 2.6 | *** |
| IV | A | 5.2 | ***4.4*** | 6.5 | 6.1 | ***6.6*** | *** |
| VI | A | 1.8 | 2.6 | ***1.8*** | ***3.0*** | 2.2 | *** |
| VII | A | 3.8 | ***2.1*** | 3.7 | 6.5 | ***5.6*** | *** |
| VIII | A | 3.0 | - | ***2.2*** | 3.3 | ***5.5*** | *** |

**Pastural landscape**

| Aggregate class | Abundance | B | H | R | S | X | Sig |
|---|---|---|---|---|---|---|---|
| I | A | 1.5 | ***1.2*** | 1.5 | 1.3 | ***2.1*** | *** |
| II | A | 3.5 | 3.8 | ***4.5*** | 3.6 | 2.0 | *** |
| II | I | ***1.4*** | ***1.2*** | 1.2 | 1.4 | 1.2 | ** |
| III | A | 2.5 | ***1.8*** | ***3.4*** | 2.3 | 3.1 | *** |
| IV | A | 4.0 | ***3.0*** | 5.1 | 5.0 | ***5.5*** | *** |
| IV | I | 1.5 | ***1.1*** | 1.3 | 1.6 | ***1.6*** | *** |
| V | A | 3.0 | ***3.9*** | ***2.8*** | 2.9 | 3.7 | *** |
| V | I | ***1.2*** | 1.2 | ***1.2*** | ***1.6*** | 1.4 | *** |

**Upland landscape**

| Aggregate class | Abundance | B | R | S | X | Sig |
|---|---|---|---|---|---|---|
| VI | A | 1.8 | ***1.5*** | ***2.4*** | 2.0 | *** |
| VII | A | 5.8 | ***5.6*** | ***8.5*** | 6.5 | *** |
| VII | I | ***1.5*** | 1.7 | 2.0 | ***2.1*** | * |
| VIII | A | 4.2 | ***2.8*** | 5.0 | ***8.5*** | *** |
| VIII | I | 1.8 | ***1.3*** | 2.0 | ***2.5*** | *** |

Table 22

| | | Aggregate class | Abundance | Change | SIG |
|---|---|---|---|---|---|
| a) ARABLE | I | Crops/weeds | A | - | *** |
| | II | Tall grassland/herb | A | + | *** |
| | III | Fertile grasslands | A | - | *** |
| | IV | Infertile grasslands | A | - | ** |
| | V | Lowland wooded | A | . | ns |
| | I | Crops/weeds | I | . | ns |
| | II | Tall grassland/herb | I | . | ns |
| | III | Fertile grasslands | I | + | ** |
| | IV | Infertile grasslands | I | . | ns |
| | V | Lowland wooded | I | . | ns |
| | I | Crops/weeds | R | . | ns |
| | II | Tall grassland/herb | R | . | ns |
| | III | Fertile grasslands | R | . | ns |
| | IV | Infertile grasslands | R | . | ns |
| | V | Lowland wooded | R | + | * |
| b) PASTURAL | I | Crops/weeds | A | . | ns |
| | II | Tall grassland/herb | A | + | ** |
| | III | Fertile grasslands | A | . | ns |
| | IV | Infertile grasslands | A | - | *** |
| | V | Lowland wooded | A | . | ns |
| | I | Crops/weeds | I | . | ns |
| | II | Tall grassland/herb | I | - | * |
| | III | Fertile grasslands | I | . | ns |
| | IV | Infertile grasslands | I | . | ns |
| | V | Lowland wooded | I | - | ** |
| | I | Crops/weeds | R | . | ns |
| | II | Tall grassland/herb | R | . | ns |
| | III | Fertile grasslands | R | . | ns |
| | IV | Infertile grasslands | R | . | ns |
| | V | Lowland wooded | R | . | ns |
| c) MARGINAL UPLAND | III | Fertile grasslands | A | . | ns |
| | IV | Infertile grasslands | A | . | ns |
| | VI | Upland wooded | A | . | ns |
| | VII | Moorland/grass mosaic | A | . | ns |
| | VIII | Heath/bog | A | . | ns |
| | III | Fertile grasslands | I | . | ns |
| | IV | Infertile grasslands | I | . | ns |
| | VI | Upland wooded | I | . | ns |
| | VII | Moorland/grass mosaic | I | . | ns |
| | VIII | Heath/bog | I | + | * |
| | IV | Infertile grasslands | R | . | ns |
| | VI | Upland wooded | R | . | ns |
| | VII | Moorland/grass mosaic | R | . | ns |
| | VIII | Heath/bog | R | . | ns |
| d) UPLAND | II | Tall grassland/herb | A | . | ns |
| | VI | Upland wooded | A | . | ns |
| | VII | Moorland/grass mosaic | A | . | ns |
| | VIII | Heath/bog | A | . | ns |
| | II | Tall grassland/herb | I | . | ns |
| | VI | Upland wooded | I | - | ** |
| | VII | Moorland/grass mosaic | I | - | ** |
| | VIII | Heath/bog | I | . | ns |
| | VI | Upland wooded | R | - | ** |
| | VII | Moorland/grass mosaic | R | + | ** |
| | VIII | Heath/bog | R | . | ns |
| e) GB | I | Crops/weeds | A | - | *** |
| | II | Tall grassland/herb | A | + | *** |
| | III | Fertile grasslands | A | - | * |
| | IV | Infertile grasslands | A | - | *** |
| | V | Lowland wooded | A | . | ns |
| | VI | Upland wooded | A | . | ns |
| | VII | Moorland/grass mosaic | A | . | ns |
| | VIII | Heath/bog | A | . | ns |
| | I | Crops/weeds | I | . | ns |
| | II | Tall grassland/herb | I | . | ns |
| | III | Fertile grasslands | I | + | ** |
| | IV | Infertile grasslands | I | - | * |
| | V | Lowland wooded | I | - | ** |
| | VI | Upland wooded | I | - | *** |
| | VII | Moorland/grass mosaic | I | - | *** |
| | VIII | Heath/bog | I | . | ns |
| | I | Crops/weeds | R | . | ns |
| | II | Tall grassland/herb | R | . | ns |
| | III | Fertile grasslands | R | . | ns |
| | IV | Infertile grasslands | R | . | ns |
| | V | Lowland wooded | R | . | ns |
| | VI | Upland wooded | R | - | *** |
| | VII | Moorland/grass mosaic | R | . | ns |
| | VIII | Heath/bog | R | . | ns |

Table 23

| Landscape type | Aggregate class I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|
| **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 |

Table 24

## HOST PLANTS INCREASING

| Plant species | No. of butterfly species | II P | III P | V A | V P | VIII U |
|---|---|---|---|---|---|---|
| *Agrostis capillaris* | 1 | | | | | ✓ |
| *Elymus repens* | 9 | ✓ | ✓ | ✓ | ✓ | |
| *Succisa pratensis* | 1 | | | | | ✓ |

## HOST PLANTS DECREASING

| Plant species | No. of butterfly species | I A | III A | III P | IV A | IV M | IV P | V P | VI P | VI U | VII M | VII U | VIII U |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *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 | | ✓ | ✓ | | | ✓ | | | | | | |

Table 25

## HOST PLANTS INCREASING

| **Butterfly species** | **II P** | **III P** | **V A** | **V P** | **VIII U** |
|---|---|---|---|---|---|
| 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** | **I A** | **III A** | **III P** | **IV A** | **IV M** | **IV P** | **V P** | **VI P** | **VI U** | **VII M** | **VII U** | **VIII U** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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 | | | |

Table 26

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

Table 27

| | Aggregate class | | | | |
|---|---|---|---|---|---|
| **Landscape type** | **I** | **II** | **III** | **IV** | **V** |
| **Arable** | ***45.0*** | 32.2 | 37.9 | 31.6 | ***29.5*** |
| **Pastural** | ***50.2*** | 34.9 | 41.0 | 32.2 | ***28.4*** |

Table 28

| | | Aggregate class | | | | |
|---|---|---|---|---|---|---|
| **Bird species** | **Landscape type** | **I** | **II** | **III** | **IV** | **V** |
| **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)*** |

Table 29

| Bird | Code | Present status: Declining | Stable | Increasing | Number of food plants with detected range changes: GB + | GB - | Increases A | Increases P | Increases M | Decreases A | Decreases P | Decreases 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 | |

Table 30

| | Increasing | | | | Decreasing | | | |
|---|---|---|---|---|---|---|---|---|
| | **GB** | **A** | **P** | **M** | **GB** | **A** | **P** | **M** |
| **Total** | 13 | 8 | 10 | 6 | 17 | 12 | 14 | 3 |

Table 31

| Food plant species | GB + | GB - | Increases A | Increases P | Increases M | Decreases A | Decreases P | Decreases 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* | | | | ✓ | | | | |

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## ITE sites

Monks Wood
(Admin HQ)
Abbots Ripton
HUNTINGDON PE17 2LS
Telephone 01487 773381-8
Fax 01487 773467
Email MONKSWOOD@ITE.AC.UK

Merlewood Research Station
GRANGE-OVER-SANDS
Cumbria LA11 6JU
Telephone 015395 32264
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

Bangor Research Unit
University of Wales, Bangor
Deiniol Road
BANGOR, Gwynedd LL57 2UP
Telephone 01248 370045
Fax 01248 355365
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)