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DIVERSITY IN BRITISH HEDGEROWS

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CONTENTS

HEDGEROW DIVERSITY - EXECUTIVE SUMMARY

AIMS: To determine how the character and diversity of hedgerows and their flora is affected by changes in hedgerow management and adjacent land use. The work will inform the development and appraisal of the Countryside Commission's plans to introduce 'hedgerow management incentives'.

1. The data for this report were collected during surveys of the British countryside carried out by the Institute of Terrestrial Ecology (ITE) in 1978, when 256 1 km squares were sampled, and in 1990 when the sample size was increased to 508 squares (thanks to funding from NERC and the Department of Environment (DoE) with additional support from the Nature Conservancy Council).

2. The woody species component will be referred to as the 'hedge', the herbaceous component as the 'hedge-bottom' and the two components together as the 'hedgerow'.

3. Data from 1176 10x1m plots, situated on one side of hedgerows only, were used to produce two classifications - one of the hedges and the other of the hedge-bottoms. There were 8 hedge classes and 17 hedge-bottom classes; the latter were combined into 4 groups which are adequate for current purposes. The two simple keys to the classifications require only limited botanical expertise.

4. The most common hedges in Britain are those classified as 'hawthorn-dominant' and 'blackthorn-predominant'; they are widely distributed with estimated lengths of 196 200 km (43% of all hedges) and 114 000 km (25% of total) respectively. Mixed-hazel hedges are the third most common type in Britain, with an estimated 65000 km (14% of total) and, although widespread, they are most abundant in SW England. The mixed-hawthorn hedges are the fourth most common type with an estimated 22 500 km (5% of total) and are particularly abundant in the Midlands, East Anglia and NE England.

5. The hedges classified as 'mixed-hazel' or 'mixed-hawthorn' were both rich in woody species, averaging 4.4 and 3.6 woody species per plot respectively. This compares with 2.0 and 3.2 woody species per plot respectively for the two most common types of hedge.

6. The woody plants in both of the richer types were predominantly native species that are common within woodlands. Mixed-hazel hedges also tended to have an associated ground flora of woodland species, whereas mixed hawthorn hedges had species more typical of intensively-managed arable ground. Nevertheless, these hedgerows are important refuges for woodland plants, especially in areas where woodlands *per se* are not abundant.

7. Hedgerows that were rich in woody species were not necessarily rich in herbaceous species and vice-versa. Therefore both strata need to be considered when determining management strategies.

8. The species-composition of most hedge-bottoms was affected more by the use and management of the adjacent land, rather than by the hedge itself. Between 1978 and 1990 there has been a general reduction in the diversity of herbaceous vegetation in hedgerows, probably due to increasing intensity of land management. Reductions of fertilizer inputs and herbicides, and/or the use of wide headlands can be valuable in maintaining or increasing the diversity of species in the hedge-bottom.

9. Very intensive land management and no management at all are both deleterious to the diversity of herbaceous species. In some situations, limited grazing could be a valuable management 'tool'.

10. Hedgerows adjacent to roads, tracks and wooded ground were particularly rich in woodland species - hedges in these situations should not be ignored.

11. Management of the hedge itself has no significant effect on species-diversity, either within or beneath the hedge. However, the hedge should be managed to maintain it as a coherent feature and to prevent its degeneration, for example into a row of trees.

12. At least 60% of the samples of both species-rich types of hedge (see 3 above) had more than 10% of gaps in their length; rejuvenation of these types should therefore include 'gapping-up' with a suitable mixture of species so that their diversity is maintained.

13. Losses of the more common types of hedge between 1978 and 1990 from all causes, including neglect, ranged from 21% (hawthorn-dominated and blackthorn) to 31% (mixed-hawthorn). The overall loss was 24%, which compares with a 25% loss of hedge length for the same period calculated from the results given by Barr *et al* (1991) in their report to the DoE. Both reports show similar losses due to removal over the 12 years - here it is 19% compared with estimates from Barr's data of 14%.

14. The positive identification of ancient hedgerows can only be achieved by detailed searches of archives. However, there is a broad association between the woody species-richness of a hedge and its age - a sample of species-rich hedges will tend to have more ancient hedges than a random sample, although the detailed calibration will vary from region to region.

15. Data are given on the regional distribution and abundance of hedges and these must be taken into account when targetting incentives. Hedges may be nationally rare e.g. wild privet, or nationally common but locally rare e.g. hazel hedges in East Anglia. Examples such as these should be conserved if national and local diversity is to be maintained. Conversely, abundant and well-managed hedges would require only minimal assistance.

16. The above results and conclusions deal mainly with the most important ecological aspects of hedgerows which should be considered when determining management strategies. However, the priority given to these ecological criteria relative to, for example, landscape and historical interest, must be decided by the relevant executive bodies.

HEDGEROW DIVERSITY

SECTION 1. INTRODUCTION

1.1 During surveys of the countryside in Great Britain conducted by the Institute of Terrestrial Ecology (ITE) in 1978 and 1990, data were collected on the florisitics and management of hedgerows, and of the adjacent land use. This report uses the results of those surveys to examine the changes in floristic diversity in the intervening 12 years, and the interactions between diversity and management.

1.2 The report was commissioned by the Department of Rural Affairs, Department of Environment (DoE), and will inform the development and appraisal of the Countryside Commission's (CC) plans to introduce hedgerow management grants.

1.3 A comprehensive account of methodology in 1990 is given in a Field Handbook (available by arrangement from ITE).

1.4 The principal tables and figures from which conclusions have been drawn are included in the text; ancillary data are given in appendices.

SECTION 2: AIMS

The aims of the project were, for Britain and, where appropriate, its main regions, to:

2.1 define the principal hedgerow types, their species composition and diversity;
2.2 identify and quantify the changes in botanical composition and species diversity of hedgerows in Britain between 1978 and 1990
2.3 assess the effect of hedgerow management and change within hedgerows;
2.4 assess the effect of hedgerow loss (either by removal or change to other types of linear features e.g. rows of trees) on diversity in the countryside.

SECTION 3. BACKGROUND

Hedges have been a feature of the British countryside for many centuries - indeed, the sites of some present-day hedges can be traced back to Saxon times (Grose1957; Rackham 1977). Generally, the older a hedge is, the more woody species it contains (Hooper 1970): some sites where hedges have been established for over 600 years may contain 6-10 woody species in a 30m length whereas hedges less than 100 years old usually have fewer than 4 species and often tend to be monotypic with hawthorn predominant (for fuller information see Rackham's "the History of the Countryside"). However, although this relationship is broadly correct, the actual ratio [number of woody species : age of hedge] will vary regionally. We would expect, for example, old hedges in the north of England to have fewer species than similar aged hedges in the south due to geographical limitations on the distribution of some species e.g. field maple and wayfaring-tree.

As an indication of the diversity of species in hedgerows, over 400 herbaceous species and 52 woody species (appendix 1, table 1) were recorded in the 1978 and 1990 surveys.

Hedges are valuable, not only for enclosing and providing shelter for domestic stock, but also for:

- Wildlife
  - . providing cover and shelter, especially for birds, insects and small mammals
  - . as corridors between isolated habitats
  - . as a food resource, not only from the fruits of the woody species but also from the foliage of associated plants such as stinging nettles which are valuable food plants for the caterpillars of butterflies and moths.
  - . providing suitable habitat/refuges for many plant species including those commonly associated with woodland

-Soil conservation
- . hedges reduce windruns and windspeed thus reducing wind erosion
- . hedges trap blown soil
- . roots help to bind soils and reduce surface erosion

-Amenity
- . hedges are an important visual component of many British landscapes

-History
- . ancient hedges are living 'archaeological' indicators of boundaries associated with, for example, old parishes or estates and historical agricultural practices

-Education
- . hedges are a spatially well-defined type of habitat and as a result are commonly used for teaching biology/ecology

For all these reasons, and because of significant losses of hedges, there has been increasing concern in recent years about the fate of British hedges, resulting in the announcement by the Government of two new measures to protect and enhance hedges:
a. In July 1991 a 'hedgerow notification scheme' was announced to prevent the unauthorised removal of hedges.
b. The Countryside Commission is currently developing plans for management grants which will be used to rejuvenate hedges, particularly in areas where they are most important to the character of the landscape and in the maintenance of biological diversity. This scheme is intended to start in 1992-3.

The implementation of these schemes requires information on hedges throughout Britain. There is, however, no national overview of the variation in hedgerow characteristics, the role of environmental factors and management in controlling these variations, and of the changes in characteristics over time. These topics are the focus of this report whereas Barr *et al.* (1991) have already reported to DoE on hedge losses *per se*.

SECTION 4: METHODS

4.1 **The sampling strategy** was the same in both the 1978 and 1990 surveys viz: a random sample of 1 km squares throughout GB, stratified according to ITE Land Classes. In 1978, 256 squares were sampled and this was increased to 508 squares in the 1990 survey, which was funded by DoE and NERC with support from the Nature Conservancy Council. The distribution of survey squares and of those containing hedges is shown in fig 1.

4.2 **The field survey methods** were similar in both years and included (a) mapping the hedges within a square and (b) describing hedge floristics using quadrats. The bulk of this report is concerned with the quadrat data. A comprehensive account of the methodology in 1990 is given in a Field Handbook (available by arrangement from ITE). Note that hedges forming the boundaries to land around buildings (curtilage) were not sampled.

4.3 **Map data**: mapped hedges were described less fully in 1978 than in 1990 and therefore the earlier data are only used here for determining hedge lengths and losses.

4.4 **Quadrat data**: in 1978, two hedge (H) plots were located in each square using a set procedure to ensure that the plots were well separated in the 1km square. Plots were relocated if there was not a clear metre between the centre of the hedge and another linear feature e.g. a ditch. Only one plot was recorded when there was less than 30m of hedge in the square. The sites of the plots were marked on 1:10 000 maps.

At each plot, a 10 x 1 m quadrat was set out running parallel to the hedge and with its 10m base along the centreline of the hedge. The species and percent cover (where greater than 5%) were recorded for all plants rooted in the quadrat.

In 1990, 259 of the plots recorded in 1978 were reliably located and, if a hedge was still present, the recordings were repeated (1990 H data). Plots were excluded from the analyses if there was any doubt about the accuracy of their location. These 259 'paired plots' i.e. recorded in both years, form the database for assessing changes.

Where a hedge was no longer present, a new plot was established as close as possible to the original site for use in future surveys. The fate of the original hedge was determined by cross-reference to the map data, which also supplied the information on hedge management and adjacent land use in 1990.

In 1990 only, up to 5 more quadrats per square were recorded alongside a random selection of boundaries in general. Sometimes these boundaries were formed by hedgerows and, if so, the data ('B' plots) have been included here.

Altogether, two hundred and seventy eight plots from 1978 and nine hundred and eighteen plots (H+B) from 1990 were used in the analyses.

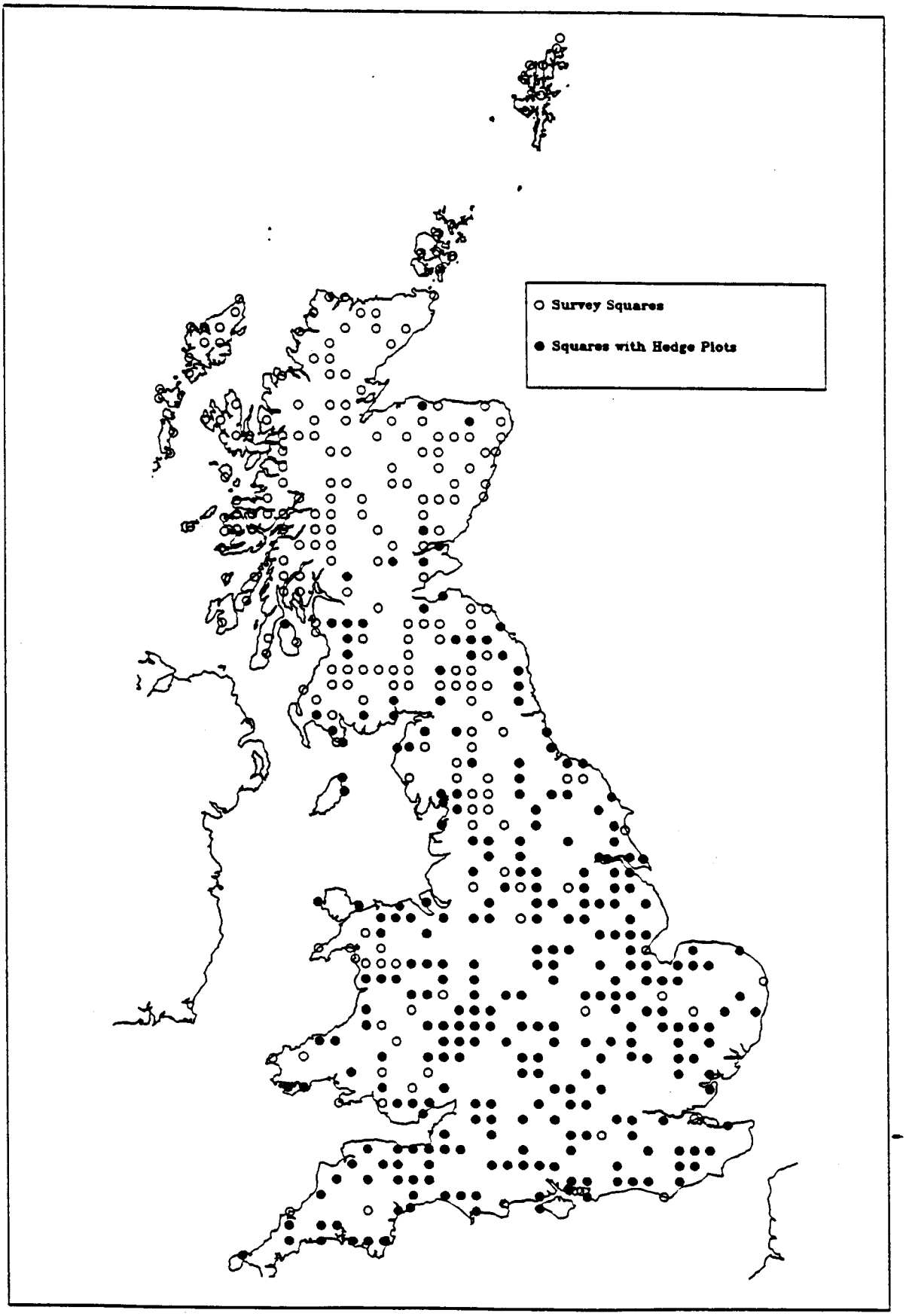


Fig. 1. Distribution of survey squares in 1990 showing those that contained hedge plots.

SECTION 5. ANALYSES

5.1 **RESULTS** are frequently presented as proportions or percentages to facilitate comparisons between groups or classes of different sample sizes.

5.2 **CLASSIFICATIONS** of hedgerows were done using the statistical analysis TWINSPAN.

5.2.1 All 1176 plots from 1978H and 1990H+B were lumped together for analysis, thus ensuring that we did not omit any hedgerow types which were present in only one year.

5.2.2 Initial TWINSPAN analyses of all the species data together (woody and herbaceous) gave a classification which was confused by the large amount of information present. Therefore the data had to be sub-divided to get interpretable results.

5.2.3 Consequently, we used percent cover to classify the woody species i.e. including roses but not soft-wooded species such as bramble (appendix 1, table 1), and presence/absence data to classify the herbaceous species within the hedge bottom.

5.3 **ASSOCIATIONS OF SPECIES:** The relationships between species, regardless of the hedgerow classes, were examined using the statistical procedure DECORANA. The scores from that analysis were then input to Nearest Neighbour analysis(woody species) or Ward's minimal variance analysis (herbaceous species) to determine the **species clusters.**

5.4 **COMPARISONS** among hedgerow classes, species clusters, changes in species composition, hedge management and land use were mostly by simple standard analyses e.g. correlation, cross-tabulation, analysis of variance.

5.5 **STATISTICS,** such as mean, range and standard error, are given where appropriate and where sample sizes are adequate. Where sample sizes are small, usually due to the sub-division of classes, results may be given if they are relevant to the composition of class as a whole. However, care must be taken when interpreting such information.

SECTION 6: RESULTS - GENERAL

It must be emphasised that the surveys were 'snapshots' at one particular time and that some aspects of the floristic and physical features of the hedgerows will have been established over much longer timescales than 12 years. Conversely, the hedgerows may have been drastically altered by short-term events. Some of these will be picked up in the results (e.g. hedge removal) and some will not (e.g. past use of herbicides on the hedge-bottom).

Note:
The following terminology will be used throughout this report:
The ***woody species component*** will be referred to as the ***'hedge'***
..... ***herbaceous.*** ..... ***'hedge-bottom'***
..... ***two components together.*** ..... ***'hedgerow'.***

Hedges .....are referred to by their ***Woody Species Class (WSC)*** } see
Hedge-bottoms .....***Herbaceous Group (HG)*** } below

SECTION 7: HEDGEROW CLASSIFICATION

It is important to note that the classifications operate on the balance between different species and/or their cover values. The appearance of a new species, or a change in % cover of an existing species, may alter the classification of a hedge/hedge-bottom even though its overall appearance is not markedly changed. Thus a species which typifies a class may not necessarily be dominant i.e. have the highest cover in a stretch of hedgerow. Consequently, we have distinguished between 'dominant', 'predominant ' (i.e. the indicator species is very frequent but not necessarily at a high cover level) and 'present' (just the presence of a species was sufficient to classify a hedge).

7.1 CLASSIFICATION BY WOODY SPECIES (HEDGES)

Initially, the classification (appendix 1 fig 1) split off a series of less common hedges - WSCs 1,2,3,7 and 8 - all but one having fewer than 20 plots in the sample (Table 1). The amount of hawthorn present was then a strong factor in subdividing the remaining 'core' hedge types.
Eleven classes of hedges resulted after several types had been aggregated into class one :

Table 1: TWINSPAN hedge classes, types and number of plots in each.

Class	Type	No. of plots	Class	Type	No. of plots
1a-d	- mostly planted non-native species	9	5a	- willow or rose dominant	6
2	- wild privet present	5	5b	- mixed-hazel predom	157
3	- beech dominant	19	6	- blackthorn predom	270
4a	- hawthorn dominant	552	7	- elm predominant	49
4b	- mixed-hawthorn	61	8	- gorse dominant	8
4c	- elder/hawthorn	40			

The woody species composition of each WSC is given in more detail, together with a brief description, in appendix 2. (Note: classes with a long list of 'other woody species' are not necessarily 'species-rich' - see discussion under 'Diversity').

The species profile of each class is illustrated in the histograms (appendix 2, fig 1) which clearly show, for example, how the balance between the amounts of hawthorn and elder affects the division of group 4 into the classes 4a, b and c.

7.2 CLASSIFICATION BY HERBACEOUS SPECIES (HEDGE-BOTTOMS)

7.2.1 The TWINSPAN analysis of herbaceous species (presence/absence data) produced 17 interpretable classes (appendix 1, fig 2) involving 41 'indicator' species (appendix 1, table 2). However, this is an excessive number of classes because some of the sample sizes are very small. Level 3 of the hierarchy gave 4 acceptable composite groups (HGs) which were used subsequently to indicate types of hedge-bottoms.

7.2.2 The frequency of occurrence and the mean % cover of all the commoner herbaceous species (i.e those present in one-fifth or more of the plots in each HG) are given in Appendix 2, table 3. Not surprisingly when dealing with very common species, several of them occur in 2 or more adjacent groups, albeit at different frequencies and % cover values. In fact 2/3 or more of the species prevalent in groups 1 and 2 were also prevalent in other groups. This contrasts with only 1/3 or less of the common species in HGs 3 and 4 being frequently present also in HGs 1 and 2.

Despite this overlap, a DECORANA analysis suggested that the herbaceous groups are typical of the following types of land use/habitats:

HG 1 - arable cropland
2 - other intensively managed ground (mainly lowland)
3 - rough grazings and less intensively managed grasslands
4 - woodland vegetation.

The effects of land use will be discussed more fully in later sections.

7.3 DISCUSSION OF CLASSIFICATION

7.3.1 The species-compositions of hedges form a series of continua ranging from the various mono-specific types to the very mixed hedges. As with any continua, sub-division will result in the extremes of one division being very similar to those of adjacent classes. The analyses used here make these divisions objectively and have resulted in two simple keys which require only limited botanical expertise and should be valuable for field-workers.

7.3.2 Some *ad hoc* tests of the key to hedges have shown that it is quick and easy to use and so far it has given satisfactory results.

7.3.3 The key to hedge-bottoms has yet to be tried in the field and both keys need further testing to ensure that they give consistent results for different types of hedgerow and in different regions of the country (see also section 13).

7.3.4 A methodology for using the keys to classify complete lengths of hedgerows in the field has yet to be determined.

SECTION 8: SPECIES CLUSTERS AND RELATIONSHIP TO HEDGE CLASSES

The classification keys show only a small proportion of all the species recorded/analysed and give very little information about the types of vegetation in the different classes. Floristic description of the classes could be very complex, especially when there are over 400 herbaceous species. Here the descriptions have been simplified by (statistically) grouping closely associated species together into a relatively small number of 'clusters' and then examining the degree of association between each cluster and the hedgerow classes. The strength of the associations is determined by whether the species from each cluster occur more or less frequently in each hedge/hedge-bottom class than one would expect statistically.
The above procedure is carried out separately for the woody and herbaceous species and each of the herbaceous clusters is named by the habitat-type which its component species have in common.

8.1 WOODY SPECIES

8.1.1 Clustering of woody species over all the hedge classes (Appendix 3, fig 1) showed 2 important groupings:

Cluster 1 a+b: Field maple, sycamore, alder, hazel, hawthorn, spindle, ash, holly, birch
Cluster 2b: Blackthorn, roses, elder, broom, guelder rose, oak

The first cluster contains essentially long-lived, woodland species that are all native, except for sycamore which was introduced in the 14th or 15th century. The species in cluster 2b are also native but, with the exception of oak and blackthorn, do not live as long as those in cluster 1 and are associated with more open scrubby habitats.

Apart from a group of 'exotics', the reasons for the clustering of other species were not obvious, often tending to be incidentals associated with a strongly dominant species e.g. beech.

8.1.2 Reference to the WSC profiles (appendix 2, fig 1) shows that species from clusters 1 and 2 occur widely across the major hedge types (4a-c, 5b and 6). Obviously the strength of the relationship between WSCs and species clusters is weighted heavily by the dominant species. For example, hedges in WSC 4a are so dominated by hawthorn (cluster 1) that there can be few species from cluster 2. In contrast, WSC 4c (elder/hawthorn) has a high proportion of cluster 2 species, in this case weighted by elder.
Although 4b (mixed-hawthorn) and 5b (mixed-hazel) have several species from both clusters, they are the only classes with a wide range of the woodland species (cluster 1).

8.2 HERBACEOUS SPECIES

8.2.1 Twelve herbaceous associations were identified (appendix 3, table 1) and they can be summarised as representing various habitat types (table 2):

Table 2: The occurrence of herbaceous species in different clusters as a percentage of all herbaceous species records.

Cluster	Habitat type	% of records
1a	- meadow	19
1b	- short-term grassland	8
2	- old meadow	5
3	- nitrogen/phosphorus-rich areas	1
4a	- acid grassland	3
4b	- acid woodland	5
5	- abandoned/derelict areas	22
6	- lowland wood/scrub	10
7	- arable weeds	2
8a	- humus-rich basophiles	14
8b	- southern derelict areas	3
9	- common weeds	7

8.2.2 Despite the physical dominance of the woody components of hedges, it is clear that the vegetation in hedge-bottoms is not confined to associations typical of woodlands; in fact the occurrence of species from the woodland clusters (4b and 6) together accounted for only 15% of the total (table 2). The unmanaged nature of many hedgerows is indicated by the 25% occurrence of species typifying abandoned or derelict areas (clusters 5 and 8b).

8.2.3 Statistically significant associations between the above clusters and the different types of hedge-bottom are shown in table 3. (Note that the absence of a sign indicates an average degree of association, not a total lack of assocation).

(a) HG1 was positively associated with species clusters typical of arable land (i.e. those of nitrogen/phosphorus-rich areas and arable weeds) and also with common species of land that was formerly managed but is now abandoned/derelict. There were negative associations with plants in all the grassland clusters, including short-term grassland, and also with acid woodland.

(b) HG2 includes species from a wide range of habitats, having no strong positive affinities, and only one negative association i.e. with species typical of acid grassland.

(c) HG3 can be generally summed-up as 'grasslands' due to its positive associations with all four grassland clusters and negative associations with the clusters more characteristic of arable areas and unmanaged ground.

(d) HG4 was the only group having positive affinities with woodland species (clusters 4b and 6); conversely, there were negative associations with species clusters typical of high management levels.

Table 3: Types of hedge-bottom and herbaceous species clusters with at least 1.5 times more (+) or fewer (-) plots than expected statistically.

+ indicates observed value is at least 1.5 times expected, ++ at least twice expected and +++ at least 3 times expected. Similarly, -, - - and - - - indicate expected is 1.5, 2 or 3 times observed.

	Hedge-bottom (HG)			
Species cluster	**1**	**2**	**3**	**4**
1a (meadow)	-		+	
1b (short-term grassland)	-		+	-
2 (old meadow)	---		++	
3 (N/P rich)	+		--	---
4a (acid grassland)	---	-	++	++
4b (acid woodland)	--			+++
5 (abandoned/derelict)	+		--	---
6 (lowland wood)				+
7 (arable weeds)	+		-	---
8b (southern derelict)			-	

8.3 RELATIONSHIP BETWEEN HERBACEOUS CLUSTERS AND HEDGE TYPES

There is a wide range of vegetation types in hedge-bottoms (tables 2 and 3) and these may be associated with different types of hedge; for example, do hedges with a lot of woodland tree species tend to have a ground flora that also is characteristic of woodlands? These relationships are examined in table 4.

Table 4: Hedge classes and herbaceous species clusters with at least 1.5 times more (+) or fewer (-) plots than expected statistically.

+ indicates observed value is at least 1.5 times expected, ++ at least twice expected and +++ at least 3 times expected. Similarly, -, -- and --- indicate expected is 1.5, 2. or 3 times observed.
Classes not shown were too rare for valid comparisons.

	Hedge Class (WSC)						
Species cluster	**3**	**4a**	**4b**	**4c**	**5b**	**6**	**7**
3 (N/P rich)			+	+	--		
4a (acid grassland)	+		-	-			---
4b (acid woodland)	++		-	-	++		---
6 (lowland wood)					+		
7 (arable weeds)					---	-	

8.3.1 Beech hedges (WSC 3) are strongly associated with herbaceous species of acid grassland and acid woodland. Both these vegetation types are present in marginal upland areas, such as Exmoor and parts of Wales, where beech hedges are frequently found.

8.3.2 Hawthorn-dominated hedges (4a) have been planted in a wide range of situations and showed no significant affinities either way with any particular hedge-bottom community.

8.3.3 Mixed-hawthorn (4b) and elder/hawthorn (4c) hedges both have the same affinities i.e. positively with species of nitrogen/phosphorus rich areas, and negatively with species of two vegetation types that are not usually managed intensively viz: acid woodland and acid grassland.

8.3.4 Mixed-hazel hedges (5b) perhaps indicate their woodland origins by a positive association with herbaceous species of both acidic and lowland woodlands, and also by very strong negative associations with species of arable land (N/P rich and arable weeds).

8.3.5 Blackthorn-predominant hedges (6), like hawthorn-dominated hedges, are widely planted and showed no strong associations. However, there was one weak association - their occurrence with arable weeds was less than expected statistically.

8.3.6 Elm hedges (7) were much less abundant than expected in association with species of acid woodland and acid grassland. This must be partly due to the southerly/ lowland distribution of these hedges.

8.4 DISCUSSION OF HEDGE/HEDGE-BOTTOM COMPOSITION

8.4.1 Hedge associations:

(a) Among the different types of hawthorn hedge (WSC 4a-c), the strong dominance of hawthorn in class 4a precludes many other plants and, inevitably, the only strong association is with cluster 1. It is probable that most of these hedges are relatively young and have yet to be invaded by many other species, although there may be some older hedges that have been remote from other seed sources since they were planted. Conversely, most of class 4b (mixed-hawthorn) are probably the older hawthorn hedges that have been invaded over the years by the woodland species of cluster 1 but they may include younger hedges alongside woodlands (see 11.2).
Elder/hawthorn hedges (WSC 4c) are likely to be type 4a hedges that have become dominated by the rapid growth of elder. This could indicate a decline in levels of hedge management because, when hedges are rigorously maintained, elder is regarded as a 'weed' and is usually removed.

b) In contrast, many of the mixed hazel hedges (5b) were originally planted using assorted species from woodlands (Pollard et al., 1974), or planted close to such woodland, hence the association with cluster 1. Because the planting of such hedges is very uncommon nowadays, many of them are probably of ancient origin.

(c) Two-thirds of the blackthorn-predominant hedges (WSC 6) also contain hawthorn (see appendix 1), possibly due to mixed plantings. Consequently they have their dominant species in cluster 2, their sub-dominant in cluster 1 and, therefore, no pronounced association with either.

(d) There were six incidental species commonly associated with elm hedges (WSC 7) - two from cluster 1 and four from cluster 2. An important factor controlling the occurrence of shrubs in this class of hedge will be their ability to compete with the strong growth of the parent elm and its suckers.

(e) Little can be said about the less common types of hedges because the sample sizes are too small to determine the relationships. Mostly these hedges are associated with woody clusters comprising a single dominant and a few incidental species i.e. what you plant is what you get.

8.4.2 Hedge-bottom associations:

It is particularly important with the herbaceous clusters to note that the results deal with the frequency of the associations between vegetation types and hedge-bottoms and do not give any indication of the areas occupied by those association. For example, the N/P rich cluster (3) shows positive and negative relationships with 3 different HGs yet species in this cluster contributed only 1.5% of the total species counts. Nevertheless, these infrequent clusters are valuable indicators in differentiating hedge-bottoms which have several species in common (c.f. appendix 1, table 3).

a. The main feature of Table 3 is that the vegetation associated with each HG can be equated with a gradient of management levels ranging from high in HG1 to low in HG4. The fact that this association with management is so apparent, rather than some other association, suggests that the adjacent land use is affecting the species composition of the hedge bottom in many areas. These results suggest similar relationships to those of the DECORANA analysis (see 7.2.2) viz:

HG 1 is associated with vegetation that is common in intensively arable areas
.. 2 .....areas with arable/grassland rotations
.. 3 .....managed grazings (including hay and silage)
.. 4 .....low-input grazings, marginal ground and woodland

These relationships will be considered later under 'Land Use'.

b. Hedge-bottoms of HGs 3 and 4 are associated with some vegetation types that are commonly perceived to be under threat, such as the various herb-rich grassland clusters and those of woodlands.

c. However, none of the associations between the HGs and the species clusters are strong enough to allow the HGs to be used as the sole means of identifying important herbaceous communities.

8.4.3 It follows from the above discussion that the associations between WSCs and herbaceous species clusters are likely to be affected more by the adjacent land use than by the hedge type. Therefore, few classes of hedge will have a specific type of ground flora. One possible exception is the association between the mixed hazel hedges and the woodland herbaceous plants

8.4.4 It is very important, therefore, that both the woody and herbaceous components of hedgerows are assessed separately.

SECTION 9: DIVERSITY

Diversity can be defined in many ways and by several formalised indices, all of which have advantages and disadvantages. In particular, care has to be taken that the chosen index gives a value which is independent of the sample size. For example, the total number of woody species recorded in each WSC (see descriptions in annex 1) is closely related to the number of plots recorded and therefore is not a good indicator.

The simple indicator of diversity used in this report is the average number of species recorded in each 10 x 1m plot .

9.1 SPECIES DIVERSITY OF HEDGE CLASSES

The results below are concerned with the more common woody hedge types i.e. those represented in more than 10 plots. The sample sizes in other classes were too small for proper statistical analysis.

Table 5: Mean number of species per plot in hedge classes with more than 10 plots.
Figures in parentheses are standard errors.

	Hedge class						
	3	4a	4b	4c	5b	6	7
Woody spp	2.8 (0.3)	2.0 (0.04)	3.6 (0.2)	2.7 (0.2)	4.4 (0.1)	3.2 (0.1)	2.9 (0.2)
Herbaceous spp	15.1 (1.2)	12.8 (0.2)	12.5 (0.7)	12.0 (0.8)	15.3 (0.6)	14.1 (0.4)	11.4 (0.8)
Total	17.9 (1.3)	14.8 (0.2)	16.1 (0.7)	14.8 (0.9)	19.7 (0.6)	17.3 (0.4)	14.3 (0.9)

9.1.1. Diversity of woody species was notably low in class 4a (hawthorn-dominant) and high in classes 4b (mixed-hawthorn) and, especially, 5b (mixed-hazel).
Classes 3 (beech), 5b and 6 (blackthorn) had considerably more herbaceous species than the others. The total diversity was clearly greatest in WSC 5b, with WSC 7 (elm) the poorest, but there is no consistent relationship between the numbers of woody species and the numbers of herbaceous species.

9.1.2 Of the rarer classes, gorse hedges (WSC 8) are possibly species-rich; the eight plots in the sample averaged 18.9 species (mainly herbaceous) per plot.

9.2 SPECIES DIVERSITY OF HEDGE-BOTTOMS (HGs)

The diversity of herbaceous species increases by about 80% in passing from HG1 to HGs 3 and 4 (table 6), and the difference between any two types of hedge-bottom was statistically significant ($p<0.05$), except between HGs 3 and 4. The differences between the woody species values were not as pronounced as in table 5, although still significant, but the woody species contribute comparatively little to the overall diversity.

Table 6: **Mean number of species per plot in hedge-bottoms (HGs)**
Figures in parentheses are standard errors

	HG 1	2	3	4
Herbaceous spp	10.2 (0.2)	14.4 (0.3)	18.2 (0.6)	18.1 (0.6)
Woody spp	2.5 (0.1)	3.0 (0.1)	2.2 (0.1)	3.3 (0.1)
Total	12.7 (0.2)	17.4 (0.3)	20.4 (0.6)	21.4 (0.6)

9.3 SPECIES DIVERSITY IN HEDGE/HEDGE-BOTTOM COMBINATIONS

9.3.1 Tables 5 and 6 suggest that there is little association between the diversity of woody species and herbaceous species within the two classifications separately i.e. plots which are rich in woody species will not necessarily be rich in herbaceous species and *vice versa*. Table 7 examines the possibility of selecting diverse hedgerows by using the two classifications jointly.

9.3.2 Due to the considerable variation within combinations of WSCs/HGs, there are few statistical differences between combinations, except at the extremes of the range (table 7). For example, if we take one of the highest means (26 for WSC 5b / HG 3) and subtract the l.s.d., we find that this combination of classes is statistically no different from any other combination with a mean of 19 species or more i.e. nearly all combinations except those involving HG1.
However, there is a trend, for overall diversity to be greatest when species-rich WSCs are combined with HGs 3 and 4.

Table 7: Mean total number of species per plot in combinations of hedges and hedge-bottoms (excludes WSCs with <10 plots)

	Hedge-bottom (HG)			
Hedge class (WSC)	1	2	3	4
3 - beech dominant	*14* *(3.0)*	*18* *(2.3)*	*21* *(3.0)*	18 (1.9)
4a - hawthorn dominant	12 (0.3)	16 (0.4)	19 (0.6)	21 (0.9)
4b - mixed- hawthorn	13 (0.9)	21 (1.2)	*15* *(3.7)*	*19* *(2.6)*
4c - elder/hawthorn	13 (1.0)	19 (1.7)	*18* *(2.1)*	*no plots*
5b - mixed-hazel	14 (0.8)	19 (0.8)	26 (1.4)	23 (0.7)
6 - blackthorn predom	14 (0.5)	19 (0.6)	24 (1.0)	22 (1.0)
7 - elm predominant	12 (0.9)	16 (1.7)	*27* *(2.6)*	*21* *(3.7)*

Least significant difference (l.s.d) = 7.2

(values in italics are combinations with 6 or fewer plots. Previous comments about small samples apply)

9.4 DISCUSSION OF SPECIES DIVERSITY

9.4.1 These results suggest that the overall species-richness of hedgerows is not determined solely by either the woody component or the herbaceous component, although it is weighted by the latter simply because there are more herbaceous species than woody species. When deciding priorities for maintenance, it is important to consider both communities, not just for the plants themselves but also for the range of wildlife dependent upon them. Furthermore, the numerical diversity of hedges must not be considered in isolation from the types of vegetation they contain. For example, two hedge-bottoms may contain similar numbers of species but one that is representative of, say, an old meadow, established over many years, will be far more difficult to re-create than a hedge-bottom with a large number of invasive weedy species.

9.4.2 The mixed-hawthorn and mixed-hazel hedges were both rich in woody species - 'rich' not just in numbers but also in the wide range of woodland species that are normally present (see 8.1). For herbaceous species, this richness is parallelled by HG4. Care must be taken that these categories are protected as far as possible from

degeneration or loss. In some regions they may be the only remnants of woodlands that were once far more extensive.

9.4.3 Hedge-bottoms in HG3 and 4 both warrant further examination because they probably contain the major examples of species-rich grassland communities and these are generally thought to be declining in extent

SECTION 10: HEDGE MANAGEMENT

Barr *et al.* (1991), used the data from all the mapped boundaries to report to DoE on the management and overall structure of hedges in terms of height and 'gappiness'. Our report deals with the data from the quadrats and due to this difference in the samples used (in fact the latter is a fairly small sample of the former), some estimates in the two reports will not correspond exactly. The sampling difference does not, of course, affect the comparisons made within this report.

10.1 MANAGEMENT AND STRUCTURE

10.1.1 Hedge classes:

(a) Table 8 shows the percentage of plots of each hedge class (WSC) that occured under different types of management, height classes and 'gappiness' scores. Results are given only for those WSCs with at least 15 plots.

(b) Overall, there were no statistically significant differences between WSCs for any of the above parameters and consequently the discussion is limited to trends in the results.

(c) The proportions of hedges that had been cut within the past two years was greatest amongst elder/hawthorn hedges (WSC 4c, table 8a). Certainly elder is a fast-growing species that demands frequent management if it is not going to get out of hand. This was the only class without any laid hedges in the sample.

(d) In contrast the lowest proportion of cutting and the highest proportion of unmanaged hedges was in the mixed-hazel class (5b). Whether this was because the hedges are not maintained adequately or because they need less frequent maintenance than other classes cannot be determined from the data.

(e) There were no pronounced differences between any of the other classes of hedge with regards to management or height.

(f) In contrast, hedges did differ markedly in 'gappiness' (table 8c). Gaps were most frequent in mixed-hawthorn (4b) and mixed-hazel (5b). This may be due to a lack of maintenance or due to the presence of non-thorny species which make it easy for livestock to break through thus creating gaps (unless, of course, the hedges are regularly-laid). The same might be expected amongst the elder/hawthorn hedges (4c) but these had the fewest gaps of all, partly due to the rapid growth rate of elder which readily fills gaps. Also, hedges with a lot of unlaid elder are very easily penetrated and, therefore, many farmers would reinforce them with fencing which would limit the creation of more gaps.

Table 8. Percentage of hedges in each class with various parameters of hedge management.

	% of plots in each hedge class				
	4a	4b	4c	5b	6
(a) Management					
Cut	61	66	75	50	58
Laid	7	6	0	9	10
Unmanaged	32	28	25	41	32
(b) Height					
<1m	3	3	5	4	4
1-2m	55	46	52	56	57
>2m	43	51	43	40	40
(c) Gaps					
None	24	20	47	29	35
<10%	6	3	0	2	10
>10%	59	67	41	62	48
Relict	12	10	12	7	7

(g) In most WSCs, there is no indication that hedges which are managed by cutting and laying are also maintained by 'gapping-up' e.g. 4b and 5b have similar scores for hedges with gaps but different proportions of cut hedges. Elder/hawthorn hedges, which had relatively high proportions of both gap-free and cut hedges, have been discussed above.

(h) There are no consistent relationships between management and the parameters of height and gappines, or the proportions of relict hedges. However, an overall analysis of all hedges together (results not given here) confirmed the conclusion of Barr *et al.* (1991) that unmanaged hedges were predominantly over 2m high.

10.1.2 **Hedge-bottoms:**

There was no statistical relationship between the occurrence of particular types of hedge-bottom and any of the parameters concerning the management of the of the hedge itself.

10.2 EFFECTS OF HEDGE MANAGEMENT ON OVERALL SPECIES DIVERSITY

There were no significant relationships between overall numbers of species per plot and the various parameters of physical structure or management of hedges (appendix 4, table 1); the mean values of 15-17 species per plot were nearly identical in the different categories while the range of values within categories was very wide.

10.3 DISCUSSION OF MANAGEMENT

10.3.1 Generally, the levels of management were similar across all classes of hedge. The greatest structural differences were in the 'gappiness' of hedges but the differences were not statistically significant and were apparently unrelated to the management levels indicated by cutting regimes. The absence of any obvious relationships suggests that other factors, such as land-use, may be of over-riding importance in determining hedge structure. Stock-rearing and the type of stock kept will obviously influence hedge management, as will the presence of fences in complex boundaries.

10.3.2 None of the results showed conclusively that any particular type of hedge was at risk through lack of management.

10.3.3 The floristic diversity of hedgerows is not obviously affected by how the hedge is managed. However, it is important to bear in mind that the assessments of management in the surveys referred to the preceding 2 years for trimming and the preceding 5 years for laying. The response of vegetation to management might not be apparent in such short time-scales and the long-term history of management is probably far more relevant to diversity. Any effects of management on diversity are likely to be subtle and only detectable in controlled experiments, such as those being conducted by ITE Monks Wood.

10.3.4 It is not necessary to have an unbroken hedge for it to be of value to wildlife, either as a habitat or as a corridor between habitats (see Pollard *et al.* for a fuller discussion). However, where livestock are reared and a hedge ceases to be stockproof, a point is reached when it is no longer cost-effective for a farmer to fill the gaps and a fence may be erected to control the stock. There is then little incentive for the farmer to maintain the hedge, except perhaps as a wind break, and so it degenerates into a line of trees or is grubbed up. (A switch from livestock production to arable crops can have similar results). This reduces the value of the hedge to the fauna, especially the close shelter which a hedge affords to some hedge- and ground-nesting birds, and also the protection for animals and birds from raptors. The flora of the hedge-bottom will also change considerably when a hedge degenerates into a line of trees, not only due to the change in the structure of the canopy but also, as often happens, because livestock are allowed to graze around the foot of the trees.

10.3.5 It is important therefore to attack the cause of the problem of declining hedgerows by ensuring that hedges are effective stockproof barriers or, in arable areas, wind-breaks. This can be achieved by 'gapping-up' with suitable species and, where appropriate, laying hedges. It is, of course, essential that there is a subsequent programme of suitable maintenance.

SECTION 11: LAND USE

Section 8.2 examined the relationship between hedgerow classes and different habitats/land uses as indicated by the herbaceous vegetation. In this section, the mapped data are used to determine directly the land use adjacent to the quadrats.

Eight of the ten categories of land use, defined in appendix 5, are examined here:

Amenity ground	Cereal crops
Intensively-managed grassland	Non-cereal crops
Other managed grassland	Trees/shrubs
Unmanaged grass/herb	Road/track

Categories with less than 10 sample plots have been excluded.

11.1 ASSOCIATIONS BETWEEN HEDGEROW CLASSES AND LAND USE

These associations were assessed by testing if the number of plots in any land-use/ hedge class combination was greater or less than expected statistically (table 9). It should be noted that the lack of a figure in any column/row indicates that the number of plots in that combination was as expected; it does not indicate that there was no association at all.

11.1.1 Hedge classes

There are 64 combinations of land-use categories with hedge classes 3 - 7. Only seven of these combinations occured in amounts that were statistically different ($p<0.1$) from expected (Table 9). In fact the relationship between land-use and hedge-type is confounded by geographically determined variations in their distributions and these results show no consistent patterns which would enable us to draw firm conclusions about the effects, if any, of land-use on the type of hedge present. However, it is notable that the two types of cropland are each associated positively with a hedge type that is species-poor (4a and 4c) and negatively with a richer type of hedge (5b and 6).

Table 9: Combinations of hedge types and land-use categories that were present more (+) or less (-) frequently than expected.

(chi^2 analysis. +/- indicates $p < 0.1$, ++/ - - $p < 0.05$)

Land use category	with	Hedge type (class)	Significance
Cereal crops		Elder-hawthorn (4c)	++
		Mixed-hazel (5b)	-
Non-cereal crop		Hawthorn dominant (4a)	++
		Blackthorn predom. (6)	- -
Non-intensive grassland		Blackthorn predom. (6)	+
		Mixed-hawthorn (4b)	- -
Tree/shrub		Blackthorn predom. (6)	- -

11.1.2 Hedge-bottoms

(a) Of the 32 possible combinations of HGs and land-use, sixteen had occurrences that were significantly greater or less than expected statistically (table 10). Land-uses have been arranged in order of management intensity and superscripts show the significance of associations. Figures without superscripts were not significantly different from expected values. Land-uses have been excluded if there were no significant differences at all between the types of hedge-bottom.

Table 10: **The percentage of plots of each HG that were adjacent to different land uses.** Superscripts indicate frequencies that were more (+) or less (-) than expected (chi^2 analysis. +/- indicates $p < 0.1$, ++/-- $p < 0.05$)

	Hedge-bottom (HG)			
Land-use	1	2	3	4
Cereals	50^{++}	17^{--}	3.0^{--}	4.3^{-}
Non-cereal crops	16^{++}	3.6^{--}	0.0^{--}	2.1^{--}
Intensively managed grass	9.1^{--}	14	27^{++}	18
Other managed grassland	11^{--}	50^{++}	54^{++}	46^{++}
Road/track	6.0	7.6	6.9	14^{++}
Unmanaged grassland	2.7	0.5^{--}	4.0	5.3

(b) Ten of the 16 significant results involved croplands and/or HG1 thus emphasising the arable associations of this type of hedge-bottom.

(c) The hedge-bottoms of group 2 were much less frequent than expected when in association with the most intensive and least intensive types of land use (croplands and unmanaged grass respectively). The only positive association was with the moderately-managed ('other') grasslands.

(d) The association between HG3 and different land-uses showed a similar, but more pronounced, relationship to management levels as HG2. The occurrence of HG3 plots was less than expected only amongst croplands and exceeded expected values amongst both types of managed grasslands

(e) The frequency of HG4 was greater than expected alongside the lightly managed land-uses 'other managed grassland' and 'road/tracksides'. One of the noticeable absences from table 10 is any significant association between HG4 and the land-use of 'trees/shrubs'. In fact, there was a strong association with woodlands but the sample size is too small for the result to be statistically conclusive.

(f) There is a strong diagonal gradient across table 10, showing that the intensity of land management adjacent to the hedgerow decreases from group 1 to 4. This pattern has been seen previously in the associations between types of herbaceous vegetation and different hedge-bottom groups (Table 3).

11.2 RELATIONSHIP BETWEEN LAND USE AND DIVERSITY

11.2.1 The species-richness of hedgerows in different land-uses is shown below (table 11) arranged from high to low total diversity:

Table 11: Number of plots (n), and diversity (mean number of species per plot) of herbaceous and woody species in hedgerows adjacent to different land use categories.

Land use	n	Mean no. of species per plot		
		Woody	Herbaceous	Total
Intensively-managed grass	116	2.7	15.8	18.6
Other managed grass	259	2.9	15.0	17.9
Road/track	64	2.8	14.0	16.8
Tree/shrub	28	3.9	12.5	16.5
Unmanaged grass	22	2.2	12.3	14.5
Amenity ground	16	3.2	11.2	14.4
Cereal crops	267	2.5	11.8	14.2
Non-cereal crops	81	2.3	10.5	12.8
(least significant difference p<0.1		1.0	3.8	3.9)

11.2.2 There was a large range in the diversity of woody species with a maximum value (3.9 for hedges alongside 'tree/shrub') that is 77% greater than the minimum (2.2 for hedges adjacent to unmanaged grassland). The value for hedges adjacent to trees/shrubs was significantly ($p<0.1$) greater than any in any other land-use except amenity ground. Conversely, hedges alongside unmanaged grassland or either type of cropland were significantly poorer ($p<0.1$) in woody species than elsewhere. None of the differences between other pairs of land uses are statisitically significant.

11.2.3 The pattern of herbaceous species diversity across land uses differed from that of the woody species and had a proportionally smaller range, the maximum being about 50% more than the minimum. The richest hedge-bottoms were adjacent to the two types of managed grassland and the poorest were alongside non-cereal crops. However, most of the differences are not statistically significant due to the considerable intrinsic variability.

11.2.4 The 'total' diversity parallels that of the herbaceous species. Although an analysis of variance over all land-uses is highly significant ($p < 0.001$), the few significant differences in pairs of land-uses are confined to those at opposite ends of the range.

11.3 DISCUSSION OF LAND USE.

11.3.1 Species diversity in hedges:

a. Due to the 'snapshot' nature of surveys, the effects of land-use on diversity can only be inferred; direct cause/effect relationships cannot be determined. This is particularly so with the woody species and there are many possible explanations for each of the associations shown in table 9. For example, hedges with few woody species are more prevalent amongst croplands than one would expect statistically but this could be because only monotypic hedges are planted there or perhaps the hedges are younger there than elsewhere and have not yet been invaded by other species.

b. The lack of any consistent patterns in table 9 reinforces earlier comments that hedges are a long-lived feature and their woody species composition is unlikely to be related to factors which fluctuate on a relatively short time scale e.g. some land-uses. Furthermore, agricultural practices are usually concentrated on the ground vegetation and it is only accidents such as spray drift which are likely to affect the diversity of woody species in a hedge (we have already shown that the hedge class is not strongly related to hedge management *per se*). However tillage, grazing, and spraying into the hedge-bottom can kill off young tree seedlings which might otherwise be recruited into the hedge, either as new species or as regeneration of existing species. This would partly account for the hedges in croplands being poor in woody species and it can be ameliorated by leaving wider headlands.

c. Many plants, particularly weeds, form large stores of dormant seeds in the soil ('seed banks') which can survive for many years and only germinate when the ground is disturbed. These reserves are an important source of regeneration. Tree species generally do not have large seed banks. Therefore some hedges, especially in arable areas, may depend on an input of seeds from other sources for regeneration/ recruitment (hence the richness of hedges adjacent to trees/shrubs).

d. It is not possible to quantify the effects of all the above factors on the diversity of species in hedges but it is important to be aware of them when, for example, ageing hedges by species counts: a hedge with, say, 3 woody species in a long-established arable area may actually be older than a hedge containing 4 species that is next to a woodland.

e. Table 9 gives some indication of the more common hedge types that are under-represented within land-use categories. Any exisiting hedges in such hedge/land-use combinations are potential targets for conservation if the current overall diversity is to be sustained.

11.3.2 Species diversity in hedge-bottoms:

a. Compared with the woody species, more substantial inferences can be drawn about the effects of land-use on herbaceous species because a direct comparison can be drawn between the vegetation in the hedge-bottom and that of the adjacent land. Comparing the results of section 8.2 with those above shows that the species associations in most hedge-bottoms resembled those of the adjacent land-use rather than the woodland-type vegetation expected of an 'unaffected' hedgerow.

b. The land-use adjacent to hedges is a major factor controlling the vegetation in hedge-bottoms and it can be effectively altered by introducing wide headlands which can then be subjected to different management regimes from the remainder of the land. This practice would be particularly valuable in croplands where hedge-bottoms have a markedly poor flora.

c. Very intensive land management and no management at all are both deleterious to the number of herbaceous species in hedge-bottoms. Hence increasing the headlands in arable situations may have only a small effect on the number of species present unless the headland is managed by cutting or grazing.

d. When deciding on management of the hedge-bottoms, it is important to consider also the types of species to be conserved - for example, the fairly high levels of grazing/cutting that would be needed to maintain a community of pasture species would be deleterious to a woodland-type community. The adverse effects of high levels of fertilizer should not be overlooked; they can promote the growth of many 'weed' species which will then out-compete the semi-natural vegetation types characteristic of some hedgerows.

e. Clearly the woodland-type species in HG4 are predominantly associated with land uses that have low levels of management and which tend to be undisturbed over relatively long periods. The likelihood of road/tracksides being refuges is noteworthy.

SECTION 12: CHANGES IN HEDGEROWS BETWEEN 1978 AND 1990

Two hundred and fifty nine of the plots sampled in 1978 were reliably located again in 1990 (referred to as 'paired plots') and these are used to assess the changes in hedgerows in the intervening 12 years.

12.1 'LOSS ' OF HEDGES

Sixty-three of the paired plots no longer had a hedge *per se* present and, therefore, the floristic recordings were not repeated. In eight cases, the last hedge in the whole 1km square had been 'lost'. The reasons for hedge loss were:

a. the hedge had been removed (or, perhaps, died in the case of short-lived species such as Western gorse).
b. the hedge had been so neglected that it had become a row of trees and thus no longer a hedge as defined.
c. the ground had been built upon, or the hedge had become part of the curtilage of a building, thus effectively removing it from the countryside environment.
d. the hedge had been replaced by a wall.

The fate of the 'lost' plots is summarised in Table 12. Again, care has to be taken when interpreting the results, particularly when sample sizes are small. Even amongst the commoner types it would be unwise to apply these results country-wide because there may be quite large geographical variations.

12.1.1 The only classes with enough samples to make reasonable comparisons were WSCs 4a, 5b and 6 (table 12a) and overall losses from these were almost identical at 21-23%. Due partly to the wide range of sample sizes, there were no statistically significant differences between the proportions of plots lost, or the causes of loss, from the different classes.

12.1.2 Altogether, 24% of the hedges sampled in 1978 had been 'lost' by 1990. This compares with a 25% loss of hedge length for the same period calculated from the results of Barr et al. in their report to the DoE (1991). The overall loss due to removal was 19% (c.f 14% calculated from Barr *et al.*).

12.1.3 The main feature amongst the hedge-bottoms was that the losses from the two types associated with high levels of land management (HGs1 and 2) were less than for the other two types (table 12b). The greatest difference was between HG2 and HG3 which lost 20% and 31% of plots respectively.

12.1.4 The losses of plots from the different land types (table 12c) show a similar relationship to management levels as was seen for the hedge-bottoms. Losses were greatest amongst the lowland grasslands (c.f. HG 3).

Table 12: Number and fate of hedges adjacent to plots sampled in 1978 but not in 1990.

G = hedge gone T = hedge became row of trees B = became built ground/curtilage
W = replaced by wall

(a) By hedge class (WSC)

WSC	No. of plots in 1978	% plots lost due to G	T	B	W	total no. lost	% lost overall
1	1	100	-	-	-	1	100
2	2	-	-	-	-	0	0
3	3	-	33	-	-	1	33
4a	128	16	2	3	-	27	21
4b	13	31	-	-	-	4	31
4c	10	10	10	-	-	2	20
5a	0	-	-	-	-	-	-
5b	46	15	4	2	2	11	23
6	39	15	3	3	-	8	21
7	11	27	-	-	-	3	27
8	6	83	-	-	-	5	83

(b) By hedge-bottom group (HG)

HG	No. of plots in 1978	% plots lost due to G	T	B	W	total no. lost	% lost overall
1	80	20	1	3	-	19	24
2	90	18	1	-	1	18	20
3	45	23	4	4	-	14	31
4	44	14	9	4	-	12	27

(c) By dominant land type

	No. of plots in 1978	% plots lost due to G	T	B	W	total no. lost	% lost overall
Cropped land	135	19	1	1	-	28	21
Lowland grass	100	20	4	3	1	28	28
Marginal upland	24	8	8	4	-	5	20
OVERALL	259	19	3	2	<1	62	24

12.2 CHANGES OF HEDGEROWS TO DIFFERENT CLASSES

After losses had been discounted, the only hedge classes with more than 15 paired plots were 4a, 5b and 6; changes in WSCs will focus mainly on those hedge types. Sample sizes are not a problem with the hedge-bottoms due to the smaller number of categories. It should be noted that, to avoid bias, surveyors in 1990 were not given information on the type of hedge recorded in 1978. Therefore they were unable to record whether a hedge had changed *in situ* or had been replaced/replanted with another hedge-type. Although the latter was probably very rare, such cases cannot be determined from the data.

12.2.1 Changes in hedges:

The WSC of many hedges changed between 1978 and 1990 (Table 13a). The proportion of plots that remained the same in each class can be seen along the top left to bottom right diagonal of the table. The most stable of the common types was the hawthorn-dominant (4a) at 75%, followed by mixed-hazel (5b) at 63% then blackthorn-predominant hedges (6) with 48%. An examination of the key to classifying the hedges (appendix 1, fig 1) indicates the sort of changes in composition required for a shift in class. For example, the balance between hawthorn and elder is important in changes from 4a to either 4b or 4c, whereas changes from 4a to groups numbered 5 and above would depend on hawthorn or elder being reduced/lost plus invasion by, for example, field maple or roses. Similar exercises would show the range of possibilities that could cause changes of class for hedges in 5b and 6 which are determined by a complex balance between hazel, blackthorn and hawthorn along with incidental species such as field maple.

Amongst the rarer hedges with only a small number of paired plots (table 13b), mixed-hawthorn (4b) is apparently a very 'fluid' class with only 22% classified the same in both years (table 13a); these hedges can change class when one or more species are lost, or when the cover of elder decreases. In contrast, elm hedges are probably amongst the more stable types of hedges with 63% remaining the same.

Despite the changes shown in table 13, the overall balance between the classes is almost identical in 1978 and in 1990, as shown by the marginal percentages for each class (table 13a).

Table 13:

a. Percentage of paired plots whose hedge class changed between 1978 and 1990.

WSC in 1978	Hedge class (WSC) in 1990												
	1	2	3	4a	4b	4c	5a	5b	6	7	8	'Lost'	1978 overall
1	-	-	-	-	-	-	-	-	-	-	-	100	<1
2	-	-	-	50	-	-	-	-	-	50	-	0	<1
3	-	-	**50**	50	-	-	-	-	-	-	-	33	1
4a	-	-	2	**75**	9	2	1	2	9	-	-	22	49
4b	11	-	-	22	**11**	22	-	-	22	11	-	31	5
4c	-	-	13	37	-	-	25	13	13	-	-	20	4
5a	-	-	-	-	-	-	-	-	-	-	-	0	0
5b	-	-	-	14	3	6	-	**63**	9	6	-	24	18
6	-	-	-	32	-	6	-	10	**48**	3	-	21	15
7	-	-	-	-	13	-	-	-	25	**63**	-	27	4
8	100	-	-	-	-	-	-	-	-	-	-	83	2
1990 overall	1	-	2	49	6	4	2	14	16	5	-	32	

b. Number of paired plots whose hedge class changed between 1978 and 1990.

WSC in 1978	Hedge class (WSC) in 1990												
	1	2	3	4a	4b	4c	5a	5b	6	7	8	'Lost'	1978 overall
1	-	-	-	-	-	-	-	-	-	-	-	1	1
2	-	-	-	1	-	-	-	-	-	1	-	0	2
3	-	-	**1**	1	-	-	-	-	-	-	-	1	3
4a	-	-	2	**75**	9	2	1	2	9	-	-	28	128
4b	1	-	-	2	**1**	2	-	-	2	1	-	4	13
4c	-	-	1	3	-	-	2	1	1	-	-	2	10
5a	-	-	-	-	-	-	-	-	-	-	-	0	0
5b	-	-	-	5	1	2	-	**22**	3	2	-	11	46
6	-	-	-	10	-	2	-	3	**15**	1	-	8	39
7	-	-	-	-	1	-	-	-	2	**5**	-	3	11
8	1	-	-	-	-	-	-	-	-	-	-	5	6
1990 overall	2	-	4	97	12	8	3	28	32	10	-	63	259

12.2.2 Changes in hedge-bottoms:

(a) As in the hedges, there was also considerable 'fluxing' between the different types of hedge-bottom (table 14). The most stable were HGs 1 and 4 i.e. at the extremes of the range of management levels. The greatest shift was of 57% of plots from HG2 to HG1.

(b) The important feature of this table is the predominant change in class of plots from higher HGs to lower HGs i.e. in the direction of increasing management or 'arablisation'. This is further emphasised by the marginal totals showing a 20% increase in the number of plots in HG 1 (this contrasts sharply with the hedges where the overall balance of plots was unchanged).

Table 14: Percentage of paired plots whose hedge-bottom classification change between 1978 and 1990.

Figures in parentheses are numbers of plots.
Marginal totals are based on the number of plots in that year.
'Lost' = percentage of plots from 1978 where no hedge present in 1990.

		HG in 1990					
		1	2	3	4	"lost"	Overall '78
HG in '78	1	**84** (51)	15 (9)	0 0	1 (1)	24 (19)	31 (80)
	2	57 (41)	**29** (21)	7 (5)	7 (5)	20 (18)	35 (90)
	3	23 (7)	35 (11)	**26** (8)	16 (5)	31 (14)	17 (45)
	4	3 (1)	16 (5)	23 (7)	**61** (19)	27 (12)	17 (44)
Overall '90		51 (100)	24 (46)	10 (20)	15 (30)	n.a. (63)	100 (259)

(c) The only significant change 'upwards' was 16% of HG3 plots that changed to HG4 suggesting that some grasslands are either less intensively managed than before or that some grazing levels have been greatly reduced. This situation could result from a change in land use or, for example, where a fence has been erected nearby.

12.3 CHANGES BY SPECIES CLUSTERS

12.3.1 Percent cover:

(a) There were increases and decreases in the average cover of different clusters for both woody and herbaceous species (figs 3a & b. Note different scales).

(b) The only statistically significant change amongst woody clusters was an increase in the maple/sycamore cluster (1a) and a decrease in the gorse cluster (7). The 10% decrease in the wych elm association (cluster 3), though not significant, may be the result of Dutch elm disease. In contrast, the English elm cluster (8) increased by about 5% which could be due to recovery via its abundant suckers.

(c) Three of the changes in herbaceous clusters were statistically significant: (i) there was an increase in the cover of species in cluster 5 ('abandoned/derelict'), such as would occur with removal of grazing, or an increase in the size of headlands in arable areas; (ii) the cover of cluster 6 (lowland woodland) also increased, reflecting the changes from HG3 to HG4 seen previously in 12.2.2; (iii) the decrease in cover of species from cluster 1b (short-term grasslands) is consistent with an increase in arable land as indicated by the changes from HG2 to HG1.

12.3.2 Number of species per plot:

(a) There was a very obvious decrease in species diversity of nearly all the woody and herbaceous clusters (figs 4a and b. Note the difference in scales). The decrease was statistically significant in 6 of the 11 herbaceous clusters and 4 of the 11 woody clusters.

(b) Neither of the increases was significant. It is interesting to note that the species diversity of the 'lowland woodland' cluster declined but the cover went up i.e. there were fewer species covering more ground.

12.4 CHANGES IN INDIVIDUAL SPECIES

Out of more than 450 species recorded, the percentage cover of thirty-three species changed significantly between 1978 and 1990 (table 15); exactly two-thirds of these were decreases.

12.4.1 Woody species:

Sycamore, which is very invasive, was the only woody species to increase in cover (by 10%). Dogwood and gorse, both relatively uncommon, decreased by 10% and 21% respectively whereas the loss of over 5% cover of hazel is quite important in absolute terms because it is widespread. Wych elm was the only large tree species to decrease significantly, by nearly 5%, thus reflecting the change in this species cluster (see also 12.3.1).

Fig. 3. **Changes in Percentage Cover of Species Clusters 1978-1990.**

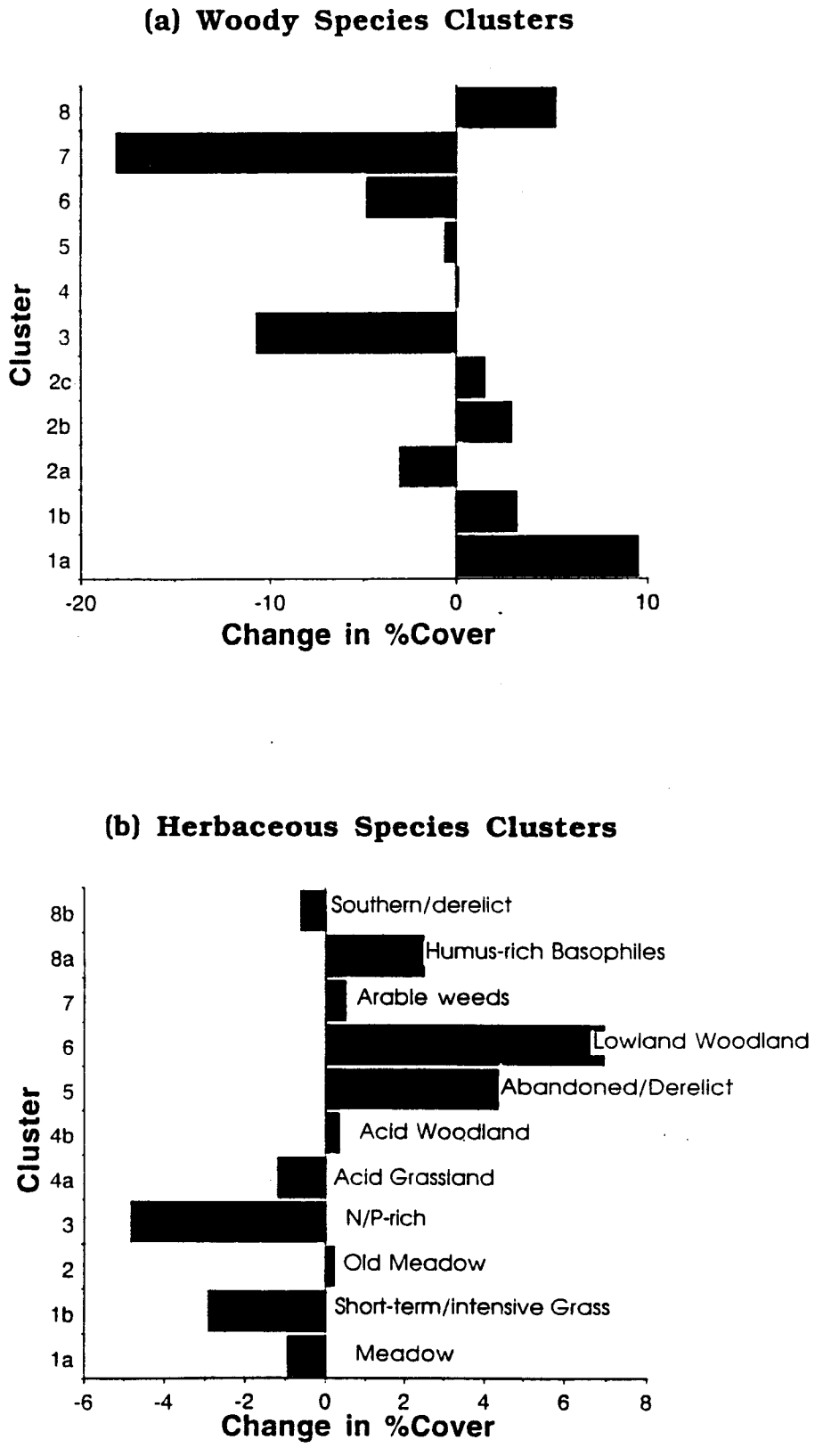
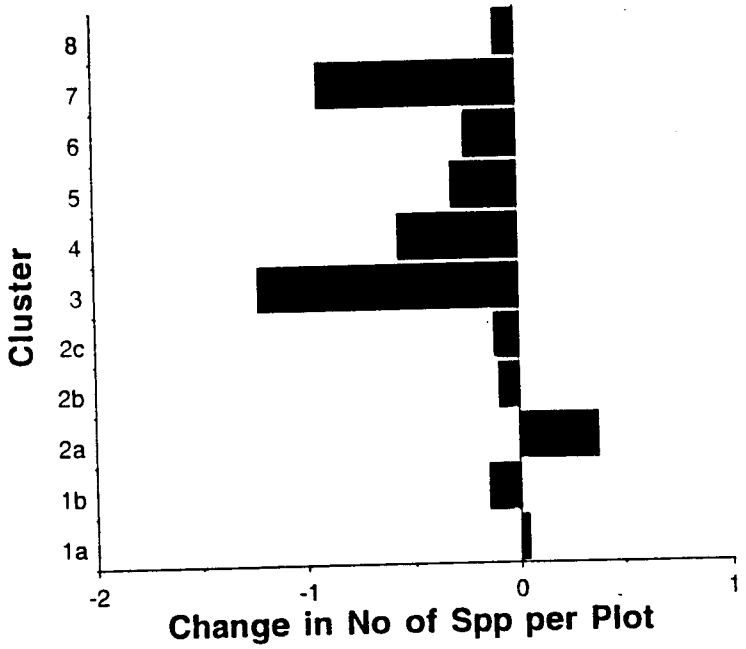
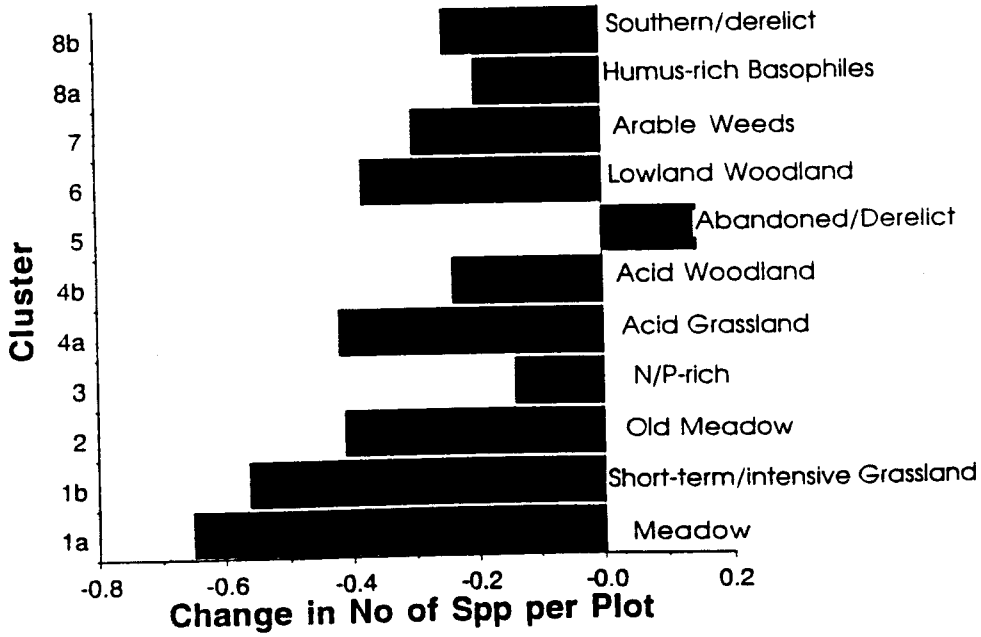


Fig 4. **Changes in Number of Species per Plot, within Species Clusters, 1978-1990.**

(a) Woody Species Clusters



(b) Herbaceous Species Clusters



12.4.2 Herbaceous species:

The large increase in the cover of ivy and the lesser increases in dog's-mercury and bramble suggests that hedge management has declined in some places, resulting in increased shading of the hedge-bottom. Most of the other species which increased are aggressive/invasive species. In contrast, the species which have decreased in cover come from a wide range of habitats and there is no obvious common reason for their decline.

Table 15. Species whose overall cover changed significantly between 1978 and 1990 in paired plots.

n = No. of plots. m.d. = Mean Difference between %cover in 1978 and 1990. s.e. = Standard Error of mean difference. sig = significance: * $p < 0.1$ ** $p < 0.01$ *** $p < 0.001$

SPECIES INCREASING	n	m.d.	s.e.	sig
Acer pseudoplatanus	29	10.3	4.6	*
Agrostis stolonifera	91	2.7	0.98	**
Bromus sterilis	60	4.1	2.0	*
Convolvulus arvensis	41	1.4	0.66	*
Festuca rubra	70	2.6	1.2	*
Galium aparine	172	5.0	1.1	***
Hedera helix	108	10.5	2.4	***
Mercurialis perennis	19	3.1	1.8	*
Rubus fruticosus agg.	179	4.1	1.6	*
Sonchus oleraceus	12	0.5	0.26	*
Trifolium repens	24	1.6	0.72	*

SPECIES DECREASING	n	m.d.	s.e.	sig
Achillea millefolium	31	-1.1	0.45	*
Agrostis gigantea	10	-0.8	0.2	**
Arrhenatherum elatius	166	-3.3	1.68	*
Arum maculatum	27	-2.0	0.75	*
Campanula rotundifolia	7	-0.6	0.20	*
Cardamine hirs/flex	5	-0.6	0.24	*
Cerastium fontanum	38	-0.4	0.13	**
Cirsium vulgare	50	-0.7	0.14	***
Cornus sanguineus	10	-10.1	3.8	*
Corylus avellana	46	-5.5	2.9	*
Epilobium montanum	21	-1.0	0.52	*
Filipendula ulmaria	15	-1.4	0.46	**
Holcus lanatus	117	-3.7	1.4	**
Plantago lanceolata	19	-0.4	0.19	*
Poa trivialis/nemoralis	107	-5.3	1.1	***
Potentilla erecta	10	-0.5	0.22	*
Silene dioica	38	-1.8	0.93	*
Stellaria media	69	-0.5	0.16	**
Taraxacum agg.	60	-0.2	0.14	*
Ulex europaeus	10	-21.2	8.5	*
Ulmus glabra	18	-4.9	2.5	*
Vicia sepium	19	-0.4	0.21	*

Total: 1 woody species
10 herbaceous species

Total: 4 woody species
18 herbaceous species

12.5 DISCUSSION OF CHANGES IN HEDGEROWS.

12.5.1 The overriding feature of the above results is not only that hedges have been lost but also that there has been a general decrease in the number of both woody and herbaceous species per plot.

12.5.2 The results do not pinpoint any common type of hedge that was particularly susceptible to loss. Of the rarer types, gorse hedges appear to be vulnerable.

12.5.3 It is not possible from the available data to determine if the change of a hedge from one class to another is the result of management or due to 'natural' vegetation successions; this could only be established by a far more intensive survey using balanced sample sizes.

12.5.4 Hedge management will vary with locality, type of hedge and adjacent land use; sometimes non-thorny and rosaceous species will be cut out of a hedge when trimming or laying, other times they will be left in. These variations obviously have a profound effect on classification and could be a major factor in the apparent instability of the mixed-hawthorn hedges, particularly in stock-rearing areas.

12.5.5 Between 1978 and 1990, the loss of hedges from particular WSCs was balanced by gains to those classes. Thus the national proportions of the different hedge types were unaltered. Unless there are mitigating local factors which threaten a particular type of hedge, there is no reason to target any particular types of hedge solely on the grounds of susceptibility to change.

12.5.6 The vegetation of the hedge-bottom is strongly influenced by the adjacent land use (see section 10). Consequently, many of the changes in herbaceous groups will be associated with changes in land use or, alternatively, in the intensity of managing existing land uses (for example applying heavy amounts of fertilizer to mixed grasslands in order to promote the cover of species such as *Lolium*, thereby reducing the need to reseed). Ameliorating the effects of land use has been discussed in section 10.

SECTION 13: REGIONAL DISTRIBUTION OF HEDGES.

The DoE administrative regions (fig 5) were selected for their relevance to the Countryside Commission in implementing Incentive Schemes (see Introduction).

It is important to note that the following results are extrapolations from the proportions of plots of each hedge class that were in different ITE land classes. Some of the rarer types of hedge may have a geographically localised distribution within a particular land class and so would not necessarily be present in all the regions containing that land class. Therefore, low values in the following tables should be treated with caution, especially the classes with small sample sizes i.e. 1, 2, 5a and 8.

13.1 **The regional abundance** of the different types of hedge is shown below:

Table 16. Estimated lengths (km x 1000) of hedges in regions

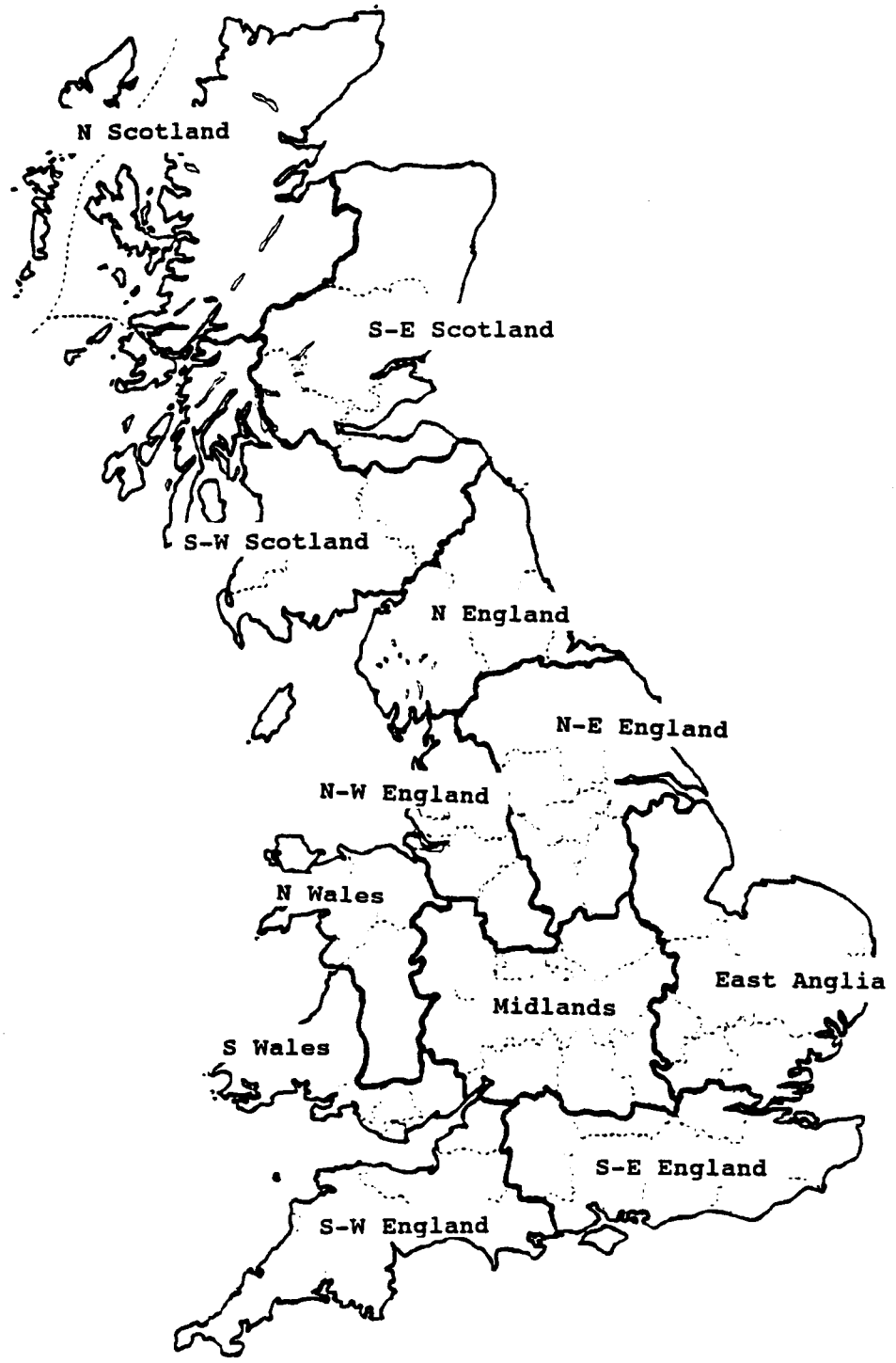
	Hedge Class										
Region	1	2	3	4a	4b	4c	5a	5b	6	7	8
S-W England	0.9	0.2	2.0	11.4	1.5	1.6	1.2	16.0	22.4	4.2	*
S-E England	0.6	0.2	0.3	17.0	1.7	2.5	0.2	5.9	18.1	3.4	*
East Anglia	0.5	0.1	0.4	29.0	4.2	3.1	0.2	4.1	19.9	4.7	*
Midlands	0.9	0.3	1.2	34.2	4.3	3.0	0.3	7.3	18.6	4.0	*
S Wales	0.2	*	0.7	5.8	0.8	0.3	0.4	7.2	8.1	1.1	*
N Wales	0.1	*	0.9	10.5	0.9	0.2	0.1	6.9	5.5	0.3	0.1
N-W England	0.1	*	0.1	15.9	1.8	0.7	0.1	3.7	4.1	0.1	0.3
N-E England	0.6	*	0.5	29.4	3.8	1.9	0.1	6.3	7.9	0.8	*
N England	0.2	*	0.5	19.5	2.2	1.0	0.1	4.5	5.3	0.4	0.1
S-W Scotland	*	*	0.3	12.7	0.8	0.3	0.1	2.2	2.7	0.1	0.2
S-E Scotland	*	*	0.5	8.3	0.4	0.1	0.1	0.1	1.1	0.1	*
N Scotland	a	a	0.2	2.5	0.1	0.1	*	0.4	0.3	*	a
TOTAL	4.1+	0.8+	7.6	196.2	22.5	14.8	2.9+	65.0	114.0	19.2+	0.7+

Note: * indicates estimated length <50km.
'a' indicates absent.

13.1.1. Clearly, some regions have much more hedgerow than others: S-W England (61400 km), East Anglia (66200 km), and the Midlands (74100 km) all have especially high lengths of hedge, while there are very few hedges in Scotland (see also table 17).

13.1.2 The commonest hedges were hawthorn-dominant (4a) totalling 196 200km i.e. 43% of all hedges. This type of hedge exceeded 10 000km in nine of the twelve regions with the greatest lengths in the Midlands, NE England and East Anglia. Blackthorn-predominant hedges were the next most common type (114 000km =25% of all hedges) and had a markedly southern distribution.

Fig. 5. **DoE Regions used for estimating regional hedge lengths.** (see Tables 16-18).



13.1.3 Of the two types that are rich in woody species, mixed-hazel hedges (5b) (65 000km = 14% of all hedges) are particularly common in SW England whereas mixed hawthorn hedges (4b) (22 500km = 5% of all hedges) have their greatest lengths in East Anglia, the Midlands and North-east England.

13.1.4 Of the rarer hedge types, the wild privet (2) and the elm (7) hedges also show a southerly concentration. The length of beech hedges (3) is notably high in South-west England whereas gorse (8) is the only type of hedge that has a northern focus.

13.2 The relative abundance of hedge classes within regions and throughout the UK is given in Table 17. It should be noted that using this parameter tends to mask the occurrence of some rarer classes which are more apparent in table 16. An asterisk indicates <1%, and, again, all very low values must be treated with caution.

Table 17. Percent of hedges in each region that are in each hedge class.

	HedgeClass										
Region	1	2	3	4a	4b	4c	5a	5b	6	7	8
S-W England	1	*	3	19	3	3	2	26	37	7	*
S-E England	1	*	1	34	3	5	*	11	36	7	*
East Anglia	1	*	1	44	6	5	*	6	30	7	*
Midlands	1	*	2	46	6	4	*	10	25	5	*
S Wales	1	*	3	23	3	1	2	29	33	5	*
N Wales	1	*	3	41	4	1	*	27	22	1	*
N-W England	*	*	*	59	7	3	*	14	15	1	1
N-E England	1	*	1	57	7	4	*	12	15	2	*
N England	1	*	1	58	6	3	*	13	16	1	*
S-W Scotland	*	*	2	66	4	1	*	11	14	1	1
S-E Scotland	*	*	4	78	4	1	1	1	10	1	*
N Scotland	a	a	6	69	2	4	*	11	8	*	a
All UK	1	*	2	44	5	3	1	14	25	4	*

13.2.1 Through England and Scotland, there is a marked contrast between the two most commonly planted hedge species: the proportion of hawthorn-dominant hedges (4a) increases steadily towards the north while blackthorn hedges (6) increase towards the south and and are the commonest hedge type in S Wales and the SW and SE England regions.

13.2.2 Mixed-hazel hedges (5b) are in particularly high proportions in SW England and Wales and contrastingly low proportions in East Anglia and SE Scotland.

13.2.3 Apart from classes 4a, 5b and 6, no types of hedge would be expected to exceed 10% of the total hedge length in any region unless there are localised concentrations.

13.3 The national distribution of each hedge class (table 18) must also be considered when deciding priorities for hedgerow conservation. Hedges which are locally abundant may be rare elsewhere and their national importance must not be overlooked by taking a parochial view.

Table 18. Percent of hedges in each hedge class that are in each region.

	Hedge Class											
Region	1	2	3	4a	4b	4c	5a	5b	6	7	8	ALL
S-W England	21	23	26	6	7	11	42	25	20	22	3	14
S-E England	15	24	4	9	7	17	6	9	18	18	4	11
East Anglia	12	9	5	15	19	21	6	6	17	25	3	15
Midlands	22	30	16	17	19	20	11	11	16	21	2	17
S Wales	5	5	9	3	4	2	14	11	7	6	2	6
N Wales	3	2	11	5	4	2	4	11	5	1	8	6
N-W England	3	2	2	8	8	5	3	6	4	1	38	6
N-E England	15	1	7	15	17	13	4	10	7	4	3	11
N England	5	2	6	10	10	7	4	7	5	2	16	8
S-W Scotland	*	2	4	6	3	2	3	3	2	1	21	4
S-E Scotland	*	*	6	4	2	1	3	*	1	*	*	2
N Scotland	a	a	3	1	*	1	*	1	*	*	a	1

13.3.1. Some regions have amounts of hedge types that are clearly important in a national context, for example SW and SE England and the Midlands have 77% of all the rare wild privet hedges (class 2). Similarly SW England has a quarter of the UK populations of both beech hedges (3) and hazel hedges (5b).

13.3.2 Species-rich hawthorn hedges (4b) are most common from central England eastwards and northwards, whereas the elder/hawthorn hedges (4c) also show an eastern concentration but become relatively more frequent towards the south. The southerly distribution of blackthorn (6) and elm (7) hedges has already been commented on, as has the northerly distribution of gorse hedges, over 75% of which are in northern England and Scotland.

13.4 DISCUSSION OF HEDGEROW DISTRIBUTION

13.4.1 The main features of hedgerow distribution have been given in the results above and the importance of considering the national, as well as the local, context has been stressed.

13.4.2 Certainly efforts should be made to ensure that the current diversity of hedge types within a region is sustained (c.f. table 17) and, in so doing, ensure that nationally rare types of hedge are given priority (c.f. table 18). Obviously this does not apply to recently planted hedges of 'exotic' species which, even though they may be rare, could be readily replaced if lost.

13.4.3 There are so many possible combinations of hedge type/regional importance/ national importance that firm criteria are needed before priority rankings can be determined from the above tables. However, the tables can be used for guidance when assessing the relative importance of different hedges in a region.

13.4.4 Table 16 indicates which regions are likely to produce the most grant applications for each of the different hedge types, *presuming that the numbers of applications are proportional to hedge lengths.* This information can be used for initial predictions of regional demands on the Incentive Scheme resources. However, the sources of applications should be monitored so that firmer predictions can be made in the future.

SECTION 14: APPLICATION OF RESULTS TO INCENTIVE SCHEME

The principal results and conclusions are given in the executive summary and discussed in the relevant sections. Here, the focus is on how administrators and fieldworkers can use the results to target and identify hedgerows.

14.1 KEYS TO HEDGEROWS:

14.1.1 All the results are based on hedgerows *as classified by the keys* (appendix 1). 'Common' names of hedge-types have been used in this report for brevity; they should not be used as a casual substitute for actually keying out hedges.

RECOMMENDATION: *It is important that objective keys are used to identify hedgerows thus ensuring compatability of assessments made in different regions by different people.*

14.1.2 *Ad hoc* tests of the hedge key showed that it is quick and easy to use and produced satisfactory results (an example is given in appendix 1, fig 3) but the hedge-bottom key has yet to be tested in the field.

RECOMMENDATION: Both keys should be tested more widely to determine their suitability for extensive field use. Such tests should include the establishment of a methodology for field procedures.

14.2 ASSESSING HEDGEROWS

14.2.1 **Ecological:** After classifying a hedge and its hedge-bottom, the following sorts of questions should be asked:

a. Is it a hedge of readily replaced exotic species? [very low priority type]
b. Is the hedge uncommon nationally? [see table 18]
c. ..... locally? [see table 17]
d. Is it a species-rich hedge type i.e. WSC 4b or 5b? [see WSC key]
e. Is the hedge-bottom a species-rich type i.e. HG3 or 4? [see HG key]
f. What is the likely effect of adjacent land-use, both now and in the foreseeable future, on species diversity [see table 11]?
g. Can potentially deleterious effects be minimised? [see table 14]

This list is not exclusive - it covers only some those questions whose answers are to be found in this report. Other questions e.g. the linking of isolated habitats should also be addressed.

RECOMMENDATION: A list of questions, or a decision tree, should be drawn up which will help to establish the ecological importance of a hedgerow; the relevant tables should be made available to assessors. [Note: the results on the distributions of hedges are available on the Countryside Information System being developed for DoE; this will facilitate the determinations of hedge lengths etc. in areas defined differently to those used here].

14.2.2 **Historical, landscape, amenity aspects:** It is outside the scope of this report to comment on these directly. How these aspects are weighted, compared to ecological considerations, will be for the executive agencies to decide. However, selecting hedges which are rich in woody species could be a useful surrogate for archival information when selecting ancient hedges, especially as archives may not be readily available to grant applicants.

RECOMMENDATIONS: (a) Agencies concerned with the Improvement Scheme should establish well-defined criteria about which hedges they consider to be important. Agreed weightings of importance for these different aspects of hedgerows should then be included in 'decision trees' used for targetting hedges.

(b) Further work should be enabled to determine the regional relationships between the ages of hedges and the numbers of woody species present.

14.3 DISTRIBUTION OF APPLICATIONS

In the absence of any other quantitative information, the executive agencies can use the lengths of targetted hedge-types (table 16) to forecast the relative uptake of the Incentive Scheme from different regions and to guide their resource planning. These forecasts will necessarily presume that the numbers of applications are proportional to the lengths of target hedges and, therefore, not subject to pronounced regional variations for other reasons (e.g. the willingness/need of farmers to maintain those hedges and to apply to the Scheme).

RECOMMENDATIONS: (a) Unless other information is available, agencies can use the lengths of target hedges as guidance for resource allocation.

(b) The number of applications from each region should be monitored so that the accuracy of the forecasted uptake can be assessed and predictions improved in the future.

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APPENDIX 1.

HEDGEROW CLASSIFICATION

1. INSTRUCTIONS FOR USE OF KEYS TO HEDGEROW CLASSES

2. FIELD EXAMPLE

3. LISTS OF WOODY (HEDGE) SPECIES AND INDICATOR HERBACEOUS (HEDGE-BOTTOM) SPECIES

APPENDIX 1

INSTRUCTIONS FOR USE OF KEYS:

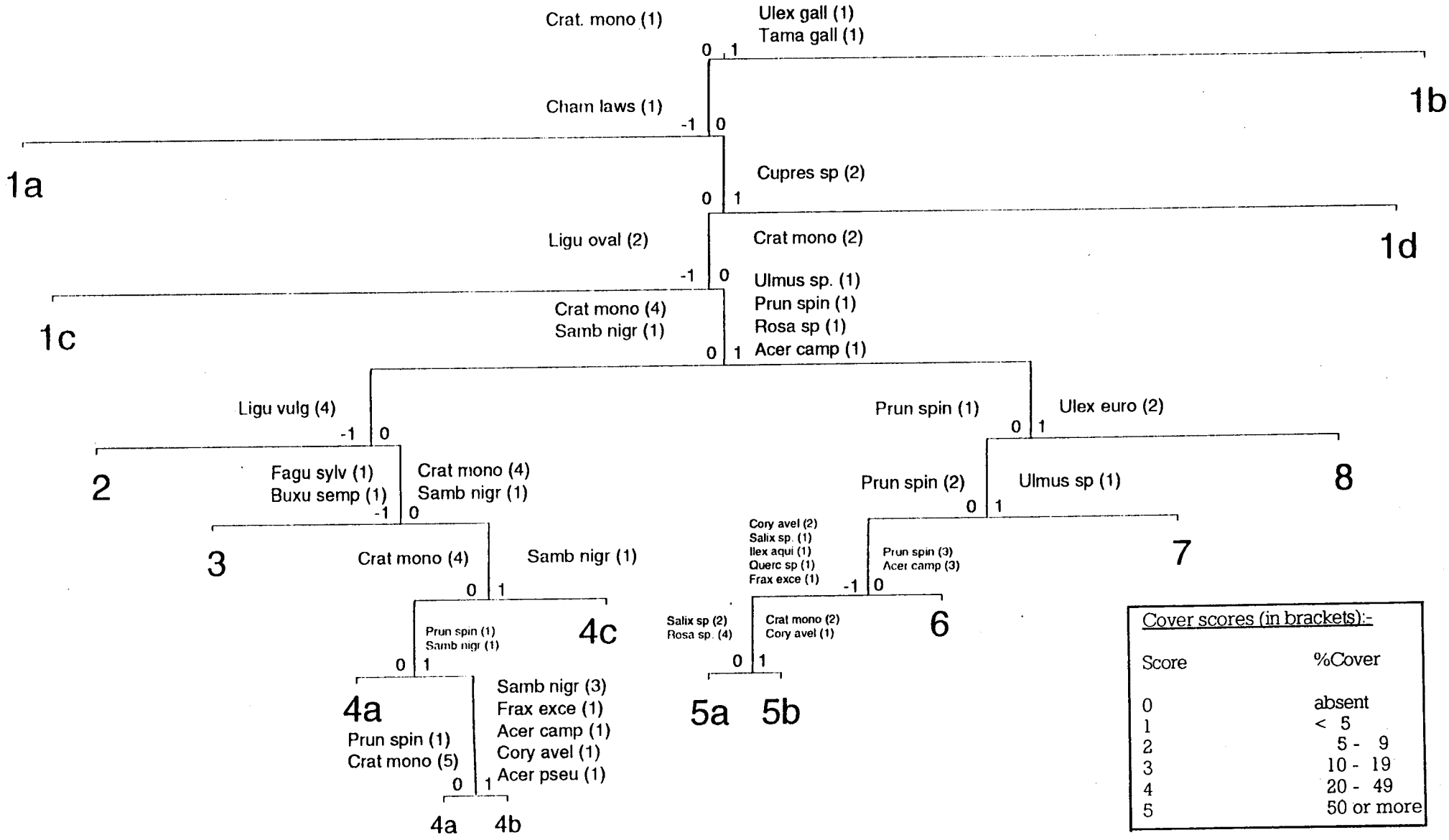
a. Count the number of species on the right and left side of each vertical line. If a cover value is given (in brackets) the species must have at least that amount of cover to be counted.

b. Subtract the count of species on the left from the count on the right.

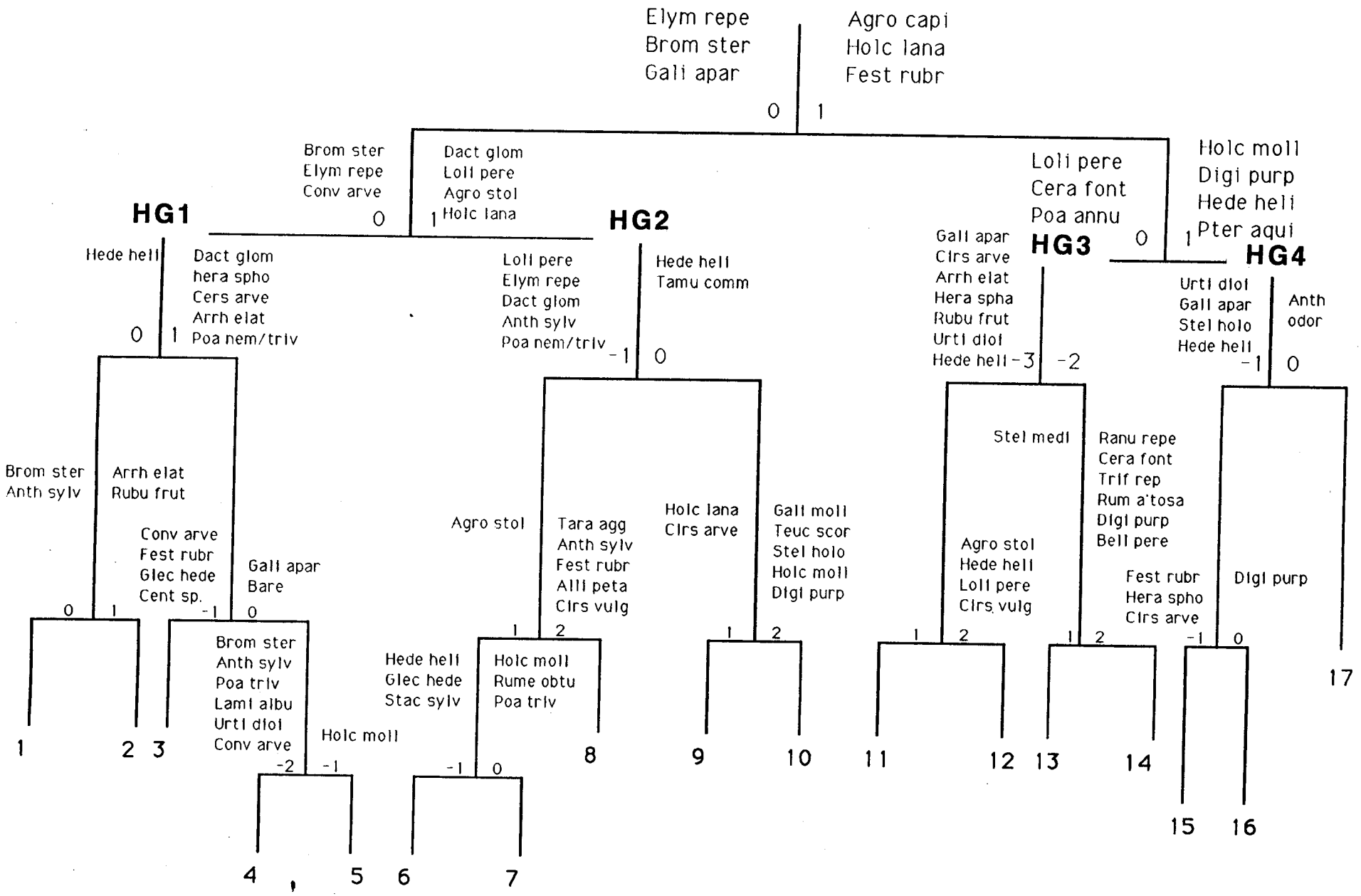
c. If the result is equal to, or less than, the figure on the left side of the vertical line , follow the key to the left.

d. Conversely, follow the key to the right if the result equals or exceeds the figure on the right of the line.

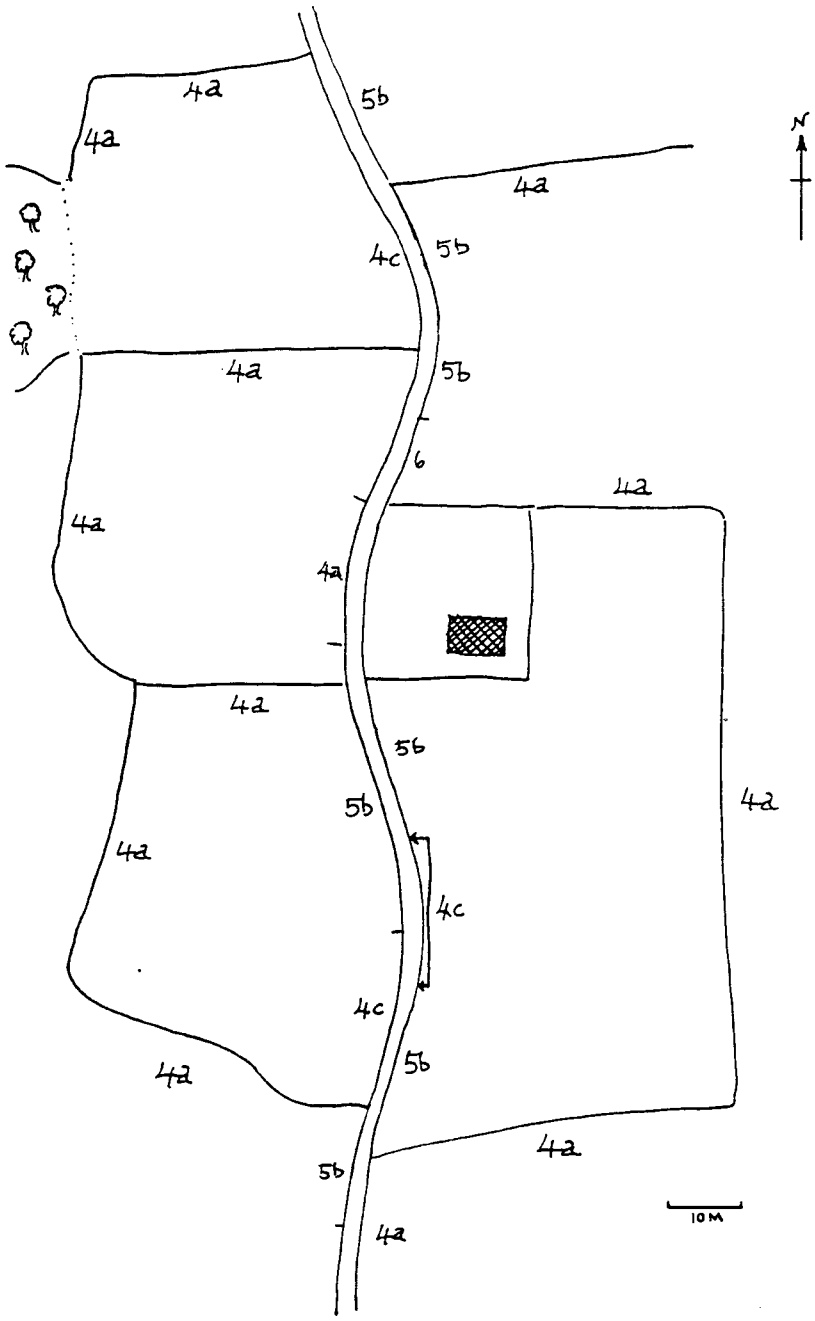
e. Repeat the procedure at each division point until a class is reached.



Appendix 1. **Fig. 1, TWINSPAN Key to Hedge Classes (WSC) using woody species percent cover scores.**



Appendix 1. **Fig. 2. TWINSPAN Key to Hedge-Bottom classes, and main Hedge-Bottom Groups (HG), using presence/absence of herbaceous species.**



Appendix 1. **Fig. 3. Example of field application of key to hedge classes at Allithwaite, Cumbria.**

Note the variety of hedge types identified by the key (see fig.1.), along the road and the contrast with the uniformity of boundaries between fields; this pattern conforms with general field observations and with the known history of the area.

Appendix 1. Table 1. **Woody species found in hedges surveyed in 1978 and 1990.**

All species are native unless indicated
I = introduced N = introduction naturalized in places

Acer campestre	Field Maple	
Acer platanoides	Norway Maple	I
Acer pseudoplatanus	Sycamore	N
Aesculus hippocastanum	Horse-Chestnut	
Alnus glutinosa	Alder	
Berberis spp	Barberries	N
Betula spp	Birches	
Buxus sempervirens	Box	
Carpinus betulus	Hornbeam	
Chamaecyparis lawsonii	Lawson's Cypress	I
Cornus mas	Cornelian-cherry	I
Cornus sanguinea	Dogwood	
Corylus avellana	Hazel	
Cotoneaster microphyllos	Cotoneaster	I
Crataegus spp	Hawthorns	
Cupressus spp	Cypresses	I
Cytisus scoparius	Broom	
Euonymus europaeus	Spindle-tree	
Fagus sylvatica	Beech	
Fraxinus excelsior	Ash	
Fuchsia magellanica	Fuchsia	I
Ilex aquifolium	Holly	
Juglans regia	Walnut	N
Laburnum anagyroides	Laburnum	N
Larix spp	Larches	N
Ligustrum ovalifolium	Garden Privet	I
Ligustrum vulgare	Common Privet	
Mahonia aquifolium	Oregon-grape	N
Malus spp	Apples (wild & cultivated)	(some I)
Picea sitchensis	Sitka Spruce	I
Pinus sylvestris	Scots Pine	
Populus spp	Poplars	(some I)
Populus tremula	Aspen	
Prunus spinosa	Blackthorn	
Prunus spp	Cherries	(some I/N)
Pseudotsuga sp	Douglas Fir	I
Quercus spp	Oaks	
Rhododendron ponticum	Rhododendron	N
Ribes nigrum/rubrum	Blackcurrant/Redcurrant	
Ribes uva-crispa	Gooseberry	
Rosa spp	Roses	
Ruscus aculeatus	Butcher's-broom	
Salix spp	Willows	
Sambucus nigra	Elder	
Sambucus racemosa	Red-berried Elder	N
Sorbus aucuparia	Rowan	
Symphoricarpus albus	Snowberry	N
Tamarix spp	Tamarisk	N
Taxus baccata	Yew	
Tilia hybrids	Hybrid Limes	N?
Ulex europaeus	Gorse	
Ulex gallii	Western Gorse	
Ulmus glabra	Wych-Elm	
Ulmus spp	Elms (English & others)	(some N)
Viburnum opulus	Guelder-Rose	

(names and information follow Clapham, Tutin and Moore - Flora of the British Isles, third edition)

Appendix 1.

Table 2.

List of herbaceous indicator species, with common names.

Agrostis capillaris	Common bent
Agrostis stolonifera	Creeping bent
Alliaria petiolata	Garlic mustard, Jack-by-the-hedge
Anthoxanthum odoratum	Sweet vernal-grass
Anthriscus sylvestris	Cow-parsley
Arrhenatherum elatius	False oat-grass
Bellis perennis	Daisy
Bromus sterilis	Barren brome
Centaurea spp.	Knapweeds
Cerastium fontanum	Common mouse-ear, Mouse-ear chickweed
Cirsium arvense	Creeping thistle
Cirsium vulgare	Spear-thistle
Convolvulus arvensis	Bindweed
Dactylis glomerata	Cocksfoot
Digitalis purpurea	Foxglove
Elymus repens	Couch
Festuca rubra	Red fescue
Galium aparine	Goose grass, Cleavers
Galium mollugo	Hedge bedstraw
Glechoma hederacea	Ground ivy
Hedera helix	Ivy
Heracleum sphondylium	Hogweed
Holcus lanatus	Yorkshire fog
Holcus mollis	Creepimg soft-grass
Lamium album	White dead-nettle
Lolium perenne	Rye-grass
Poa annua	Annual meadow-grass
Poa trivialis/nemoralis	Rough/Wood meadow-grass
Pteridium aquilinum	Bracken
Ranunculus repens	Creeping buttercup
Rubus fruticosus agg.	Bramble
Rumex acetosa	Sorrel
Rumex obtusifolius	Broad-leaved dock
Stachys sylvatica	Hedge woundwort
Stellaria holostea	Greater stitchwort
Stellaria media	Chickweed
Tamus communis	Black bryony
Taraxacum agg.	Dandelions
Teucrium scorodonia	Wood sage
Trifolium repens	White clover
Urtica dioica	Stinging-nettle
----------	Bare Ground

APPENDIX 2.

HEDGEROW CLASS DESCRIPTIONS

1. DESCRIPTIONS OF HEDGE CLASSES (MAIN SPECIES OCCURRENCE AND PROPORTIONS, INCIDENTAL SPECIES, MAIN LAND CLASSES, AND BRIEF OVERALL DESCRIPTIONS OF EACH CLASS).

2. COMPARATIVE SPECIES PROFILES OF MAIN WOODY SPECIES, BY HEDGE CLASS.
(Fig. 1)

3. COMPARATIVE TABLE OF MAIN HERBACEOUS SPECIES OCCURRENCES AND COVER IN HEDGE-BOTTOM CLASSES.
(Table 1)

HEDGE CLASS 1

Number of plots sampled in class = 9

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

		%	p			%	p
1	Ligustrum ovalifolia	26 (100)	0.44	6	Acer pseudoplatanus	<1	0.11
2	Cupressus spp.	11 (80)	0.22	7			
3	Chamaecyparis lawsoniana	3 (30)	0.11	8			
4	Ulex gallii	1 (10)	0.11	9			
5	Tamarix spp.	<1 (5)	0.11		BARE	41 (90)	0.89

OTHER WOODY SPECIES: NONE

1		18	
2		19	
3		20	
4		21	
5		22	
6		23	
7		24	
8		25	
9		26	
10		27	
11		28	
12		29	
13		30	
14		31	
15		32	
16		33	
17		34	

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
1 (125), 6 (75)

OTHER LAND CLASSES: 2, 4, 7, 9, 12 (range 30-50 m)

Description:

Usually planted single-species hedges of non-native species such as cypresses or garden privet; occasionally with sycamore as an invasive 'weed'. Exceptions are mixed hedges with Ulex gallii present, most commonly in South-west England.

The average amount of bare ground present is some 12% greater than in any other woody class.

HEDGE CLASS 2

Number of plots sampled in class = 5

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Ligustrum vulgare	26 (40)	1.0	6		
2 Crataegus spp.	12 (60)	0.2	7		
3 Acer pseudoplatanus	7 (35)	0.2	8		
4 Fraxinus excelsior	6 (5)	0.2	9		
5 Ulmus glabra	1 (5)	0.2	BARE	10 (25)	0.6

OTHER WOODY SPECIES: NONE

1	18
2	19
3	20
4	21
5	22
6	23
7	24
8	25
9	26
10	27
11	28
12	29
13	30
14	31
15	32
16	33
17	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
8 (50), 1 (50)

OTHER LAND CLASSES: None

Description:

Any hedges with wild privet present at 5% or more cover. Sycamore, wych elm and ash occasionally present, usually as hedgerow trees.

HEDGE CLASS 3

Number of plots sampled in class = 19

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

		%	p			%	p
1	Fagus sylvatica	47 (100)	0.95	6			
2	Crataegus spp.	5 (40)	0.68	7			
3	Buxus sempervirens	5 (45)	0.16	8			
4	Rosa spp.	<1	0.16	9			
5					BARE	25 (95)	0.63

OTHER WOODY SPECIES

1	Fraxinus excelsior	18	
2	Quercus spp.	19	
3	Ribes uva-crispa	20	
4	Ilex aquifolium	21	
5	Acer pseudoplatanus	22	
6	Cytisus scoparius	23	
7	Ligustrum vulgare	24	
8	Betula spp.	25	
9	Corylus avellana	26	
10	Ulex europaeus	27	
11		28	
12		29	
13		30	
14		31	
15		32	
16		33	
17		34	

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
6 (225), 11 (100), 17 (100)

OTHER LAND CLASSES: 1, 10, 25, 27, 28 (range 25-100 m)

Description:

Essentially, hedges with beech the main species. Key species are beech and box, the latter providing only a few hedges in this class and forming less than half the cover in the hedges of which it is a component.

HEDGE CLASS 4a

Number of plots sampled in class = 552

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Crataegus spp.	50 (100)	1.0	6		
2 Sambucus nigra	2 (60)	0.20	7		
3 Rosa spp.	1 (50)	0.27	8		
4 Prunus spinosa	1 (40)	0.12	9		
5			BARE	25 (90)	1.0

OTHER WOODY SPECIES

1 Acer campestre
2 Acer pseudoplatanus
3 Aesculus hippocastaneum
4 Alnus glutinosa
5 Betula spp.
6 Carpinus betulus
7 Cornus sanguinea
8 Corylus avellana
9 Euonymus europaeus
10 Fagus sylvatica
11 Cupressus spp
12 Fraxinus excelsior
13 Ilex aquifolium
14 Fuchsia magellanica
15 Laburnum anagryoides
16 Ligustrum vulgare
17 Malus spp.
18 Picea spp.
19 Pinus spp.
20 Populus spp.
21 Populus tremuloides
22 Prunus spp.
23 Pseudotsuga spp.
24 Quercus spp.
25 Ribes nigrum/sanguineum
26 Ribes uva-crispa
27 Salix spp.
28 Sorbus aucuparia
29 Tilia (hybrids)
30 Ulex europaeus
31 Ulmus glabra
32 Ulmus spp.
33 Rhododendron ponticum
34 Mahonia aquifolium

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per $1km^2$):
9 (2050), 11 (1925), 13 (1900), 10 (1825), 16 (1700)

OTHER LAND CLASSES: 1 - 8, 12, 14, 15, 17, 25 - 28 (range 100 - 1450 m)

Description:

This class covers two distinct types of hedge:-

Type (i): Hawthorn hedges with at least 25% hawthorn cover. This type covers a wide range of hedges with inclusion of many incidental mixtures of other hedge shrubs and hedgerow trees. Although hawthorn is always present with high percentage cover it may not always be the single dominant species (see also species profiles, Fig. 1 this appendix).

Type (ii): A small group of almost monotypic hedges lacking indicators that would put them into any other class may occasionally key out here by default.

HEDGE CLASS 4b

Number of plots sampled in class = 61

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Crataegus spp.	38 (100)	0.97	6 Corylus avellana	2 (45)	0.16
2 Sambucus nigra	11 (60)	0.89	7 Rosa spp.	2 (20)	0.28
3 Acer campestre	8 (80)	0.21	8 Malus spp.	1 (45)	0.13
4 Fraxinus excelsior	7 (100)	0.31	9		
5 Acer pseudoplatanus	4 (70)	0.20	BARE	25 (90)	0.70

OTHER WOODY SPECIES

1 Acer platanoides	18
2 Aesculus hippocastaneum	19
3 Fagus sylvatica	20
4 Ilex aquifolium	21
5 Laburnum anagryoides	22
6 Ligustrum ovalifolium	23
7 Ligustrum vulgare	24
8 Populus spp.	25
9 Prunus spinosa	26
10 Quercus spp.	27
11 Salix spp.	28
12 Taxus baccata	29
13 Ulex europaeus	30
14 Ulmus glabra	31
15	32
16	33
17	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
11 (400), 16 (350), 10 (275)

OTHER LAND CLASSES: 1, 2, 5, 6, 9, 12 - 15, 17, 25 - 27 (range 25 - 200 m)

Description:

Similar to 4a but with higher cover of 'other' woody species (only hawthorn itself averages more than 2% cover in 4a, whereas in 4b five species reach that level). The number of 'incidental' species is lower than in 4a, but this is mainly because of the much smaller number of plots sampled.

HEDGE CLASS 4c

Number of plots sampled in class = 40

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Sambucus nigra	23 (90)	1.0	6 Prunus spinosa	3 (40)	0.20
2 Crataegus spp.	5 (50)	0.57	7		
3 Rosa spp.	4 (40)	0.33	8		
4 Ulmus spp.	4 (70)	0.17	9		
5 Quercus spp.	3 (70)	0.17	BARE	12 (70)	0.45

OTHER WOODY SPECIES

1 Acer campestre	18
2 Acer pseudoplatanus	19
3 Aesculus hippocastaneum	20
4 Betula spp.	21
5 Cornus sanguinea	22
6 Corylus avellana	23
7 Fraxinus excelsior	24
8 Ilex aquifolium	25
9 Larix decidua	26
10 Malus spp.	27
11 Pinus spp.	28
12 Ruscus aculeatus	29
13	30
14	31
15	32
16	33
17	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
11 (250), 2 (175), 3 (150)

OTHER LAND CLASSES: 1, 6, 9, 10, 12, 13 (range 25 - 125 m)

Description:

Hedges in this class always had elder present as a key species in a group of moderately mixed hedges. Standard thorn-hedge species (hawthorn and blackthorn), while frequently present, were never dominant.

HEDGE CLASS 5a

Number of plots sampled in class = 6

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

		%	p			%	p
1	Salix spp.	47 (90)	0.83	6	Sambucus nigra	<1 (1)	0.17
2	Rosa spp.	17 (40)	0.50	7			
3	Fraxinus excelsior	1 (5)	0.17	8			
4	Crataegus spp.	<1 (1)	0.50	9			
5	Prunus spinosa	<1 (1)	0.17		BARE	29 (70)	0.83

OTHER WOODY SPECIES: NONE

1		18	
2		19	
3		20	
4		21	
5		22	
6		23	
7		24	
8		25	
9		26	
10		27	
11		28	
12		29	
13		30	
14		31	
15		32	
16		33	
17		34	

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
5 (200)

OTHER LAND CLASSES: 1, 6, 12, 16, 26 (range 25 - 75 m)

Description:

A small class of hedges dominated by willow species, with a smaller proportion of roses, as the two key species.

HEDGE CLASS 5b

Number of plots sampled in class = 157

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Corylus avellana	19 (95)	0.78	6 Fraxinus excelsior	4 (100)	0.33
2 Crataegus spp.	12 (70)	0.73	7 Rosa spp.	3 (40)	0.62
3 Prunus spinosa	6 (80)	0.55	8 Acer pseudoplatanus	2 (50)	0.08
4 Ilex aquifolium	5 (75)	0.25	9		
5 Quercus spp.	4 (100)	0.29	BARE	14 (100)	0.48

OTHER WOODY SPECIES

1 Acer campestre	18 Sambucus nigra
2 Alnus glutinosa	19 Sorbus aucuparia
3 Betula spp.	20 Taxus baccata
4 Carpinus betulus	21 Ulex europaeus
5 Cornus sanguinea	22 Ulmus glabra
6 Cytisus scoparius	23 Ulmus spp.
7 Euonymus europaeus	24
8 Fagus sylvatica	25
9 Juglans regia	26
10 Ligustrum ovalifolia	27
11 Ligustrum vulgare	28
12 Malus spp.	29
13 Populus spp.	30
14 Populus tremuloides	31
15 Prunus spp.	32
16 Ribes nigrum/rubrum	33
17 Salix spp.	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
6 (1450), 15 (1075), 5 (1000)

OTHER LAND CLASSES: 1 - 4, 8 - 11, 13, 16 - 18 (range 25 - 600 m)

Description:

Mixed-species hedges; hazel and hawthorn are principal components, frequently with blackthorn as a subsidiary, but often there is no dominant, or even main species. A species-rich group, with many shrubs and hedgerow trees; only in class 4a, with more than 3 times the number of plots, were more woody species found.

HEDGE CLASS 6

Number of plots sampled in class = 270

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Prunus spinosa	34 (100)	0.93	6 Sambucus nigra	1 (35)	0.10
2 Crataegus spp.	15 (95)	0.66	7		
3 Acer campestre	5 (85)	0.23	8		
4 Corylus avellana	2 (90)	0.22	9		
5 Rosa spp.	2 (25)	0.52	BARE	23 (100)	0.57

OTHER WOODY SPECIES

1 Acer pseudoplatanus	18 Ruscus aculeatus
2 Alnus glutinosa	19 Sorbus aucuparia
3 Cornus mas	20 Ulex europaeus
4 Cornus sanguinea	21 Ulmus glabra
5 Cotoneaster microphyllos	22 Ulmus spp.
6 Cytisus scoparius	23
7 Euonymus europaeus	24
8 Fraxinus excelsior	25
9 Ilex aquifolium	26
10 Ligustrum vulgare	27
11 Malus spp.	28
12 Populus tremuloides	29
13 Prunus spp.	30
14 Quercus spp.	31
15 Ribes nigrum/rubrum	32
16 Ribes uva-crispa	33
17 Salix spp.	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
6 (1700), 1 (1575), 15 (1325), 3 (1125)

OTHER LAND CLASSES: 2, 4, 5, 7 - 13, 16 - 18, 26, 27 (range 25 - 850 m)

Description:

Predominantly blackthorn hedges, with hawthorn as a major subsidiary. Moderately rich in incidental species.

HEDGE CLASS 7

Number of plots sampled in class = 49

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Ulmus spp.	40 (100)	0.98	6 Rosa spp.	1 (10)	0.29
2 Crataegus spp.	6 (60)	0.51	7 Quercus spp.	<1 (10)	0.10
3 Acer campestre	2 (40)	0.18	8		
4 Prunus spinosa	2 (20)	0.35	9		
5 Sambucus nigra	1 (35)	0.20	BARE	19 (90)	0.63

OTHER WOODY SPECIES

1 Acer pseudoplatanus	18
2 Berberis spp.	19
3 Cornus sanguinea	20
4 Corylus avellana	21
5 Fraxinus excelsior	22
6 Ilex aquifolium	23
7 Ligustrum ovalifolia	24
8 Malus spp.	25
9	26
10	27
11	28
12	29
13	30
14	31
15	32
16	33
17	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
1 (450), 5 (375), 3 (325)

OTHER LAND CLASSES: 2, 6, 7, 9 - 11, 26 (range 25 - 225 m)

Description:

Hedges of English elm (U. procera). The limited number of subsidiary species may be partly due to the suckering habit of this species, which assists its spread and ability to dominate a hedge.

HEDGE CLASS 8

Number of plots sampled in class = 8

% = mean % cover (max % cover) for woody species present in more than 10% of plots
(Note: where sample size <10, any woody species that is present at all comes into this category)

p = proportion of plots in class where species was present (if >10%)

WOODY SPP. PRESENT IN >10% OF PLOTS

	%	p		%	p
1 Ulex europaeus	27 (80)	1.0	6 Rosa spp.	<1	0.13
2 Crataegus spp.	1 (5)	0.13	7		
3 Acer pseudoplatanus	<1	0.13	8		
4 Pseudotsuga spp.	<1	0.25	9		
5 Quercus spp.	<1	0.13	BARE	2 (15)	0.13

OTHER WOODY SPECIES: NONE

1	18
2	19
3	20
4	21
5	22
6	23
7	24
8	25
9	26
10	27
11	28
12	29
13	30
14	31
15	32
16	33
17	34

LAND CLASSES WITH HIGHEST LENGTH OF HEDGE (mean length (m) per 1km^2):
13 (75), 8 (25)

OTHER LAND CLASSES: None

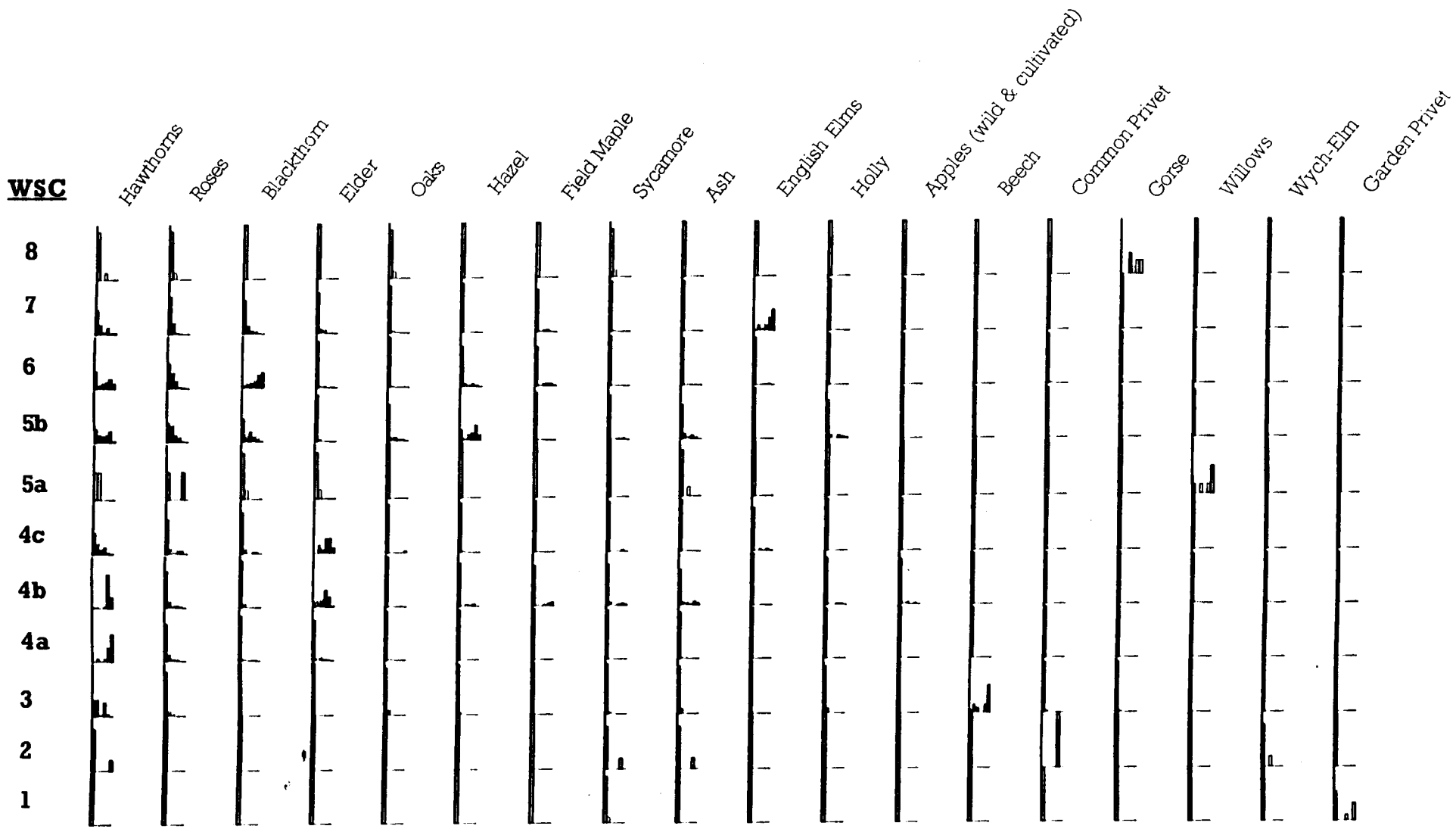
Description:

An infrequent type of hedge dominated by gorse. The thick acid litter commonly found beneath gorse, plus its heavy shade, tends to limit establishment of other species.

Appendix 2. **Fig. 1. Species Composition of Hedge Classes (WSC).**

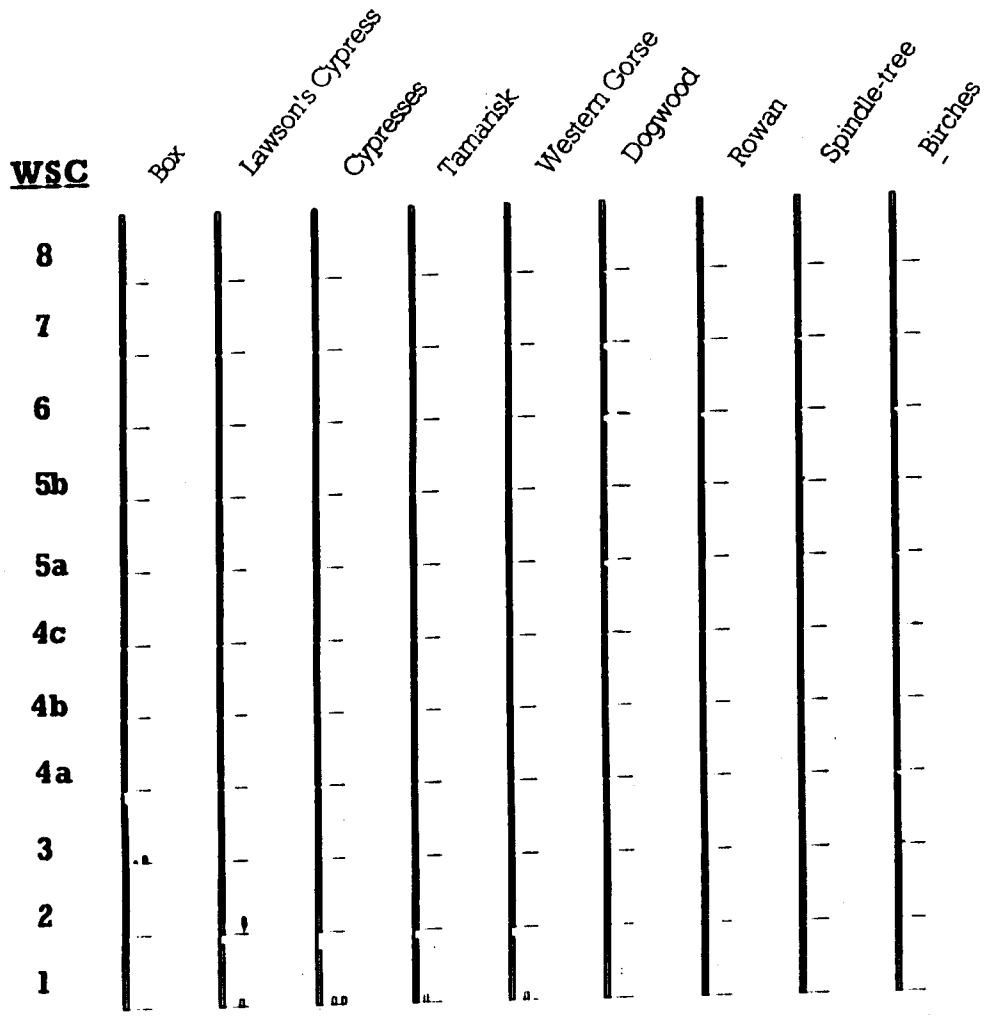
Histograms show the percentage of plots in each hedge class with species present at %Cover of 0, 1-5, 5-9, 10-19, 20-49, and 50 or more (corresponding to the levels used in the TWINSPAN keys, Appendix 1). Open bars are hedge classes with less than 10 plots sampled.

(a) Main/Common Species: all species present in more than 2 classes and in more than 10% of plots in any one class.



Appendix 2. **Fig. 1. Species Composition of Hedge Classes (WSC).**

(b) Minor/Rarer species: species not fulfilling the criteria for inclusion in set (a), but still present in at least 2 classes or key indicator species for a class.



Appendix 2.

Table 1.

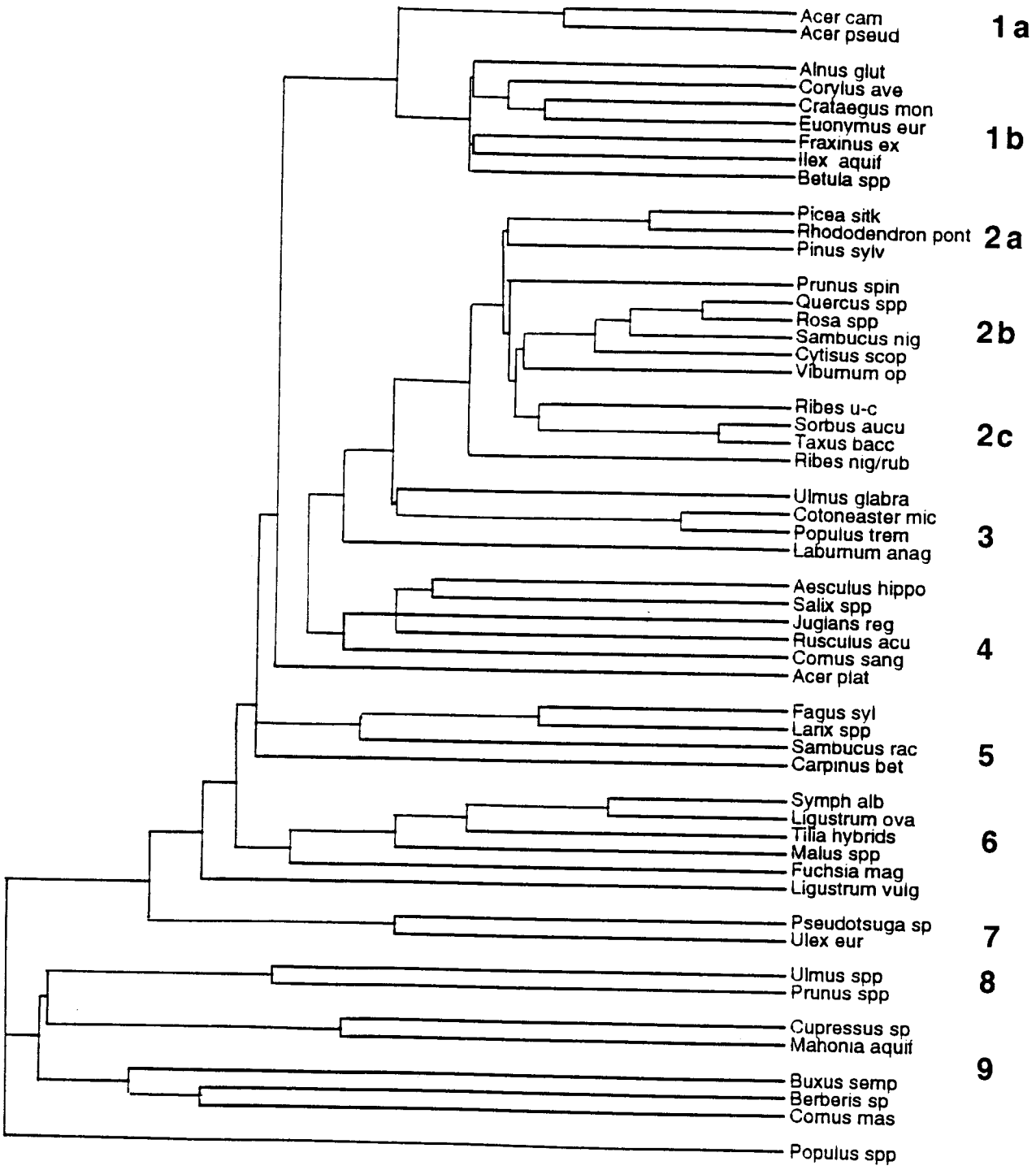
The percent frequency of occurrence and mean percentage cover, within hedge-bottom groups, of the most common herbaceous species (i.e. those present in at least 20% of plots in the group).

+ indicates <1%

	Percent Frequency (% cover) in Hedge-bottom Group			
Species	**1**	**2**	**3**	**4**
Galium aparine	78 (8)	67 (3)	28 (+)	37 (+)
Urtica dioica	76 (6)	76 (6)	59 (2)	53 (3)
Elymus repens	68 (9)	42 (5)		
Rubus fruticosus	67 (7)	78 (8)	52 (5)	79 (8)
Arrhenatherum elatius	61 (9)	62 (7)	35 (3)	42 (4)
Bromus sterilis	51 (5)			
Anthriscus sylvestris	34 (+)	31 (+)		
Hedera helix	31 (7)	51 (8)	22 (2)	58 (8)
Heracleum sphondilium	31 (+)	32 (+)	28 (+)	21 (+)
Dactylis glomerata	31 (1)	65 (4)	78 (6)	68 (3)
Cirsium arvense	28 (+)	40 (1)	41 (+)	
Convolvulus arvensis	25 (+)			
Poa trivialis/nemoralis	21 (+)	34 (2)	24 (1)	25 (+)
Glechoma hederacea		23 (1)		
Agrostis stolonifera		43 (3)	45 (5)	30 (3)
Holcus lanatus		45 (4)	75 (7)	59 (3)
Holcus mollis		22 (2)	20 (2)	64 (7)
Lolium perenne		41 (3)	75 (11)	25 (1)
Rumex obtusifolius			24 (+)	
Taraxacum agg.			21 (+)	44 (+)
Stellaria media			24 (+)	
Festuca rubra			57 (4)	41 (3)
Ranunculus repens			52 (1)	26 (+)
Agrostis capillaris			54 (7)	60 (7)
Cerastium fontanum			46 (+)	
Poa annua			41 (2)	
Trifolium repens			35 (+)	
Rumex acetosa			32 (+)	29 (+)
Poa pratensis			23 (+)	
Achillea millefolium			23 (+)	
Veronica chamaedrys			22 (+)	
Cirsium vulgare			20 (+)	
Digitalis purpurea				48 (+)
Pteridium aquilinum				38 (5)
Stellaria holostea				33 (+)
Viola riviniana/reichenbachiana				29 (+)
Silene dioica				27 (+)
Geranium robertianum				27 (+)
Dryopteris filix-mas				22 (+)
Dryopteris dilatata				21 (+)

APPENDIX 3.

COMPOSITION OF SPECIES CLUSTERS



Appendix 3. **Fig. 1. Woody Species Clusters (Nearest Neighbour clustering)**

(see text for descriptions and interpretations of main groups).

Appendix 3.

Table 1.

HERBACEOUS SPECIES CLUSTERS (Ward Minimal Variance)

Main groups are at c. half max. semipartial R^2. Subgroups (a, b) are where main group subdivides only slightly below this level.

!a (Meadow)

Achillea millefolium
Cerastium fontanum
Cardamine hirsuta/flexuosa
Deschampsia caespitosa
Bellis perennis
Cardamine pratensis
Cynosurus cristatus
Crepis spp.
Geranium molle
Festuca rubra
Lathyrus pratensis
Hypochaeris/Leontodon spp.
Plantago lanceolata
Rumex acetosa
Agrostis stolonifera
Alopecurus pratensis
Hordeum secalinum
Bromus hordeaceus
Cirsium arvense
Cirsium vulgare
Dactylis glomerata
Holcus lanatus
Equisetum spp.

1b (Short-term/ intensive grass)

Humulus lupulus
Sonchus asper
Lolium perenne
Poa annua
Plantago major
Poa pratensis
Poa trivialis/nemoralis
Rumex obtusifolius
Lolium multiflora
Senecio vulgaris
Stellaria media

2 (Old meadow)

Lotus corniculatus
Prunella vulgaris
Ranunculus acris
Luzula multiflora/campestris
Sagina spp.
Ranunculus repens
Taraxacum agg.
Trifolium repens
Veronica serpyllifolia
Veronica arvensis
Stellaria alsine
Trifolium pratense
Veronica chamaedrys
Potentilla reptans
Rumex crispus
Trisetum flavescens
Senecio jacobea
Sinapsis arvensis
Sonchus oleracea
Sonchus arvensis

5 (Abandoned/derelict)

Elymus repens
Arrhenatherum elatius
Bromus sterilis
Galium aparine
Heracleum sphondylium
Alliaria petiolata
Calystegia spp.
Arctium spp.
Clematis vitalbs
Epilobium hirsutum
Bryonia dioica
Convolvulus arvensis
Geranium dissectum

6 (Lowland woodland)

Ajuga reptans
Lamiastrum galeobdolon
Galium mollugo
Galium palustre
Geranium robertianum
Athyrium filix-femina
Dryopteris filix-mas
Galeopsis tetrahit
Festuca arundinacea
Lapsana communis
Brachypodium sylvaticum
Bromus ramosus
Cruciata laevipes
Geum urbanum
Glechoma hederacea
Glyceria spp
Hedera helix
Lonicera periclymenum
Mercurialis perennis
Asplenium scolopendrium
Primula vulgaris
Cirsium palustre
Festuca ovina
Filipendula ulmaria
Juncus spp.
Lysimachia nemorum
Oxalis acetosella
Potentilla sterilis
Stellaria graminea

7 (Arable weeds)

Artemisia vulgaris
Ballota nigra
Capsella bursa-pastoris
Chenopodium spp.
Galium verum
Hieracium spp.
Myosotis spp.
Matricaria matricarioides
Polygonum aviculare
Polygonum persicaria
Lamium purpureum
Malva sylvestris
Papaver spp.
Silene vulgaris
Sisymbrium officinale
Fallopia convolvulus
Tripleurospermum spp.
Viola arvensis
Silene latifolia

3 (N/P-rich)

Conium maculatum
Lamium album
Hordeum murinum
Phragmites australis
Ranunculus ficaria
Picris echioides
Vicia sativa
Matricaria recutita
Brassica napus
Alopecurus myosuroides
Smyrnium oleastrum
Carduus acanthoides

4a (Acid grassland)

Aegopodium podograria
Campanula rotundifolia
Conopodium majus
Agrostis canina/vinealis
Agrostis capillaris
Anthoxanthum odoratum
Agrostis gigantea
Chamaenerion angustifolium
Angelica sylvestris
Deschampsia flexuosa

4b (Acid woodland)

Digitalis purpurea
Hyacynthoides non-scripta
Dryopteris dilatata
Galium saxatile
Holcus mollis
Polypodium vulgare
Pteridium aquilinum
Teucrium scorodonia
Potentilla erecta
Rumex acetosella

8a (Humus-rich basophiles)

Lotus uliginosus
Potentilla anserina
Rubus idaeus
Silene dioica
Stellaria holostea
Umbilicus rupestris
Stachys sylvatica
Asplenium adiantum-nigrum
Rubus fruticosus
Urtica dioica
Torilis spp.
Veronica montanum
Vicia sepium
Vicia cracca
Festuca pratensis
Linaria vulgaris

8b (Southern/derelict)

Rubus caesius
Rumex conglomeratus/sanguineus
Solanum spp.
Tamus communis
Viola hirta/odorata
Carex spp.
Moehringia trinerva
Chaerophyllum temulentum
Arum maculatum
Bromus erectus

9 (Weeds and bare ground)

Avena fatua
Aethusa cynapium
Veronica agrestis
Fumaria spp.
Epilobium montanum
Viola riviniana/reichenbachiana
Centaurea spp.
Hypericum spp.
Oenanthe spp.
Phleum spp.
BARE GROUND

APPENDIX 4.

DIVERSITY AND MANAGEMENT.

The relationship between numbers of all species (woody + herbaceous) per plot and:

(a) HEDGE HEIGHT

Height	No. of plots	Number of species Min	Mean	Max
<1m	12	10	16	20
1-2m	239	7	17	48
>2m	178	5	15	41

(b) "GAPPINESS"

Derelict and relict hedges had >10% gaps and were not stockproof

	No. of plots	Number of species Min	Mean	Max
No gaps	119	5	17	48
Gaps <10%	25	7	17	33
Gaps >10%	214	5	15	41
Derelict	33	8	16	31
Relict	38	6	15	28

(c) CUTTING

	No. of plots	Number of species Min	Mean	Max
Flailed	39	6	15	31
Laid	36	9	17	36
Trimmed	235	5	15	48
Uncut	119	5	16	41

APPENDIX 5.

DEFINITIONS OF LAND-USE CLASSES

The LAND USE CLASSES refer to the land nearest to the hedge plot. For example, if, a hedge has a ditch or track between it and an adjacent field, the adjacent land-use will be classified as water or road/track, rather than whatever is in the field.

INTENSIVELY MANAGED LOWLAND GRASSLAND
..... Lowland agricultural grass with more than 50% cover of *Lolium perenne*, or other evidence of intensive or short-term management (e.g. ley, ploughed, *Lolium multiflora* present, *Lolium* used for hay/silage).

OTHER (NON-INTENSIVELY MANAGED) LOWLAND GRASSLAND
..... Lowland agricultural grass, with species other than *Lolium spp* dominant; also herb-rich, or explicitly "unmanaged" or "unimproved" grassland.

"ROUGH" GRASS/HERB
.....Upland/moorland grass; also "unmanaged", "unimproved" or "neglected" herbaceous vegetation; tall-herb; herb-rich vegetation; bracken.

CEREAL ..... All cereal crops (inc maize) plus ploughed land that had been under cereals in that year.

NON-CEREAL CROP ..... All other crops, including commercial horticulture, but excluding orchards.

TREE/SHRUB ..... Blocks or belts of coniferous and/or broadleaf trees, including orchard.

AMENITY GROUND ..... All recreational or related grasslands or "open space", plus public gardens.

ROAD/TRACK ..... All roads, tracks or paths.

less than 10 plots
{WATER .....Any water feature (eg ditch, canal, river).
{URBAN .....Buildings, plus commercial or residential gardens/grounds.