Session 2

Field Margins as Wildlife Habitats

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BOTANICAL DIVERSITY IN BRITISH HEDGEROWS

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ABSTRACT

The Institute of Terrestrial Ecology conducted surveys on the countryside of Great Britain in 1978 and 1990, collecting detailed botanical data on the composition of hedgerows. These data were analysed to define the botanical diversity currently present in British hedgerows and the changes that have taken place over that period. Classifications of hedgerows are described based on woody and herbaceous species separately. No particular type was lost preferentially but diversity declined, mainly in pastural landscapes.

INTRODUCTION

Although the botanical interest in hedgerows has concentrated on the woody species, there has also been much interest in the vegetation growing at the base of the hedge. Pollard *et al.* (1974) and Rackham (1986) provide the ecological background on the hedges in Britain. Of particular interest has been the work of Hooper (1970) who showed that generally the older the hedge the more woody species it contained. Thus, he reported that some sites where hedges had been established for over six hundred years, there may be 6-10 woody species in a 30 m length, whereas hedges less than one hundred years old usually have fewer than four species and often tended to be mono-typic with hawthorn predominant. However, although this relationship is broadly correct the actual ratio, ie number of woody species to age of hedge will vary regionally. Thus, old hedges in the north of England would be likely to have fewer species than similar aged hedges in the south, due to geographical limitations on the distribution of some species, eg *Acer campestre* and *Viburnum lantana*. Few regional studies have been carried out to support the general relationship expressed by Hooper and this is even more so in relation to the ground vegetation. Marshall (1989) has described details of hedge floras around fields in the south and east of Britain, but otherwise only fragmentary information is available. Bunce & Hallam (1993) described the difference between the flora of the hedgerows and the surrounding fields, emphasising that many species in lowland Britain in particular are only present in hedgerows, rather than the open fields surrounding. Thus, in the south, species like *Digitalis purpurea* and *Teucrium scorodonia* would be found only in hedgerows and not in the surrounding fields. The National Vegetation Classification describes hedgerows in the woodland context.

The results described in the present paper were derived from the surveys of the countryside of Great Britain conducted by the Institute of Terrestrial Ecology (ITE) in 1978 and 1990 (Barr *et al.*, 1993). Data were collected for a wide range of features of the countryside but the present paper describes those relating to the vegetation and management of hedgerows and the adjacent land use. The Department of the Environment and the former Nature Conservancy Council part-funded the 1990 survey but the previous survey was carried out by the Natural Environment Research Council.

METHODS

The sampling strategy was the same in both the 1978 and 1990 surveys, ie a random sample of 1 km squares throughout GB, stratified according to ITE Land Classes (Barr *et al.*, 1993). In 1978, 256 squares were sampled, which was increased to 508 squares in the 1990 survey. The field survey methods were similar in both years and included:

a. mapping the hedges within a square, and
b. describing the hedge floristics using quadrats.

In 1978, two plots were placed along hedges in each square using a set procedure to ensure that the plots were well separated in the 1 km square. Plots were relocated if there was not a clear metre between the centre of the hedge and another linear feature. At each plot a 10 x 1 m quadrat was set out running parallel to the hedge with its 10 m base along the centreline of the hedge. The species and percentage 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 relocated and, if the hedge was still present, the recordings were repeated. In 1990 only, further hedge plots were recorded beside a random selection of boundaries. Altogether, 278 plots from 1978 and 918 from 1990 were used in the analysis. Initial TWINSPAN analysis of all the species together, ie woody and herbaceous, gave a classification which was confused by the large information present. It was therefore decided to separate the woody and herbaceous species and create separate classifications, which was also convenient for the interpretation of the data. Percentage cover was therefore used to classify the woody species and presence/absence data to classify the herbaceous species within the hedge bottom. The relationships between species, regardless of the hedgerow classes, were examined using the statistical procedure DECORANA. The scores from that analysis were then used within nearest neighbour analysis (woody species) or Wards Minimum Variance Analysis (herbaceous species) to determine species associations. Full details of these analyses and the groupings that they produced are provided in Cummins *et al.* (1992). The following terminology is used in the paper:

- the woody species component will be referred to as the hedge
- the herbaceous component as the hedge bottom
- the two components together as the hedgerow
- Hedges are referred to by their woody species class and hedge bottoms by their herbaceous groups.

RESULTS

Hedgerow classifcation

The classification of woody species initially divided a series of less comon hedges, all but one having fewer than 20 plots in the sample (Table 1). The amount of hawthorn present was a strong factor in sub-dividing the remainder core hedge types. Eleven classes of hedges are summarised in Table 1. The four species profiles of the hedgerows are described in Cummins *et al.* (1992) but the most widespread type was the hawthorn dominant type 4a, probably associated with the extensive planting of hawthorn during the enclosures. The two most diverse types are those of 4b, mixed hawthorn type, more typical of eastern Britain and the mixed hazel type, 5b, more typical of the west. Certain types, eg type 8, was dominated by a single species, in this case, gorse. The TWINSPAN analysis of herbaceous species produced 70 interpretable classes. However, these were summarised at Level 3 of the hierarchy to give four composite groups which were used subsequently to indicate the types of hedge bottom floras. Many species occur throughout the groups but are present in different quantities. The four herbaceous groups may be described as typical of the following types of land use:

HG1 - arable and crop land
HG2 - other intensively managed ground (mainly lowland)
HG3 - rough grazing and less intensively managed grasslands
HG4 - woodland vegetation

TABLE 1. TWINSPAN hedge classes as described by Cummins *et al.* (1992), types and the number of plots in each class.

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

The structure of the TWINSPAN classifications can be used to categorise the characteristics of the different types and these are recognisable in the field. Further work using the discriminant function could produce more robust keys.

The strength of the associations between the woody species and the herbaceous species were assessed by the two classifying techniques described in the analysis procedures. The clustering of the woody species showed two groupings. The first, typical of long-lived woodland species which are all native except for sycamore. The second group was also native with the exception of oak and blackthorn, but do not live as long as those in the first cluster. Apart from that, a group of exotics, the reasons for clustering other species were not obvious, often tending to be incidental, associated with strongly dominant species. Thus, the conclusion from this is that there was a core of native species separated into the longer-lived as opposed to the shorter-lived, more temporary species, with individual other exotics, such as beech, interpolated between them.

Twelve herbaceous species associations were identified, summarised in Table 2 according to the main habitat types which they represent. The full list of the species comprising these types is given in Cummins *et al.* (1992). Despite the physical dominance of the woody components of hedges, it was clear that the vegetation of hedge bottoms is not confined into associations typical of woodlands. The occurrence of species from the woodland clusters, 4b and 6, together accounted for only 15% of the total. The unmanaged nature of many hedgerows was indicated by the 25% occurrence of species typifying abandoned or derelict areas. As emphasised in the report on the Countryside Survey 1990 (Barr *et al.*, 1993) these results emphasised the significance of hedgerows in maintaining species of open habitats within intensively farmed landscapes. The association between the clusters of the herbaceous species and the classification of the overall composition of the hedge bottom species are shown in Table 3. Thus, the arable group was associated with clusters typical of arable land, ie those of nitrogen and phosphorus rich areas and arable weeds. The second group included species from a wide range of habitats, having no strong positive affinities. The third group could be generally summed as grasslands, due to the positive association with all four grassland clusters and negative associations with the clusters more characteristic of arable areas and unmanaged ground. The fourth group was the only group having positive affinities with woodland species. Detailed analysis of the results showed that the vegetation was associated primarily with a gradient in management levels, from high to low intensity. This association with management, rather than with other factors, suggested that the adjacent land use was affecting the species composition of the hedge bottom in many areas. The herbaceous species clusters were therefore 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 with the possible exception of the mixed hazel hedges and woodland herbaceous plants of the west of Britain. It is therefore important that both the woody and the herbaceous components of the hedgerows are assessed separately, which has important implications in future management proposals for hedgerows.

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 weeks	2
8a	humus-rich basophiles	14
8b	southern derelict areas	3
9	common weeds	7

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

		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)			-	

+ 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

Diversity

Bunce *et al.* (1992) described the various approaches which have been used to define diversity and concluded that direct records of species number was one of the most appropriate measures of diversity. The results of the species diversity with hedge class are shown in Table 4. The diversity of woody species was notably low in Class 4a, hawthorn dominant, and high in Classes 4b and 5b. Of the rarer classes, gorse hedges were possibly species-rich, whereas those of the elm were probably the poorest. The diversity of herbaceous species increases by about 80% in passing through the series. This is demonstrated in Table 5. The difference between the woody species values was not as pronounced as Table 4, although still significant, but the woody species contribute comparatively little to the overall diversity because of the far more abundant herbaceous species. There is therefore, little association between the diversity of woody species and herbaceous species within the two classifications separately, ie plots which were rich in woody species will not necessarily be rich in herbaceous species and vice versa. The results suggested that the overall species richness of hedgerows was 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. Furthermore, the numerical diversity of species in hedgerows should not be considered in isolation from the types of vegetation they contain. Thus, 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 more difficult to recreate than a hedge bottom with a large number of invasive weed species. Analysis of the relationship between management and the diversity of the hedgerows showed that very intensive land management and no management at all were both deleterious to the diversity of herbaceous species. In some situations, the indications of the analysis suggested that limited grazing could be a valuable management tool. Hedgerows adjacent to roads, tracks and wooded ground were particularly rich in woody species. Management of the hedge itself had no significant affect on species diversity either within or between the hedge. However, the hedge should be managed to maintain it as a coherent feature and to prevent its degeneration, eg into a row of trees, because otherwise different species would not be able to maintain themselves within the hedge boundary. At least 60% of the samples of both species-rich type of hedges had more than 10% gaps in their length. Rejuvenation of these types is probably therefore necessary in order to maintain the current mixture of species and the maintenance of their diversity.

TABLE 4. 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)

TABLE 5. 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)

Changes in hedgerows between 1978 and 1990

Two hundred and fify-nine of the plots sampled in 1978 were reliably relocated in 1990 and were used to assess the changes in the hedgerows. Losses of the more common types of hedge between 1978 and 1990 from all causes, including neglect, range from 21% (hawthorn dominated and a blackthorn) to 31% (mixed hawthorn). However, there was no evidence that any one particular type of hedge was being lost to a greater degree than any other type. The same analysis was carried out on the herbaceous hedge classification, with similar conclusions. Loss of hedgerows was therefore proportionately taking place throughout all the major types of hedges. 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). Both reports showed similar losses due to removal over the 12 years. Full details of these changes are described in Cummins *et al.* (1992).

In relation to the average cover of the different species there were increases and decreases in the average cover of both woody and herbaceous species. The only statistically significant change amongst woody clusters was an increase in the maple/sycamore cluster and a decrease in the gorse cluster. The 10% decrease in the wych elm association (cluster 3) although not significant, may be the result of Dutch elm disease. In contrast, the English elm cluster increased by about 5% which could be due to recovery by its abundant suckers. Three of the changes in herbaceous clusters were statistically significant:

1 There was an increase in the cover of species in cluster 5 (abandoned derelict such as would occur with the removal of grazing or an increase in the size of headlands in arable areas).

2 The cover of cluster 6 (lowland woodland) also increased, reflecting the changes described above.

3 The decrease in cover of species from short-term grasslands is consistent with an increase in arable land.

The change in individual species is best summarised by looking at the different landscape types described by Barr *et al.* (1990). These results are shown in Table 6. There was a decline in diversity in both the landscape types with large samples, but only the pasture was significant. These results were consistent with other results reported in the Countryside Survey 1990 and showed that the biggest changes over the period of time were within pastural landscapes.

TABLE 6. Change (1978-90) in species numbers recorded in paired plots placed along hedgerows, by landscape type.

Landscape type	No of plots	Mean species no 1978	Mean species no 1990	Change in mean species no.	SE of change	P
Arable	116	11.0	10.2	-0.8	0.6	
Pastural	111	14.6	13.1	-1.5	0.6	*
Marginal upland	24	17.0	17.5	0.4	1.3	
GB	251	13.1	12.2	-1.0	0.4	*

(Significance is based on pair t-test. Probability (P) * <0.1).

In relation to changes in the individual species, out of more than 450 species recorded, the percentage cover of 33 species changed significantly between 1978 and 1990 (Table 7). Exactly two-thirds of these changes were decreases. In relation to woody species, sycamore, which is very invasive, was the only species to increase in cover, whereas dogwood and gorse, both relatively uncommon, decreased. Wych elm was the only large tree species to decrease, by almost 5%, probably due to Dutch elm disease. A major increase in the cover of *Hedera helix* and bramble suggested that hedge management has declined in some places, resulting in increased shading of the hedge bottom. Observations suggest that *Clematis vitalba* has spread extensively on the chalk. Most of the other species which increased are aggressive/invasive species. In contrast, the species which have decreased in cover came from a wide range of habitats.

CONCLUSIONS

In conclusion therefore, not only have hedges been lost, but there has also been a general decrease in the number of both woody and herbaceous species per plot. The results do not pinpoint any common type of hedge that was particularly susceptible to loss, except that gorse hedges appeared to be vulnerable. National proportions of the different hedge types were unaltered and therefore there is no reason to target any particular types of hedges solely on the grounds of susceptibility to change. The vegetation of the hedge bottom is strongly influenced by the adjacent land use. Hence, changes associated with land use and the intensity of management are more likely to reflect the hedge flora than other factors.

TABLE 7. 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

	n	m.d.	S.E.	P
Species increasing				
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	*
Sochus oleraceus	12	0.5	0.26	*
Trifolium repens	24	1.6	0.72	*
Species decreasing				
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	*

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BOTANICAL DIVERSITY IN ARABLE FIELD MARGINS.

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ABSTRACT

The plant communities of Britain's arable field margins have evolved over the past 5000 years. There is considerable variation within the arable flora, chiefly related to soil type and climate. Farming practices have however undergone radical changes since 1945, and many species associated with arable cultivation have become extremely rare. Most of the sites where species-rich communities survive are on calcareous soils in the south and east of England. In addition to overall reductions in range and abundance of these species, they are in most cases now confined to the extreme edges and corners of fields, and the removal of field margins in recent years has contributed to the decline of the arable flora.

INTRODUCTION

Arable crops have been grown in Britain since about 3000 BC. The weed communities of these early arable fields are unknown, but it may justifiably be said that these plant communities have an origin of similar antiquity to coppiced woodlands, hay meadows and other anthropogenic habitats.

Farming has undergone great changes during the past 200 years, particularly since 1945. Since then, herbicides have become the major method of weed control, amounts of nitrogen applied to cereal crops have increased by over 600%, and highly nitrogen-responsive crop varieties have been developed. Mechanisation has been almost complete, and fields have been enlarged to facilitate the use of large machinery (Wilson, 1990).

These and other developments have had profound consequences for the flora of Britain's arable field margins, and have imposed an impoverished uniformity on the arable ecosystem. Conservation of the arable flora is therefore an urgent priority. In order to carry out effective conservation however, an understanding of the variation within arable vegetation is necessary, as is an understanding of the processes affecting it.

THE ORIGINS OF BRITAIN'S ARABLE FLORA

H. Godwin (1956) recorded 31 species now characteristic of arable habitats from the fossil record of the last inter-glacial period. While there is no evidence for continuity of habitat since then, Godwin considered that suitable open habitat could have remained between the last glaciation and the start of arable farming. Several arable species including *Petroselinum segetum, Galeopsis angustifolium* and *Ranunculus parviflora* still occur in semi-natural habitats. Arable agriculture would have opened up large areas of land for such species to expand into.

Other species probably arrived with successive waves of human immigration and opening of new trade routes. The majority of these originated around the Mediterranean, are at the climatic limits of their distributions in north-western Europe, and are therefore particularly susceptible to environmental changes (Holzner, 1979). Other species have arrived more recently. *Veronica persica* was first recorded in 1825 and is of Asian origin, while the New World was responsible for *Matricaria matricarioides* (Salisbury, 1961). Other species including *Bromus sterilis* and *Galium aparine* originating in habitats adjacent to arable fields have become prominent in recent years.

VARIATION WITHIN BRITAIN'S ARABLE FLORA

Britain's arable flora includes over 200 species. As arable agriculture extends from the Scilly Isles to the Shetlands, and ranges from the intensive cereal growing of south-eastern England to the machair farming of the Hebrides, there is much potential for variation within the associated flora.

Silverside's phytosociological study of Britain's arable flora detected 15 plant associations (Silverside, 1976)(Table 1). A survey aimed at areas where uncommon arable species were still known to occur (Wilson, 1990) recorded four of the five alliances recorded by Silverside, the *Arnoserìdion minimi* having become extremely rare in Britain.

Although many species such as *Veronica persica, Polygonum aviculare* and *Stellaria media*, are ubiquitous throughout Britain, most are restricted either geographically or to particular soil types or farming practices. The majority of sites that still support rich arable floras are to be found on calcareous soils in the south-east of England. At their richest, such communities include *Adonis annua, Papaver hybridum, Papaver argemone, Petroselinum segetum, Galeopsis angustifolium, Buglossoides arvensis, Fumaria parviflora, Fumaria densiflora* and *Valerianella dentata*. *Papaver hybridum, P. argemone, V. dentata* and *F. densiflora* can all be quite common in localised areas of south-east England. Species such as *Scandix pecten-veneris, Euphorbia platyphyllos* and *Torilis arvensis* also occur on chalky soils, but are less typical. Such vegetation corresponds to Silverside's *Caucalidion lappulae* and the *Caucalidion platycarpi* of central Europe (Hüppe and Hofmeister, 1990). Several species extinct in Britain or no longer known from true arable habitats, including *Caucalis platycarpos, Melampyrum arvense, Bunium bulbocastaneum, Bupleurum rotundifolium* and *Ajuga chamaepitys*, are characteristic of the most thermophilous of these communities in Germany (Hüppe & Hofmeister, 1990).

TABLE 1. Classification of arable plant communities (class Stellarietalia) in Britain under the Zürich-Montpellier system (Silverside, 1976).

Order Polygono-Chenopodietalia.	Roots and spring cereals
1. Fumario-Euphorbion	
a. Veronico-Lamietum hybridi	Loams, E. Anglia
b. Alopecuro-Matricarietum chamomillae	Loams, E. Anglia
c. Fumarietum bastardii	Loams, Atlantic
2. Spergulo-Oxalidion	
a. Spergulo-Chrysanthemetum segeti	Sands
b. Stachys arvensis community	Loams, south-west
c. Chenopodio-Violetum curtisii	Hebridean machair
d. Lycopsietum arvensis	Sands, east England
e. Descuranio-Lycopsietum arvensis	Sands, Breckland
Order Centauretalia cyani.	Cereal crops.
1. Arnoseridion minimi	
a. Teesdalio-Arnoseridetum minimae	Poor sands, eastern
2. Aphanion arvensis	
a. Papaveretum argemonis	Basic sands, southern
b. Alchmillo-Matricarietum chamomillae	Clays, southern
c. Euphorbia exigua-Avena fatua community	Basic clays
3. Caucalidion lappulae	South-eastern
a. Linarietum spuriae	Chalk
b. Papaveri-Melandrium noctiflori	Chalk
c. Adonido autumnalis-Iberidetum amarae	Calcareous loams

Sandy soils can also support rich communities. The most outstanding are in the East Anglian Breckland, where the former low intensity farming systems on marginal land, the continental climate and the mixture of calcareous and acidic sandy soils, combined to favour a flora unique in Britain. The Breckland has many rare arable annuals including *Veronica praecox, Veronica verna* and *Apera interrupta*. Other species which are rare in the rest of Britain can be very common in the Breckland. These include *Descurania sophia* and *Apera spica-venti*, and to a lesser extent *Silene noctiflora, Anthemis arvensis* and *Lamium hybridum.* Elsewhere calcareous sands provide suitable conditions for rare species outside their main ranges. In Cornwall and Norfolk, coastal fields have populations of *P. hybridum, P. argemone* and *Silene noctiflora*. Oolitic sands on the southern side of the North Yorkshire Moors are a northerly limit for *S. noctiflora, Legousia hybrida* and *Stachys arvensis*, and in east Scotland, coastal sands support outlying populations of *F. densiflora* and *P. argemone.*

Most very freely draining sandy soils tend to be acidic, and support several characteristic and uncommon species. Spring barley and root crops are typical. Less common species include *Fumaria bastardii, Fumaria purpurea, Misopates orontium* and *Silene gallica* especially in the south-west, while *Chrysanthemum segetum* is scattered mainly over the west of the country as far north as the Shetlands. *Fumaria occidentale* is an endemic species found only in arable fields and hedgerows in Cornwall.

The few localities where rich arable floras persist on heavy clay soils are highly vulnerable to changes in farming practices. The most well known site is at the Rothamsted Experimental Station, where part of the Broadbalk winter wheat experiment has never received herbicides, and where *Ranunculus arvensis, S. pecten-veneris, T. arvensis* and *Galium tricornutum* still occur. The first three of these occur in other of the richest clay soil sites, one of which, owned by the Somerset Wildlife Trust, is among the three best sites for the arable flora in Britain, with populations of *Euphorbia platyphyllos, Valerianella rimosa* and *Vicia tenuissima*. *Scandix pecten-veneris* is still considered a farming problem in one area of Suffolk, and in its few sites elsewhere can occur in large quantities. Areas where water collects in the winter support a distinctive flora dominated by *Polygonum spp.*, and uncommon species include *Myosurus minimus* and in two locations, *Lythrum hyssopifolia*.

CHANGES IN BRITAIN'S ARABLE FLORA

Many species including some which were once very common have become extremely rare in recent years (Table 2). Improved methods of seed-cleaning were probably responsible for the early declines of some species including *Agrostemma githago* and *Bupleurum rotundifolium* whose seeds have similar dimensions to cereal grains (Salisbury, 1961). The majority have however declined since the 1940s, coincidental with the massive changes that have occurred in farming practices. At the same time, other species which were pre-adapted to modern high-input farming methods, such as *Bromus sterilis* and *Galium aparine* have increased to become the new problems of modern cereal farming.

TABLE 2. The status of some uncommon arable weeds in Britain in terms of the number of 10km. squares in which they have been recorded. Taken from Perring & Walters, 1990; Smith, 1986; Wilson, 1990; A. Smith, pers comm.. Casual records excluded.

	1930-60	1960-75	1976-85	1986-89
Adonis annua	36	34	13	12
Agrostemma githago	>150	14	17	0
Bupleurum rotundifolium	17	8	1	0
Centaurea cyanus	264	<100	<50	3
Galeopsis angustifolia	238	-	-	18
Galium tricornutum	77	16	7	2
Ranunculus arvensis	432	169	71	22
Scandix pecten-veneris	426	86	<20	20
Torilis arvensis	136	35	16	10
Valerianella rimosa	60	17	11	5

Twenty five species in Britain's arable flora are classified as "Nationally Scarce", a further 24 were included in the "Red Data Book" (Perring & Farrell, 1983), and at least five further species are now of "Red Data Book" status. Of these "Red Data Book" species, seven are now extinct, and ten others no longer occur in strictly arable habitats. Nine are now fully protected under the Wildlife and Countryside Act (1981), although only two of these still occur at all in arable habitats (Table 3).

Table 3. "Nationally scarce" and "Red Data Book" (Perring & Farrell, 1983) species in Britain.

Red Data Book status species. e extinct, n no longer in arable habitats, p legally protected, * not included in Perring & Farrell.		Nationally scarce species (Strictly arable species only.)
Adonis annua	*	*Anagallis foemina*
Agrostemma githago	e	*Apera interrupta*
Ajuga chamaepitys	n*p	*Briza minor*
Alyssum alyssoides	np	*Bromus arvensis*
Anthoxanthum puelii	n	*Bromus secalinus*
Arnoseris minima	e	*Buglossoides arvensis*
Bromus interruptus	e	*Euphorbia platyphyllos*
Bunium bulbocastaneum	n	*Fumaria densiflora*
Bupleurum rotundifolium	e	*Fumaria parviflora*
Caucalis platycarpos	e	*Fumaria bastardii*
Centaurea cyanus	*	*Fumaria vaillantii*
Echium plantagineum		*Galeopsis angustifolium*
Filago apiculata	np	*Geranium columbinum*
Filago pyramidata	p	*Misopates orontium*
Fumaria martinii	np	*Myosurus minimus*
Fumaria occidentale		*Papaver argemone*
Galeopsis segetum	e	*Papaver hybridum*
Galium spurium		*Petroselinum segetum*
Galium tricornutum	*	*Ranunculus arvensis*
Gastridium ventricosum		*Ranunculus parviflorus*
Lolium temulentum	*e	*Scandix pecten-veneris*
Lythrum hyssopifolia	p	*Silene gallica*
Melampyrum arvense	np	*Silene noctiflora*
Rhinanthus serotinus	np	*Valerianella dentata*
Teucrium botrys	np	*Vicia tenuissima*
Valerianella rimosa		*Lathyrus aphaca*
Veronica praecox		
Veronica triphyllos	np	
Veronica verna		

DISCUSSION

Developments in farming practices are thought to have been responsible for the changes in the composition of arable weed communities. The richest communities have survived on calcareous soils where the climate is more favourable to species whose centres of distribution are around the Mediterranean. This has also been observed from the rest of Europe (Holzner, 1979), and it is possible that with the loss of species such as *Arnoseris minima* or *Caucalis platycarpos* from Britain we have lost whole communities of our most thermophilous annual plants. The species most sensitive to agricultural change seem to have retreated to refugia where the effects of modern agriculture are less extreme. These refugia are not simply areas of optimum climate or soil, but may also be places where agricultural activities are less intensive and crop performance is poorer, such as around the edges or in corners of fields. A survey of weed distribution in relation to distance from field margins (Wilson, in press) demonstrated a concentration of uncommon species and diversity within four metres of the field edge. It therefore appears that the more sensitive arable species are not only becoming rarer on a national scale, but also are becoming restricted to the most favourable areas of the fields in which they still occur. The extreme edge of the field between the regularly cultivated area and the hedge bottom is of vital importance for a number of threatened species including *Ajuga chamaepitys* and *Teucrium botrys* that now rarely grow within arable crops. Large-scale field boundary removal in recent years may have contributed greatly to the decline of many species.

Although the origins of the arable flora are in many cases obscure, and some species may not be truly "native" to Britain, arable weed communities nevertheless represent an unique document of man's agricultural activities. They form well-defined and stable communities similar to those in Europe, and can show considerable persistence at sites. They also contain some of Britain's most endangered plants, many of which are experiencing more rapid declines than any others in the British flora. Field margins are therefore extremely important areas for the conservation of some of Britain's most threatened species, and plant communities of great aesthetic value.

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