uestion 3: What is the status of, and changes in, the weed flora of different crop types (eg roots and vegetables) as recorded in CS2000 and what is the conservation value of the species concerned?

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INTRODUCTION

This report arises from the FOCUS (Finding Out Causes And Understanding Significance) research programme undertaken by CEH Merlewood. This research programme is designed to further analyse data from Countryside Survey 2000, a national survey of land cover, landscape features, vegetation, soils and freshwaters.

http://www.cs2000.org.uk/FOCUS_home.htm

Here we address one of the tasks within this project:

What is the status of, and changes in, the weed flora of different crop types (eg roots and vegetables) as recorded in CS2000 and what is the conservation value of the species concerned?

1. *In consultation with appropriate sponsors, carry out a brief review of the policy context for this research question and produce a 'policy context statement' (including how the outputs are expected to contribute to policy and/or practice).*
2. *Examine the frequency of arable dicotyledons, food plants and scarce arable plants recorded in the A plots for categories of crops.*
3. *Examine change in the frequency of arable dicotyledons, food plants and scarce arable plants between 1978 and 1998 using all repeat plots.*
4. *Discuss results with relevant arable weed specialists (including members of the Cereal Field Margins HAP Steering Group) and report likely consequences of the results for wildlife conservation.*

This report summarises progress to November 2002 (excluding feedback from the Steering Group meeting in October 2002), for discussion at the Cereal Field Margin HAP Steering Group in December 2002. Analyses that include soil type effects are planned for early 2003. The work will then be revised and updated before being submitted as part of the final FOCUS report in March 2003.

<u>Definitions</u>

- Arable plants are all whose habitats include the cultivated areas of arable fields; normally crop plants and volunteers are excluded.
- "A plots" are the arable field margin plots introduced in CS2000. They run 100 m along arable field edges, and extend from the limit of cultivation inwards towards the field centre by 1 m. All plant species are recorded in each plot (Firbank et al., 2002)

Policy Context Statement

In consultation with appropriate sponsors, carry out a brief review of the policy context for this research question and produce a 'policy context statement' (including how the outputs are expected to contribute to policy and/or practice).

Changes in the flora of arable fields were recognised in the early 20 th century, when it was noted in regional florae that some former arable plants were becoming scarce. (Firbank, 1988) Studies during the later half of the 20 th century demonstrated a shift in arable plant flora towards grass weeds, that were associated with changes in tillage and increases in winter crops and inputs of fertilisers and herbicides (e.g. Firbank, 1999) Some arable plants became increasingly localised, to the point that the arable flora was the most threatened group of plants in GB (Stewart et al., 1994).

The changes in the arable flora were also being implicated in the declines of farmland bird species. Potts (1997) demonstrated the links between arable plants, invertebrates and population change in grey partridge, and Wilson et al. (1999) noted the relationships between arable flora and other farmland birds. In general, the shift away from dicotyledonous plants to grass weeds disfavoured the plants that are important food sources for birds, leading to the development of prescriptions for Conservation Headlands, intended to maintain these food resources at little cost to the farmer (Sotherton, 1991).

Concern over the direct and indirect conservation value of arable plants remains high. The UK Biodiversity Action Plan names several arable plant species, including *Adonis annua* and *Centaurea cyanus*, while *Agrostemma githago* is now considered extinct in the wild. The Cereal Field Margin Habitat Action Plan aims to maintain and restore 15,000 ha of habitat (Anon, 1995). This plan is supported through over 40 local BAPs, and, in England, through the new Arable Options of the Countryside Stewardship Scheme.

Countryside Survey records arable plants from main plots, the new arable margin plots and field boundary plots. These have already demonstrated national declines in food plants for farmland birds between 1978 – 90 (Smart et al. 2000), and confirmed the impression of shifts towards greater levels of grass weeds (Bunce et al., 1999). The new research will update these results, stressing differences between crop types, and the further analysis of the Arable Margin plots will give a baseline assessment of species diversity in this habitat.

Examine the frequency of arable dicotyledons, food plants and scarce arable plants recorded in the A plots for categories of crops

A vegetation survey of arable field margins was undertaken during 1998 as part of Countryside Survey 2000. 569 1 km squares of Great Britain were selected on a random stratified basis, and within these, five main vegetation plots were positioned at random. Where these plots were located within an arable field, a margin plot was established, 100 m x 1 m, extending inwards from the edge of cultivation. All plant species were recorded within the 547 plots.

Mean species richness per plot was 13.8, and was greater in the west of England and Wales, and was greater in root crops and vegetables than in cereals (Fig. 1). 294 non-crop species were recorded, 110 of which were found in ten or more plots. The most frequent were *Cirsium arvense, Galium aparine, Elytrigia repens, Poa annua, Urtica dioica, Anisantha sterilis, Rumex obtusifolius, Arrhenatherum elatius, Convolvulus arvensis*. and *Veronica persica.* Of the other major arable weeds, *Avena fatua* and *Alopecurus myosuroides* were ranked 28 and 37 in frequency.

The most frequent forage plants for birds, butterfly larvae and bees are given in Table 1. This list is dominated by generalist species favoured by high nutrient levels, rather than by specialist arable plants. There appear to be differences between crop types (Table 2 – *stats tests to follow*), with set-aside being particularly rich in forage plants for farmland birds.

No species listed in the UK Biodiversity Action Plan were recorded, nor were any of the species listed as extinct, rare or scarce by Firbank & Wilson (1995). Nevertheless, some species were of conservation interest in their own right, including *Kickxia spuria* (6 plots), *K. elatine* (3 plots) and single records of *Chrysanthemum segetum* and *Silene noctiflora.*

Fig. 1 *Box and whisker plots of species number per arable margin plot in the different crop types surveyed. The crops were grouped as follows (sample sizes under labels): Cereals: barley, barley and wheat, oats, sorghum / kale, wheat. Stubbles: set-aside (natural regeneration), stubble, stubble – barley, stubble – oats, stubble – oilseed rape, stubble – rape, stubble – wheat. Root crops: potatoes, potatoes and beet, sugar beet, swedes, turnips. Vegetables: Brassica spp., broccoli, cabbage, carrots, cauliflowers, field beans, onions and sugar beet, peas, sprouts. Oil seed rape: includes spring and winter sown. Other: flax, hay, kale, linseed, lucerne, maize, sorghum / kale. Differences among crop types were significant ($F_{5,451}$ = 5.64, $p < 0.001$, with differences between cereals and root crops at $p < 0.07$ and between cereals and vegetables at $p < 0.09$, Tukey HSD for unequal sample sizes).*

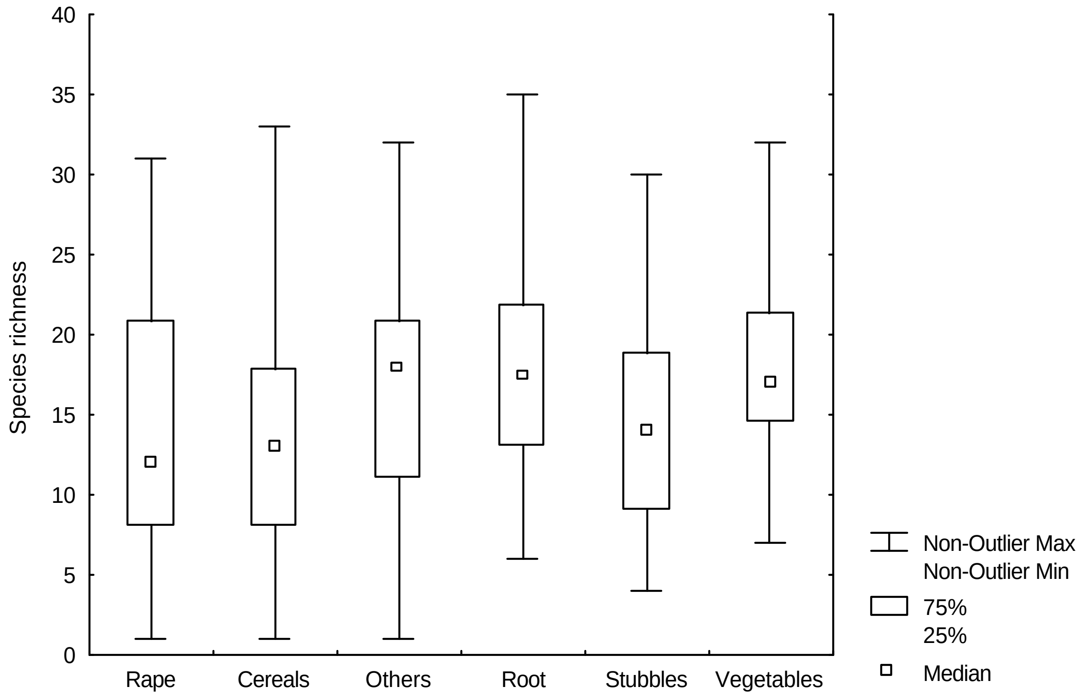


Table 1. Frequencies of forage food plants for farmland birds, bees and butterfly larvae in all 552 A plots, excluding crop plants

Bees	Lowland farmland birds	Butterfly larvae	Species	Number of A plots	%Freq
y	y	y	*Cirsium arvense*	295	53
		y	*Elytrigia repens*	265	48
	y	y	*Poa annua*	228	41
	y	y	*Urtica dioica*	212	38
	y		*Rumex obtusifolius*	167	30
		y	*Arrhenatherum elatius*	160	29
y			*Convolvulus arvensis*	159	29
	y		*Stellaria media*	153	28
	y		*Polygonum aviculare agg.*	151	27
y			*Heracleum sphondylium*	149	27
y	y	y	*Cirsium vulgare*	146	26
	y	y	*Lolium perenne*	141	26
	y	y	*Holcus lanatus*	126	23
	y	y	*Poa trivialis*	125	23
	y		*Senecio vulgaris*	121	22
		y	*Dactylis glomerata*	118	21
y	y		*Lamium purpureum*	102	18
	y		*Chenopodium album/polyspermum*	96	17
y	y		*Ranunculus repens*	96	17
	y		*Viola arvensis*	94	17
y	y		*Sonchus asper*	92	17
y	y		*Taraxacum agg.*	92	17
y			*Lapsana communis*	89	16
		y	*Geranium molle*	85	15
	y		*Persicaria maculosa*	83	15
	y	y	*Capsella bursa-pastoris*	81	15
	y		*Myosotis arvensis*	75	14
y	y		*Rubus fruticosus agg.*	68	12
		y	*Plantago major*	64	12
		y	*Sisymbrium officinale*	62	11
y	y		*Sonchus oleraceus*	56	10
y			*Papaver rhoeas*	56	10
	y		*Poa pratensis sens.lat.*	56	10

Table 2 *Mean richness of forage plant species per A plot for bees, butterfly larvae and farmland birds by crop type*

	No. plots	Bees	Butterfly larvae	Farmland birds
Cereals	307	3.4	4.7	6.1
Rape	65	3.8	5.7	7.6
Beet	21	5.7	6.2	10.6
Grass	4	4.3	9.8	11.3
Other veg	74	4.3	5.8	9.1
Ploughed	31	1.5	1.9	2.4
Other root	8	3.4	4.5	6.6
Set-aside	7	6.9	8.0	12.1
Stubbles	21	3.7	4.8	5.9
Unknown	7	3.6	4.6	8.4

Examine change in the frequency of arable dicotyledons, food plants and scarce arable plants between 1978 and 1998 using all repeat plots.

Haines-Young *et al.* (2000) reported that there had been an increase in the diversity of the boundaries of arable fields. This was on the basis of a small sample of 22 boundary plots (B plots) between 1990-98, many of which had shifted into grassland communities. Therefore, in order to look at the changes in arable plant communities, new analyses were required.

For these analyses, arable land was defined as land that was in the Arable and Horticultural Broad Habitat in 1990 and 1998 (land in 1978 cannot be mapped to Broad Habitat) and had vegetation from the crops/weeds Aggregate Class. This was to ensure that waste ground was not included, nor was land that shifted to or from other vegetation types, including longer-term set-aside. The plots were relocatable quadrats of 200 m^2, positioned away from field margins. The sample size was 71, the vast majority of which were in Environmental Zones 1 and 2, representing eastern lowland England and lowlands of Wales and western England. We present data on the changing richness of plant species in these plots over time, categorising species in different ways. Given the small sample size, data are presented by Environmental Zones.

The significance of changes, and interactions between Environmental Zones and years, were analysed using ANOVA with a repeated measure at the plot level and square as a random effect. Since all data were counts, the error was specified as Poisson with a log link function. All analyses implemented using the %GLIMMIX macro in SAS. Degrees of freedom were estimated using the Satterthwaite approximation.

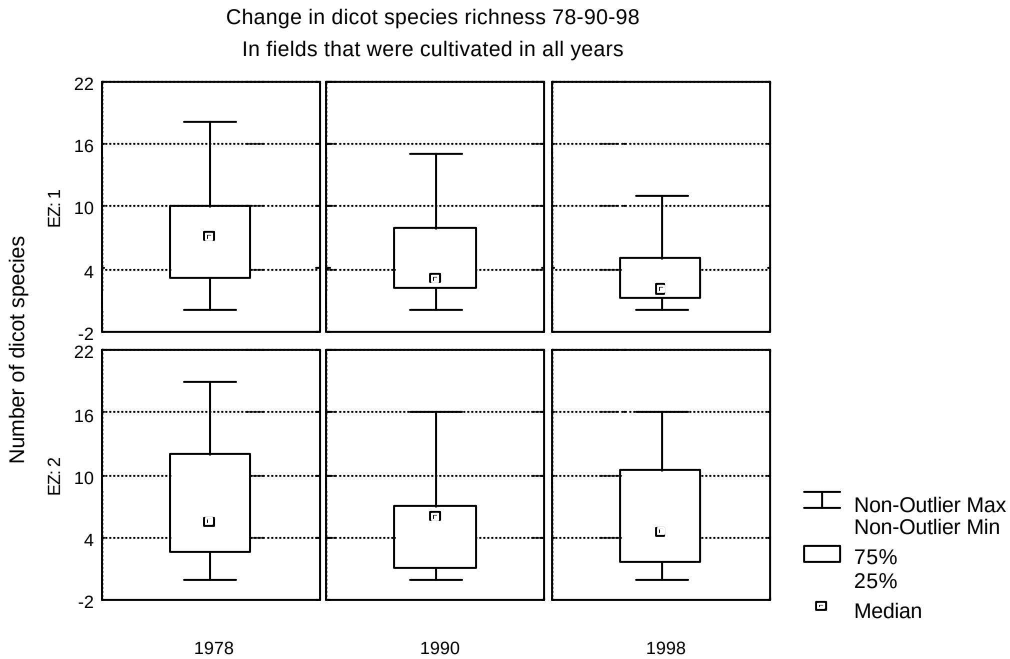
The list of most abundant forage plants are as given in Table 1, but this excludes the less frequent species. A total of 123 species have been recognised within the CS database for bees, 279 for farmland birds and 170 for butterflies (see Smart et al., 2000). Not all species are found in arable habitats.

No BAP-listed arable plants were found in these plots at any time.

Total no. species, dicotyledonous plants

There has been a marked reduction in the mean species richness of dicots in Zone 1, but not in Zone 2 (differences in zones, n.s; in years, $p = 0.002$, interaction $p = 0.029$).

Fig 2. *Changing species richness of dicotyledonous plants in arable field centres*

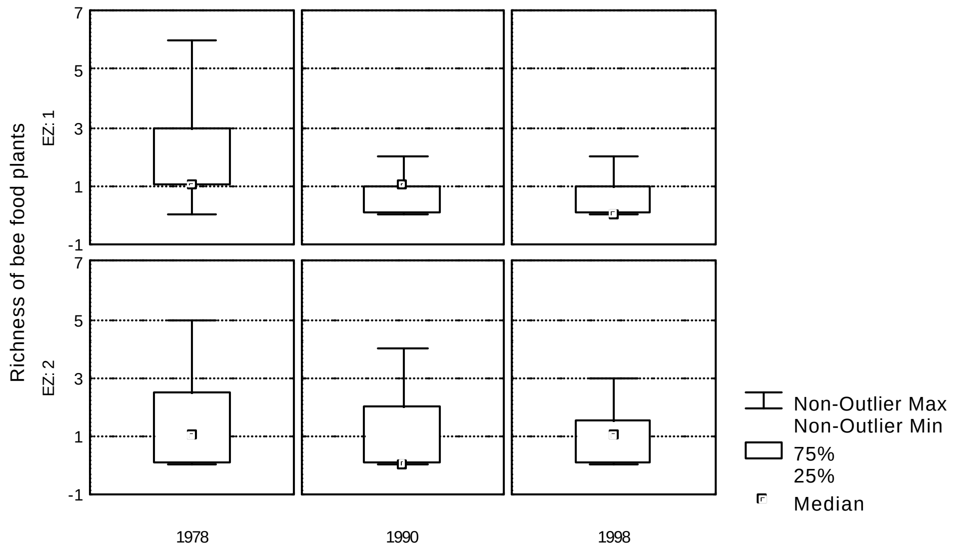


Total no. species, bee forage plants

There was evidence of substantial declines in species richness of bee food plants ($p = 0.0003$). This decline seemed more pronounced in Environmental Zone 1, but the difference was not significant statistically.

Fig 3. *Changing species richness of forage plants for bees in arable field centres*

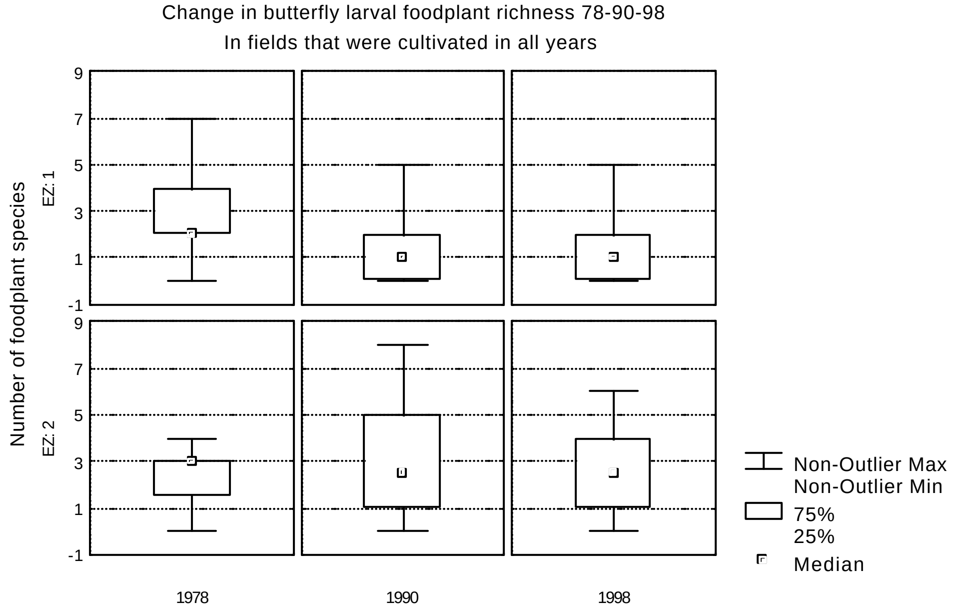
Change in bee foodplant species richness 78-90-98
In fields that were cultivated in all years



Total no. species, butterfly larvae forage plants

Evidence of declines of food plants for butterfly larvae was also strong (p = 0.003), and they were significantly greater in Environmental Zone 1 (p = 0.032).

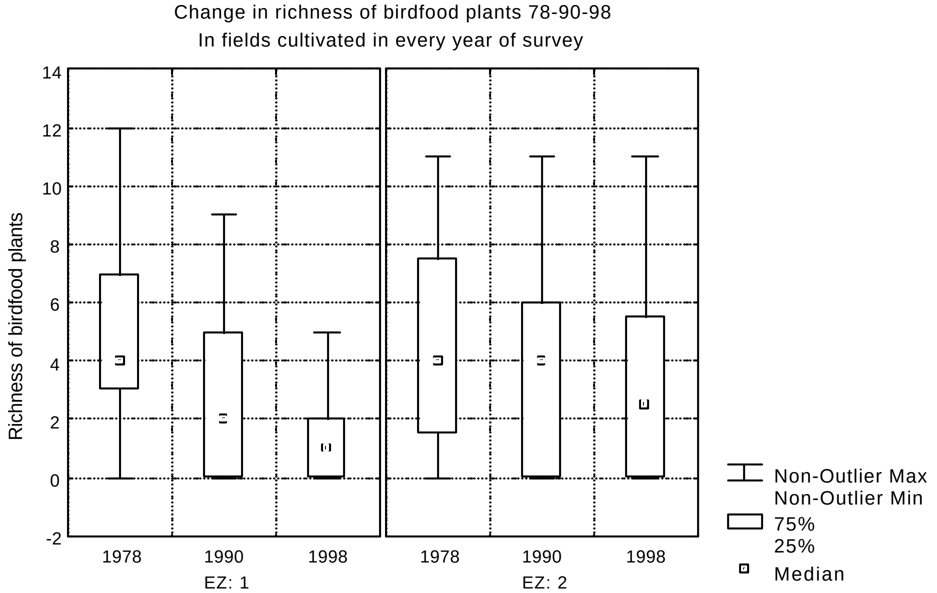
Fig 4. *Changing species richness of forage plants for butterflies in arable field centres*



Total no. species, forage plants for farmland birds

Declines in species number were also observed for food plants for farmland birds (p = 0.0003), and while they appeared steeper in Environmental Zone 1, the zone x year interaction was not significant.

Fig 5. *Changing species richness of forage plants for farmland birds in arable field centres*



Changes in frequency of bird food plants have already been analysed in further detail, and published in the proceedings of the AAB conference "Birds and Agriculture" (Firbank & Smart, 2002). The summary of this work is as follows:

> One of the explanations for declining populations of farmland birds is the decline in frequency of food plant species that are important in bird diets. Published results from the Countryside Surveys of 1978 and 1990 have demonstrated that such declines did, indeed, take place in the wider countryside. Here we include data from the Countryside Survey 2000, considering plots taken from field centres on arable land in 1990 and 1998. These show a range of trends for food plants, ranging from increases (e.g. *Cirsium arvense*), stabilisation of past declines (e.g. *Poa annua*) to continued declines (*Polygonum aviculare* and *Stellaria media*). The last two species are now found in only around 20 % of sample plots, compared with around 50 % in 1978. In general, arable field centres remain a much poorer source of food plants for farmland birds than in 1978.

The key evidence for these statements are to be found in the tables extracted from the paper, that consider changes in key bird food plants observed in main plots recorded in 1978 and 90 and for 1990 and 98; note, the sample size for the latter was larger (Table 3):

Table 3. *Frequency of food plant species as a percentage of total number of plots in weed-crop plant communities in 1978, 1990 (a, using only those plots surveyed in 1978, and b, using those plots surveyed in 1998) and 1998. Percentage changes are shown per year between two sets of survey data; note inconsistencies arise because of rounding.*

Plants	% frequency of plots				% annual change	
	1978	1990a	1990b	1998	78-90	90-98
Cerastium fontanum	8	4	1	1	-4	3
Cirsium arvense	18	11	7	13	-3	7
Holcus lanatus	6	4	1	1	-2	0
Holcus mollis	1	1	1	0	0	-6
Lolium perenne	21	14	12	11	-3	0
Poa annua	55	36	31	36	-3	1
Persicaria maculosa	22	9	7	8	-5	2
Poa pratensis	4	6	3	4	4	3
Poa trivialis	29	8	9	11	-6	2
Polygonum aviculare	49	33	30	22	-3	-2
Rumex acetosa	2	1	0	0	-6	-8
Rumex obtusifolius	9	8	6	9	-1	4
Stellaria media	57	35	29	21	-3	-2
Taraxacum agg.	5	6	3	6	2	8
Trifolium pratense	4	0	0	1	-8	
Trifolium repens	11	11	7	4	-1	-3
Urtica dioica	8	7	7	6	-1	-2

Effects of soil type

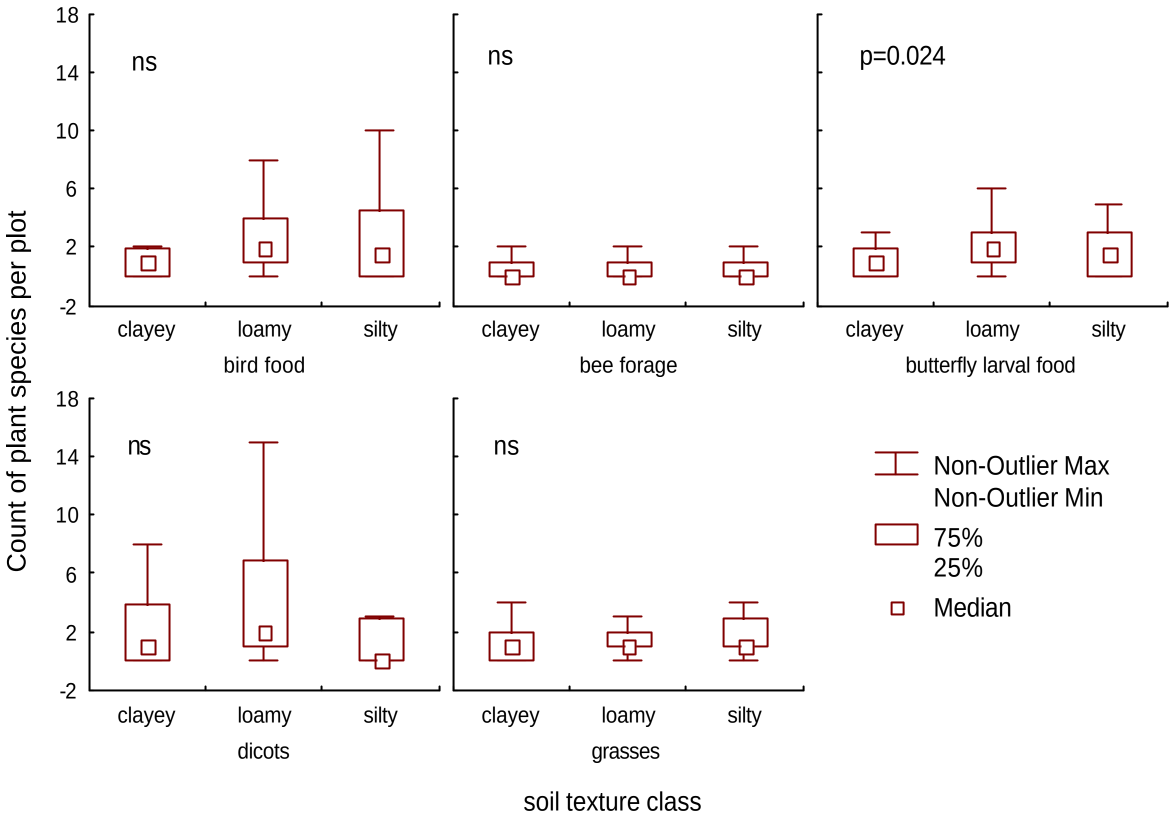
Following soil sampling in 1998 from X plots that were first recorded in 1978, analyses of differences in botanical character could be carried out by soil texture class. A total of 88 X plots were available for analysis. All were recorded in aggregate class 1 in 1998 but may have been allocated to other aggregate classes in 1978.

The only significant difference in richness between soil classes was detected for count of buttefly larval food plants (Fig 6). Low sensitivity in the analysis was linked to low sample size. Also, there were too few sandy soil samples for analysis.

Table 4. *Number of plots per soil texture class.*

Texture class	Number of X plots in 1998
Loamy	285
Clayey	95
Silty	60

Fig 6. *Differences in counts of plant species groups between X plots on arable land in 1998 when grouped by soil texture class. Soil texture was assessed from soil samples taken in 1998.*



Summary

Work thus far indicates that the Countryside Survey report (Haines-Young et al., 2000) may have underestimated the continued declines of the conservation value of arable habitats.

BAP-listed arable plants have simply not been recorded within the CS surveys, even when they were extended in 1998 to include much larger lengths of field edge.

Declines in species richness of forage plants for animals were less steep between 1990-98 than previously, but still continued. The continued declines of the major animal food plant species *Polygonum aviculare* and *Stellaria media* are of potential concern. Moreover, there is evidence that some of these declines have been more severe in the easterly lowlands of England than in arable land further west.

The arable plot data provide an important baseline for detection of future trends, but the lack of comparable data make them rather hard to interpret at the moment.

Discussion point

While arable species can be conserved very effectively within special areas such as conservation headlands and game cover, for many species, such measures may not be covering enough area to compensate for the loss in ecological quality of field centres. While field centres may be low in species richness and abundance, they are vast in area compared with conservation measures – how well BAP targets for arable flora and fauna be conserved against this backdrop of large scale declines in species richness of those plants that form the base of food webs?

Acknowledgements

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