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Pilot study to link Environmental Change Network and Countryside Survey vegetation monitoring.

Draft Final Report

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CONTENTS

Summary

1. The objective of this study was to assess the feasibility and potential value of introducing an annual vegetation monitoring system at Environmental Change Network sites, as an aid to the interpretation of Countryside Survey results.

2. ECN has a good coverage of the main vegetation types identified by the Countryside Surveys. Arable vegetation is not currently included in ECN vegetation monitoring, but there is scope to do this in future.

3. 1997 survey results were compared with those from a survey carried out in 1996, using the same methodology. This showed large annual fluctuations (up to 20 %) in mean species number for some vegetation types.

4. Annual fluctuations in vegetation as a result of, for example, weather conditions, can be substantial and it is important to take account of this in the interpretation of Countryside Survey data. ECN sites and methodology are an effective way of detecting these fluctuations.

5. It is recommended that annual vegetation monitoring at ECN sites should be included in or put into the associated work programme for CS2000 and subsequent Countryside Surveys.

Pilot study to link Environmental Change Network and Countryside Survey vegetation monitoring.

1. Introduction

The Countryside Surveys (Barr et al. 1993) were established to provide a comprehensive overview of land cover, landscape features and habitats in Great Britain. An important component of their methodology is to record which plant species are present in permanent monitoring plots within a stratified random sample of 1 km squares. Surveys have been carried out in 1978, 1984 and 1990 and the next is scheduled for 1998. Between 1978 and 1990 substantial changes were recorded, both in land use and in the species composition of plots. The number of species per plot is a basic measure of biodiversity and was used throughout the Countryside Survey 1990 (CS90) main report; even this relatively simple measure showed substantial change. For example, plots which remained woodland between 1978 and 1990 lost a mean of 3.2 species (19.9%) over that time. It is important that the reasons for such large changes are investigated and in particular to establish whether the changes that have been detected are long term trends or short term fluctuations. One possible explanation is that year to year differences in weather may give rise to large short term variation in vegetation composition. Because of the long intervals between Countryside Surveys it is not possible to assess this hypothesis directly from those data. This in turn means that it will take several more repetitions to have confidence that long term trends in vegetation are being detected.

One way of resolving this problem is to supplement the Countryside Surveys by annual vegetation recording at a limited range of sites. This could be done using randomly selected Countryside Survey (CS) plots, but a better solution is to make use of Environmental Change Network (ECN) sites. ECN is a collaborative programme involving many research institutes, government agencies and departments, including the DETR. The network was established to provide detailed environmental monitoring at a varied range of sites throughout the country. Not only are there already detailed vegetation records for these sites, but there are also ongoing measurements of the aspects of the physical environment most likely to cause change in ecological systems, including climate, air pollution and hydrology. Thus confirmation or refutation of the Countryside survey results can be linked to explanation via understanding of causal links. ECN has already implemented a comprehensive list of vegetation monitoring protocols (Sykes & Lane, 1996) which are scheduled to take place at either 3 or 9 year intervals. The present study was commissioned by DETR to assess the feasibility and potential value of adding an annual vegetation monitoring component, with the particular aim of aiding interpretation of Countryside Survey data. The aims of the investigation are:

1. To compare the botanical monitoring protocols used at ECN sites and in the Countryside Survey 1990 and to assess the representation of UK vegetation at ECN sites.
2. To develop and test an annual vegetation monitoring protocol compatible with Countryside Survey methods and representing the range of vegetation at ECN sites during the summer of 1997.
3. To assess the significance of observer error in detecting annual variation in vegetation.

4. To demonstrate analytical procedures which may be used to compare data from ECN sites and Countryside Survey and assess the impact of weather on year to year variation in vegetation.
5. To make recommendations for modifications to vegetation monitoring procedures to be implemented in Countryside Survey 2000.

2. ECN and the Countryside Survey

2.1 Comparison of vegetation protocols in ECN and Countryside Survey 1990

The details of recording vegetation are complex for both the Countryside Survey and ECN; each has a range of different sampling techniques to deal with particular situations. The methods of both schemes are outlined in Table 1.

Although there are differences, the core of the vegetation recording in both ECN and CS90 is based on the principal of recording plant species in quadrats which can be relocated, allowing change to be detected. Both also make provision for a quantitative assessment of each species, ECN by recording *frequency* across sub-cells of the quadrat and CS90 by estimating *cover* of a species. The main differences between the core vegetation measurements in the two schemes are:

1. Quadrat size.

Countryside survey uses quadrats of size 200 m^2 (main plots) and 4 m^2 (habitat plots) whereas ECN uses quadrats of size 100 m^2 (fine grain plots) and 4 m^2 (coarse grain plots). Quadrat size does have an effect on results but the two schemes match closely enough for the effect of the discrepancy to be minimal. Since the CS main plots are chosen randomly and hence form the basis of CS assessment of change, ECN fine-grain plots are most suitable as the basis of the proposed annual monitoring scheme.

2. Estimates of "cover".

CS estimates cover directly, a procedure known to be difficult and prone to error (Sykes *et al*, 1983) while ECN uses frequency counts from sub-cells, which is less error prone but gives only a relative estimate of cover. In estimating change, however, only relative estimates are needed so the two measures can be considered equivalent for this purpose.

3. Scope of recording.

Identification levels are similar for the two schemes with ECN recording more detail for bryophytes, lichens and some "difficult" groups of species. Thus ECN results can be made entirely compatible with CS recording levels.

In conclusion, therefore the sampling techniques of the two schemes are compatible and provide comparable measurements. In particular the ECN fine-grain plots can be used to supplement and interpret results from the CS main plots. Under both schemes it is possible to estimate levels of change in species which are increasing or decreasing at sites across Britain. Provided therefore that ECN sites are sufficiently representative of the UK vegetation it is possible to use annual monitoring at ECN sites to aid interpretation of the results of Countryside Surveys.

Table 1. Comparison of ECN and Countryside survey vegetation monitoring

ECN	Countryside Survey 1990
Location of sites	
• 11 terrestrial sites. Areas range from 190 ha to 6500 ha. Selected for coverage of the UK and to ensure stable management.	• 384 squares 1 km x 1 km (100 ha). A stratified random sample of Great Britain based on land classification.
Vegetation mapping	
• 'Baseline' vegetation survey of whole site using 2 x 2m quadrats on a grid (additional 10 x 10m plot for trees centred on the 2 x 2).	• Land use and major vegetation features mapped within squares. Classified according to ITE land classification.
Recording interval	
• 3 or 9 year intervals (+ baseline). Pilot study on annual vegetation recording c.f. this report.	• Varied, six or eight years to date.
Scope of recording	
• Vascular plant species rooted in quadrats, Bryophytes and lichens, except those growing on rocks or trees. (identification to species level in 'fine grain' and 'baseline' plots, but not 'coarse grain'). • Arable areas excluded.	• Vascular plants rooted in plots. (identification to species level not required for specified difficult groups). Only common bryophytes and lichens recorded. • Recording of quadrats in arable areas included, but limits of plot estimated and not marked out.
Permanent marking	
• Permanent marking at corners of plots.	• One permanent marker per plot if possible
Standard Quadrats	
• 'Coarse grain'. Every 9 years. Up to 50 quadrats of 2 x 2 m selected randomly from baseline grid positions. Occurrence of species in 25 regularly arranged sub-quadrats of 0.4 x 0.4 m^2 recorded to give frequency.	• 'Main plots'. 5 square quadrats of $200m^2$ (14.14 x 14.14 m) per 1 km square, pre-positioned at random Species list and cover estimates made.
• 'Fine grain'. Subjectively placed quadrats of 10 x 10 m in each NVC type; at least 2 per vegetation type. Occurrence of species in 10 randomly located sub-quadrats recorded to give frequency. Every 3 years.	• 'Habitat plots' 5 quadrats 4 m^2 per 1 km square, subjectively placed in land cover types where there is not already a 200 m^2 quadrat. Where there are >5 unrepresented land cover types they are chosen randomly; where there are <5, the 5 are distributed according to area covered. Linear features can be assessed by changing the shape of the quadrat, as long as it remains 4 m^2 area.
Boundary (linear) plots	
• OPTIONAL additional measurement only: A series of 0.4 x 0.4 m quadrats are located along a line running perpendicular to the boundary. Number of quadrats and length of line adjusted to suit situation. Where the line crosses a hedge row, woody species are record 5 m. either side of the line.	• 10 m x 1m plots along the edge of (i) boundaries closest to 200 m^2 quadrats in enclosed land (ii) up to 2 hedgerows (iii) up to 5 stream-sides (iv) up to 5 roadsides. Extra 10 x 1m quadrats are established adjacent, in parallel in water for the stream sides and on verges wider than 2m. Cover estimates made.
Tree monitoring	
• 'Coarse grain' plots within woodland. A 10 x 10 m plot is centred on the 2 x 2m plot. Tree species recorded and up to 10 trees marked and diameter at breast height (every 3 years) and height (every 9 years) measured. Seedlings recorded in 10 randomly distributed sub-quadrats of 0.4 x 0.4 m. • Forest Health may be recorded on ECN sites using the UN-ECE method.	• No comparable measurement
Pasture and cereal productivity monitoring.	
• Additional protocols implemented by some sites.	• No comparable measurement.

2.2 Coverage of vegetation types by ECN

A new classification of British vegetation has recently been produced by the Land Use Section at ITE Merlewood using results from all three Countryside Surveys. The classification comprises 100 vegetation categories aggregated into 8 main classes. A preliminary analysis (Table 2) shows that the sample of ECN fine grain plots used for a Quality Assurance (QA) exercise in 1996 provides a good representation of all of the aggregate classes, except arable. The omission of arable is to be expected as ECN monitoring excludes arable land from vegetation monitoring at present. In comparison with the proportion of CS plots used to create the classification, aggregate class 2, tall grasslands, is under-represented, possibly because the ECN plots did not include boundary vegetation or set-aside where such types may predominate, and class 5, Lowland wooded, is over-represented. At the level of the individual vegetation types the preliminary analysis showed that ECN QA plots cover 39 of the 94 non-arable classes. Given the relatively small number of ECN QA plots this is a surprisingly good match which provides a sound basis for comparison of results.

Table 2. Classification of ECN QA plots into Countryside Survey aggregate vegetation classes

Aggregate Vegetation Class	Alice Holt	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton	Rothamsted	Sourhope	Wytham	Total	Total %	CS Classes	CS Plots	CS Plots (%)
1. Crops/weeds											0	0	6	536	5
2. Tall grassland/herb				1			1	2		1	5	5	15	2448	22
3. Fertile Grassland		11		3		1				1	16	15	5	1559	14
4. Infertile Grassland	1		3		1	2	7		1	3	18	17	17	2310	21
5. Lowland wooded	6			4		4	2	8		6	30	28	9	1104	10
6. Upland wooded	4			2	1	1			1		9	8	12	811	7
7. Moorland grass/mosaic			2		9				7		18	17	17	1384	12
8. Heath/bog			5		5				1		11	10	19	1094	10
All	11	11	10	10	16	8	10	10	10	11	107	100	100	11246	100

3. Trial annual vegetation monitoring method

As a result of the considerations in Section 2, the ECN 'fine grain' vegetation monitoring protocol (Table 1) was used to test the feasibility and value of annual vegetation recording. At most ECN sites plots were set up for the first time in 1996. During 1996 a quality assurance exercise was carried out on a subset of the plots at each site which were surveyed both by locally appointed surveyors and by an independent consultant botanist, Ms. Caroline Hallam. Since this subset of plots are broadly representative of CS data (Section 2.2) they form an ideal basis for the pilot study since the acquisition of two consecutive years data enables a preliminary assessment of annual variation to be made. In 1997 these plots were again recorded by consultant botanists; the upland sites by Mr. Gordon Common (Macaulay Land Use Research Institute) and the lowland sites by Dr. Phil Wilson and Ms. Marion Read (Wessex Environmental Associates). These surveyors had undertaken the original 1996 recording at Sourhope and Porton respectively, so comparison with Ms. Hallam's work was possible. The dates of survey and the surveyors used for each site are given in Table 3. As an additional check on the effects of observer bias during the 1997 survey, ten plots at Wytham were also recorded by Dr. Michael Morecroft and two at Moorhouse by Mr Doug MacCutcheon. At the Wytham site, plots were originally set up and recorded in 1994 so it was possible, for this site only, to make comparisons with 1994 as well as between 1996 and 1997; this is particularly informative as the summer of 1995 was extremely hot and dry and the drought appears to have caused changes in the species composition of the grassland areas.

Table 3. ECN sites surveyed in 1996 and 1997

Site	number of plots *	1996 Date	1997 Date	1997 surveyors
Alice Holt	10	19-20 Aug	24 - 25 July	Wessex Env. Associates
Drayton	10	26-27 Aug	6 Aug	Wessex Env. Associates
Glensaugh	10	3-4 Sept	21 - 23 July	MLURI
Hillsborough	8	10 Sept	22-23 Aug	Wessex Env. Associates
Moorhouse & Upper Teesdale	14	29 Aug - 2 Sept	18 - 21 Aug	MLURI
North Wyke	10	17 - 19 July	17 - 18 July	Wessex Env. Associates
Porton Down	11	21 - 23 Aug	14 - 15 July	Wessex Env. Associates
Rothamsted	10	28 - 29 Aug	30 July	Wessex Env. Associates
Sourhope	10	17 - 18 Sept	4 - 15 July	MLURI
Wytham	11	15 - 16 July	27 June - 1 July	Wessex Env. Associates

* A few plots had to be excluded in 1997 for practical reasons, hence the numbers differ slightly from Table 2.

4. Significance of observer error

Observer error may contribute to annual differences in vegetation and this was investigated in the 1996 ECN quality assurance study described above. Results for those sites recorded by the surveyors which took part in this pilot study are shown in Table 4 broken down by plant type and surveyor. The percentage agreement is calculated as the number of records (i.e. presence of a species in a sub-quadrat) in common compared to the total number of distinct records. This method of calculating agreement is standard but gives a worst case result since, for example, mis-identification of a species results in two non-matching records whereas agreement produces only one match. For the complete study levels of agreement ranged from 50% to 75% with only three sites less than 69%. These results are similar to the levels of agreement arising from QA work performed for other studies. In 1997 a comparison of the results obtained at Wytham by the Wessex Environmental Associates surveyors and the site manager, M.D. Morecroft gave an overall 73% agreement which is consistent with the 1996 result.

It can be seen from Table 4 that some types of species were more consistently recorded than others. Bryophytes and lichens in particular are well known to be inherently more difficult to identify and are recorded in CS to only a limited degree for this reason. Knowledge of which species groups are more consistently identifiable allows such groups to be targeted for analysis.

Table 4. Selected Results from ECN QA assessment 1996. Percentage agreement between QA surveyor and surveyors whose work features in this report; broken down according to plant type

Plant type	Porton Down (P. Wilson / M. Read)	Sourhope (G. Common)	Wytham (M. Morecroft)
Ferns	-	100	88
Grasses	76	78	79
Forbs	77	77	72
Horsetails	-	-	86
Bryophytes & lichens	67	66	51
Rushes & sedges	91	54	69
Trees (mainly seedlings)	58	-	69
All	**75**	**73**	**70**

The numbers of species recorded for each of these sites and those in common is shown in Table 5. The agreement is somewhat better than for the number of records in common.

Table 5 Number of species recorded at Porton, Sourhope and Wytham by different surveys in 1996

	Porton Down (P. Wilson / M. Read)	Sourhope (G. Common)	Wytham (M. Morecroft)
Original Survey	109	74	109
QA survey	106	77	114
Both (with %)	90 (84%)	55 (73%)	87 (78%)

The quality assurance work shows that differences between observers can be substantial: even experienced, expert botanists, such as used here, are unlikely to get complete agreement. Indeed an individual botanist may not get 100% comparable results when duplicating recording on separate occasions - plots may not be aligned in exactly the same way, plots may have been recently grazed in one case but not the other and inconspicuous species may simply be overlooked on a chance basis. This problem can be minimised by having two botanists working in tandem, taking turns to check each others results, but even this will not solve all the problems

Lack of complete agreement between observers is not necessarily a serious obstacle to monitoring change provided (a) that the errors are not systematic (e.g. persistent failure to identify certain groups) and (b) a sufficiently large number of sites and plots are recorded to allow statistical techniques to separate trends from 'noise'. Point (a) is addressed by using competent and experienced surveyors, by the use of training, and through periodic QA checks. Point (b) will be considered again later in the report, but it is worth pointing out at this stage that too small a sample is more likely to result in failure to detect real changes rather than in false ones being identified.

5. Analysis

5.1 Changes in species number in Countryside Survey from 1978 to 1990

Different aspects of the vegetation composition of plots can be analysed but we concentrate here on the number of species per plot. CS data on changes in species number in different vegetation types were presented by Barr *et al.* (1993). Since then, however, the classification of vegetation has been refined into a system with 8 aggregate groups. We therefore present in Table 6 the data for changes in species number according to the new system. These data show that there have been significant declines in the number of species per plot for crops/weeds, infertile grassland and upland wooded vegetation. When all plots are taken into account there was also a significant increase in the number of heath/bog species.

Table 6. Changes in mean species number between 1978 and 1990 Countryside Surveys for aggregate vegetation classes. Data from the main plots only and from all plots (including for example ones for linear features) are shown separately. Significance levels were tested with paired t-tests:
*** p < 0.05; ** p <0.01; *** <0.001.**

Vegetation Class	Main plots			All plots - including linear		
	1978 mean	1990 mean	% change with significance	1978 mean	1990 mean	% change with significance
1. Crops/weeds	6.80	5.02	-26.07 **	6.81	5.28	-22.43 **
2. Tall grasslands	11.77	14.46	22.88	13.32	13.83	3.8
3. Fertile Grasslands	10.73	9.95	-7.26	12.49	11.99	-3.97
4. Infertile Grasslands	21.67	18.29	-15.56 **	21.21	18.27	-13.83 **
5. Lowland wooded	13.45	16.86	25.34	12.53	12.75	1.80
6. Upland wooded	19.59	15.54	-20.69 **	20.39	16.11	-20.99 **
7. Moorland grass/mosaic	22.06	21.67	-1.79	22.10	20.74	-6.16
8. Heath/bog	17.39	18.24	4.89	17.63	18.65	5.78 *

5.2 Changes in species number from 1996 to 1997 at ECN sites

5.2.1 Statistical methods

To avoid unwarranted distributional assumptions non-parametric statistical tests (Siegal, 1956) have been used throughout this report to analyse the data from the pilot and QA studies. Unless otherwise stated, Wilcoxon signed rank tests are used to test for change between pairs of years and Kruskal-Wallace analysis of variance to compare several sets of observations. The significance of results is presented in terms of the probability value of the test. Traditionally a significant result is taken as one in which a value less than 0.05 is obtained, with values of 0.01 and 0.001 representing increasing levels of significance. A note of caution should be sounded regarding probability values, however which should be borne in mind when interpreting results. When a number of comparisons are made the chances of obtaining a spurious significance are clearly increased compared to where only one comparison is made. Conversely when sample numbers are small the chances of detecting significant differences are reduced.

5.2.2 General differences

The number of species per plot were examined for 1996 and 1997 for each ECN site and each of the eight major vegetation types. Taking the dataset as a whole there was no significant difference between years ($p = 0.213$). However there was a significant effect of vegetation type on change in species number ($p = 0.043$). The data for each vegetation type individually are summarised in Table 7. It can be seen that there were substantial variations in mean species numbers between years. In lowland wooded vegetation there was a significant ($p<0.001$) increase of 1.9 (19 %) in mean species number per plot. Other vegetation types did not differ significantly; it should be remembered, however, that the sample size was small in some cases.

Table 7. Species number (all species) in plots at each vegetation type

Vegetation type	Number of plots	mean number of species 1996	Mean number of species 1997	Percentage Change	p (Wilcoxon)
2. Tall grassland/herb	5	12.2	12.4	1.64	0.891
3. Fertile Grassland	14	9.1	9.2	1.10	0.975
4. Infertile Grassland	18	27.7	28.9	4.33	0.378
5. Lowland wooded	28	9.8	11.7	19.39	**0.001**
6. Upland wooded	9	14.8	16.4	10.81	0.438
7. Moorland grass/mosaic	17	26.1	25.6	-1.92	0.144
8. Heath /bog	10	21.3	19.5	-8.45	0.091

Vegetation change may vary with site rather than vegetation type, reflecting for example regional differences in climate, soils or management, and a significant difference between sites ($p=0.015$) was found. In general those sites showing an increase in species numbers tended to be in the South East, whilst those showing a decrease were in the North and West (Table 8). Tests at individual sites indicated that there was a decrease in species number ($p=0.045$) at Moor House and an increase in species number at Rothamsted ($p= 0.007$). Vegetation type and site are not independent variables and there are likely to be interactions between the two, thus it is difficult to determine which is responsible for the observed differences. What is clear however is that species numbers can vary significantly between years and the difference is unlikely to be uniform across sites or vegetation types.

Table 8. Species number (all species) in plots at each site

Site	mean number of species 1996	Mean number of species 1997	Percentage Change	p (Wilcoxon)
Alice Holt	15.2	16.5	8.55	.235
Drayton	8.8	8.8	0.00	.757
Glensaugh	18.8	18.9	0.53	.905
Hillsborough	9.9	9.9	0.00	.731
Moor House	24.4	22.1	-9.43	**0.045**
North Wyke	16.5	15.2	-7.88	.347
Porton	28.4	31.8	11.97	.092
Rothamsted	5.4	8.5	57.41	**.007**
Sourhope	26.4	26.1	-1.14	.550
Wytham	16.5	17.3	4.85	.511

5.2.3 Contrasting plant types

As discussed in section 4 above, some species groups are subject to more observer error than others; some plant types are also likely to be more responsive to year to year changes in climate or management. Two broad plant types were considered in detail: forbs and bryophytes. Forbs (herbaceous dicotyledones) are a large enough group to be well represented at all sites and are reasonably consistently identified. They also include many ruderal species, which, with their short life cycles, high reproductive rates and effective dispersal are likely to be responsive, even to short term changes. The bryophytes (mosses and liverworts) are another large group of species well represented across the network. They are however subject to high observer error.

The forbs (Table 9) did show some year to year differences, though not generally so pronounced as for all species together. There was a significant decline in species number in heath/bog communities ($p=0.025$), which paralleled a decrease in overall species number for this vegetation class ($p = 0.091$; Table 7). Overall tests, however, showed no effect ($p > 0.05$) of either site or vegetation category on species number.

Table 9. Number of forb species in each vegetation type in 1996 and 1997.

Vegetation type	Number of plots	mean number of species 1996	Mean number of species 1997	Percentage Change	p (Wilcoxon)
2. Tall grassland/herb	6	6.2	6.2	0.00	-
3. Fertile Grassland	15	2.6	3.6	38.46	.192
4. Infertile Grassland	18	14.1	14.0	-0.71	0.731
5. Lowland wooded	27	3.8	4.3	13.16	0.123
6. Upland wooded	9	4.6	5.1	10.87	0.317
7. Moorland grass/mosaic	16	7.1	7.1	0.00	-
8. Heath/bog	10	4.9	4.4	-10.20	**0.025**

Bryophyte species number also varied by year (Table 10) but similarly failed to show any significant overall effect of site or vegetation type. Only lowland wooded vegetation showed a significant individual change, representing an increase in 1997 compared to 1996, in line with the trend for all species (Table 7), although the moorland grass/mosaic and heath/bog categories were close to significance.

Table 10. The number of bryophyte species by vegetation type in 1996 and 1997

Vegetation type	Number of plots	mean number of species 1996	Mean number of species 1997	Percentage change	p (Wilcoxon)
2. Tall grassland/herb	6	1.4	1.4	0.00	-
3. Fertile Grassland	15	1.1	1.0	-9.09	.557
4. Infertile Grassland	18	3.5	4.5	28.57	.205
5. Lowland wooded	27	2.4	3.1	29.17	**.013**
6. Upland wooded	9	3.8	4.6	21.05	.200
7. Moorland grass/mosaic	16	7.3	6.6	-9.59	.065
8. Heath/bog	10	8.2	6.9	-15.85	.072

5.3 Changes in species number 1994 - 1997 at Wytham ECN site

As the plots at Wytham have a slightly longer record they allow the opportunity to demonstrate in more detail what information it is possible to gain from annual vegetation recording. The weather conditions during this four year period were exceptional with a very dry, warm summer in 1995 (Figs. 1 & 2). The summer of 1996 had more typical temperatures and was wetter (although still drier than the long term mean); that of 1997 was warmer than average but substantially wetter than 1995.

Fig. 1 Temperature during the period 1994 - 1997 with long term mean values from Oxford. Arrows indicate dates of vegetation recording.

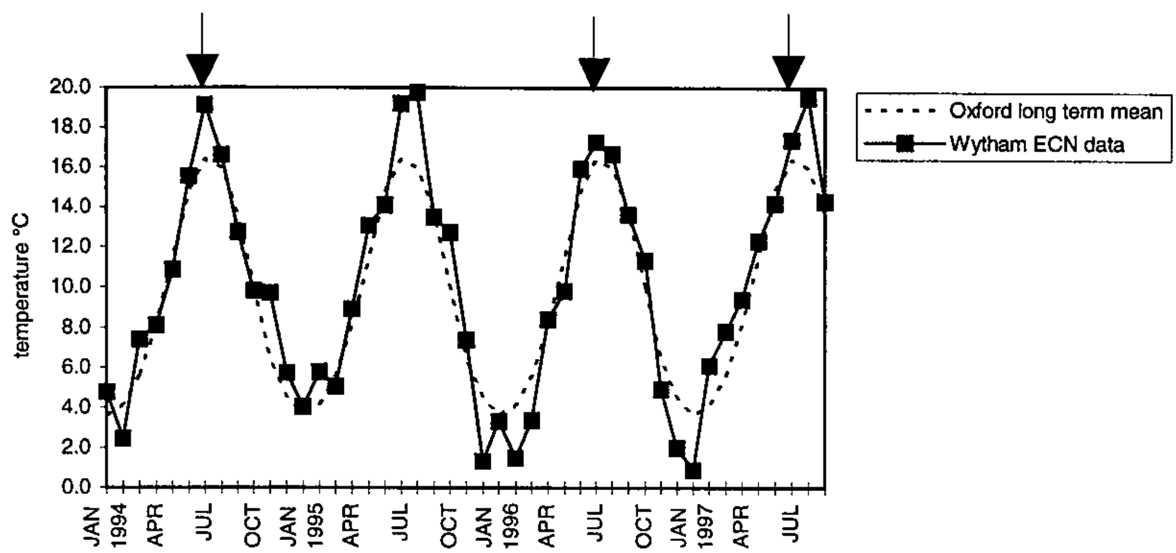
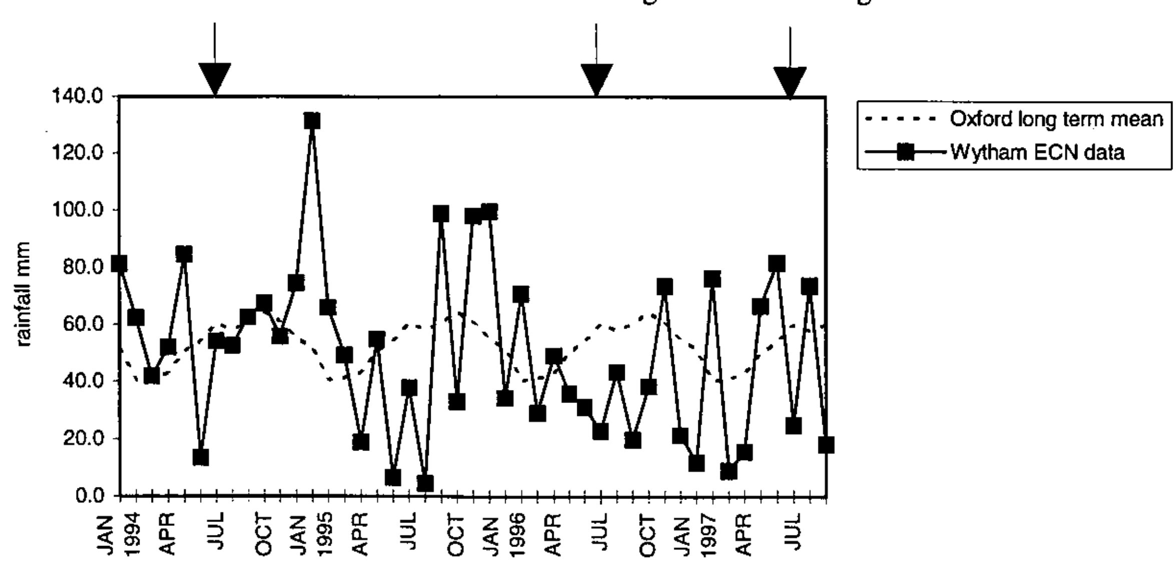


Fig. 2 Rainfall during the period 1994 - 1997 with long term mean values from Oxford. Arrows indicate dates of vegetation recording



Over the same period ECN vegetation monitoring detected changes in species composition. Figure 3 shows the total number of species recorded across ten of the plots at Wytham, which were surveyed on all occasions. Species are separated into monocotyledones, dicotyledones and bryophytes. It can be seen that an increase in the number of dicotyledone species was observed between 1994 and 1996 and that this was maintained in 1997. The differences between surveyors were relatively minor. In contrast, the monocotyledones, which were mainly grasses and sedges remained very constant across years as well as between the surveyors. The results for bryophytes are ambiguous with more evidence of surveyor differences. When the number of records (species in a cell) are studied (Figure 4), the increase in dicotyledones with time is also seen but the difference between surveys in bryophytes is not.

It is believed that the increase in dicotyledone species is related to climate. Grassland areas were observed to die back during the summer of 1995 and gaps subsequently opened up in the sward. In 1996 these gaps tended to be colonised by ruderal species, 'weed' species with short life cycles and high reproductive rates, the majority of which are dicotyledones. The most dramatic example was on an area of semi-natural mesotrophic grassland where *Crepis capillaris* was not recorded in 1994 but was present in all cells in 1996. Table 11 shows that ruderal species increased both in absolute terms and as a percentage of the number of dicotyledones. Another component of the increase in dicotyledones was higher numbers of tree seedlings in 1996 and 1997; trees show substantial year to year differences in seed production so it is hard to read too much into this, though the control of 'masting' (years with high seen production are termed 'mast' years) is an interesting subject.

Table 11 Ruderal species in different years and surveys with percentages of total for dicotyledones

	1994	1996 local	1996 central	1997 local	1997 central
number of species	9 (23%)	12 (24%)	17 (29%)	20 (36%)	19 (34%)
number of records	50 (28%)	81 (31%)	95 (35%)	90 (35%)	96 (37%)

Examination of the results showed that the surveyor difference in bryophyte species number was caused by whether or not small, uncommon species were detected; this depends on the surveyors' ability with this group and also on the state of the vegetation at the time of survey - after recent rain bryophytes re-hydrate and may be more obvious. The overall number of records of bryophytes is more reliable as it is dominated by relatively few abundant species which are more easily noticed.

Fig. 3 Number of species of different plant types in different years and different surveys at Wytham

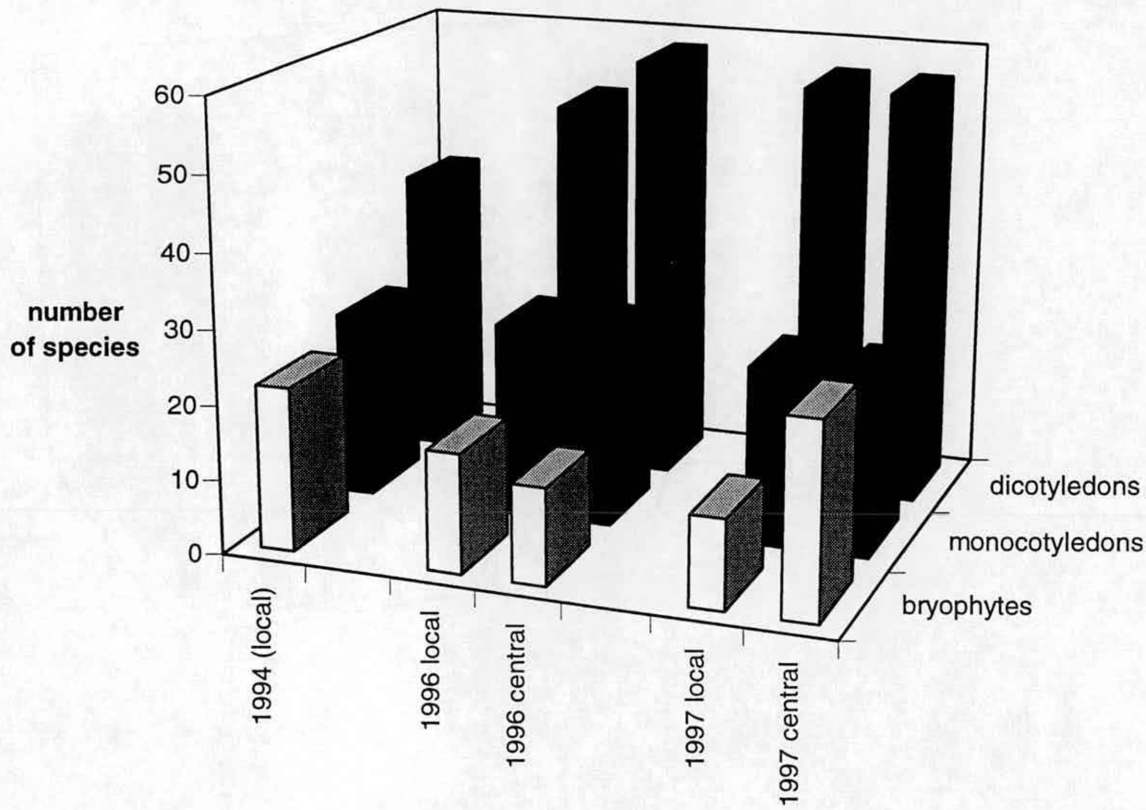
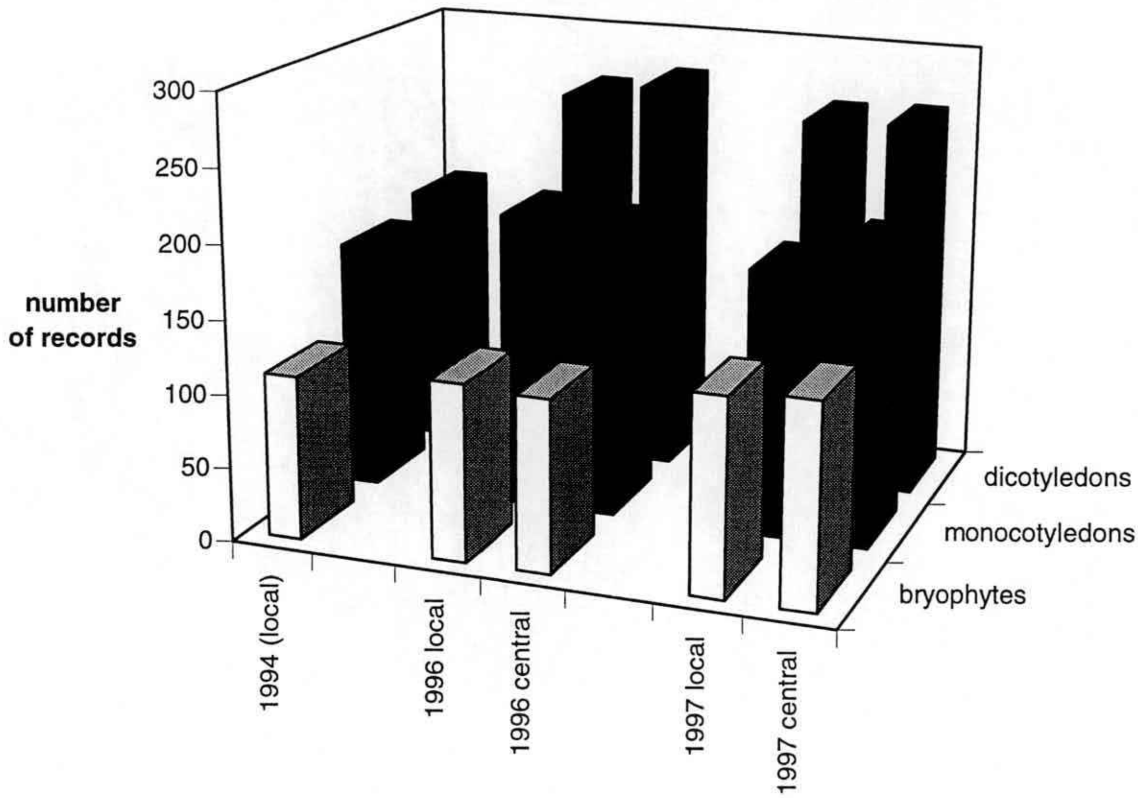


Fig. 4 Number of records of different plant types in different years and different surveys at Wytham



5.4 Comparison of vegetation changes from 1996 to 1997 with those from 1978 to 1990

The changes in species number between 1978 and 1990 in plots from different vegetation types in the Countryside Survey were described in Section 5.1. These have been plotted alongside the equivalent data for 1996 - 97 across ECN sites in Figure 5. (It should be noted that species number for the Countryside Survey is not the total species number as, unlike ECN data, certain species with major identification problems have been omitted leaving just 'Category 1' species. This is not a problem for comparisons as it is the percentage change we consider). It is clear that similar orders of magnitude of change could be found between successive years as between 1978 and 1990. It is worth briefly considering each vegetation type separately.

Class 1 Crops/weeds. As previously described this vegetation type is not included in the ECN scheme at present. There was a large decrease in species number from 1978 to 1990, probably because of agricultural intensification. The arable weed communities do however contain large numbers of short lived species and are potentially very sensitive to annual variations.

Class 2 Tall grassland/herb. This vegetation type did not show a significant change in species number in either the Countryside Survey or this study and appears to be reasonably stable. However only 5 ECN plots were included in this work which makes it very unlikely that any change could have been detected.

Class 3 Fertile grassland. This class did not change significantly in either comparison. These grasslands typically have very low diversity with perennial rye grass (*Lolium perenne*) easily the most abundant species. This situation is actively maintained by use of herbicides and re-seeding.

Class 4 Infertile grassland. These less productive grasslands tended to loose species through intensification between 1978 and 1990. No significant change was detected between 1996 and 1997 and the difference detected by the Countryside Survey may well be a long term trend.

Class 5 Lowland wooded. This was the vegetation type which showed the most dramatic change between 1996 and 1997; in contrast the Countryside Survey did not find any change. It may be that wet weather in 1997 promoted germination of new species - especially in disturbed ground where forestry operations had taken place. There were also more tree seedlings recorded in 1997 than 1996 (161 record compared to 122 across all sites).

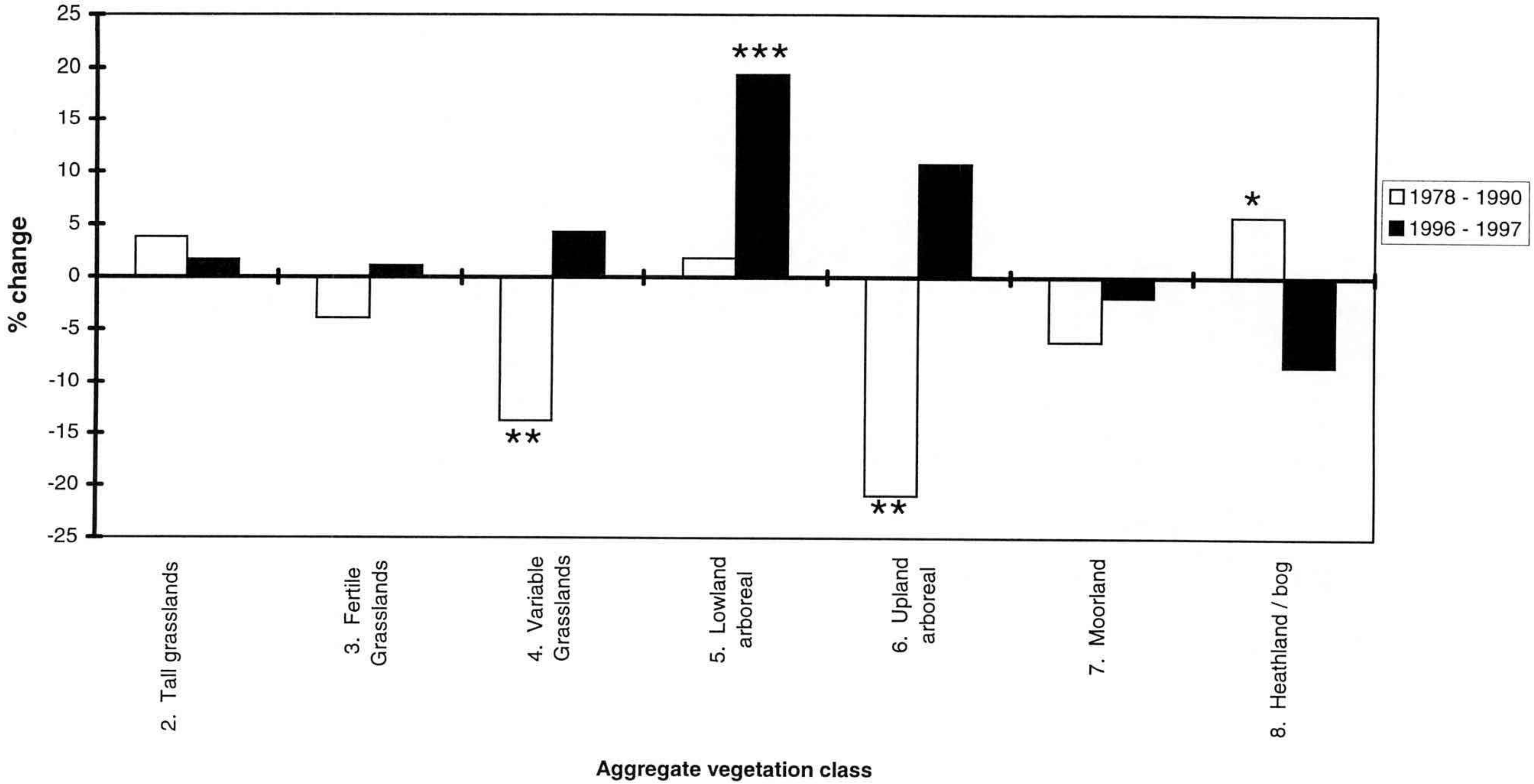
Class 6 Upland wooded. This group showed a major decline in species number in the Countryside Survey between 1978 and 1990; the probable explanation is increased growth and canopy closure of conifer plantations. There was a substantial increase in species number at ECN sites between 1996 and 1997, although the difference was not significant (the number of plots was relatively low). This suggests that even large, significant changes with plausible explanations, need to be viewed with caution when they are based on comparison of two years.

Class 7 Moorland grass/mosaic. Significant changes in species number were not found in either comparison. As for fertile grasslands, one species (in this case heather, *Calluna vulgaris*) often predominates and stability is actively maintained.

Class 8. Heath/bog. A small but significant increase in species number was detected by the Countryside Survey. At ECN sites there was a *decrease* of similar magnitude; whilst this was not actually significant, it was close to it considering the small number of plots involved; for forbs the decrease was significant. The reasons for these changes are not clear but may relate to variations in water status.

Inspection of Figure 5 shows that even data from a limited number of years may be useful in guiding the interpretation of data from Countryside Surveys. Given longer time series from ECN sites, the power of this approach could be increased by developing simple models which relate change in species number to climate variables monitored by ECN.

Fig. 5 Percentage Change in species number between 1978 and 1990 (CS) and 1996 and 1997 (ECN)



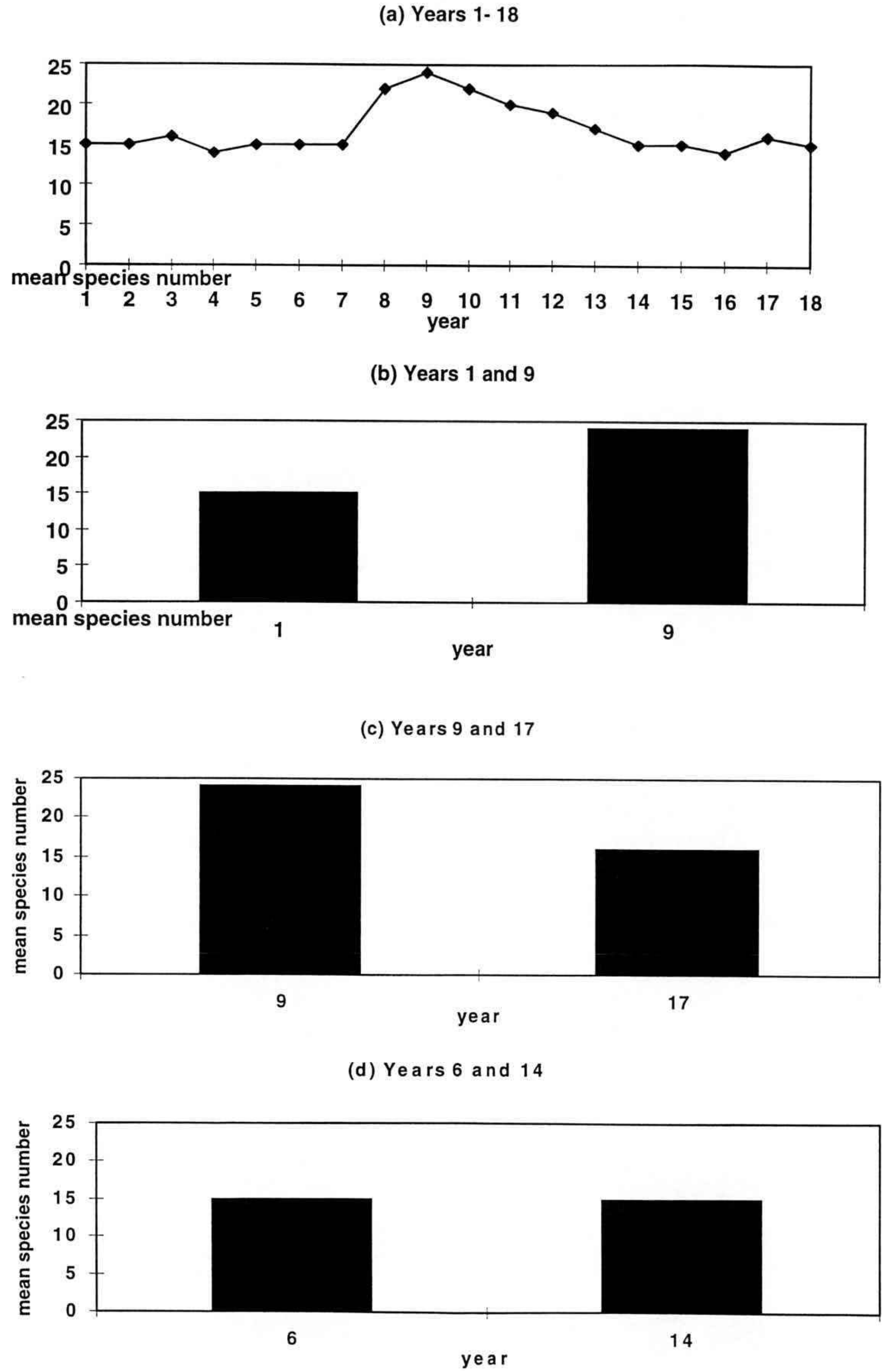
6. Implications for the Countryside Survey

It is clear that vegetation changes of the order of those between 1978 and 1990 can take place between two successive years. It is therefore not possible to automatically regard the Countryside Survey data as evidence of long term changes in vegetation. This is a serious problem which needs to be urgently addressed in order to interpret results of the next Survey in 1998. There is a need for substantially more work on annual vegetation changes both to gain a fuller characterisation of the problem and to understand the mechanisms underlying it. These results show that an annual vegetation monitoring scheme can be successfully run at ECN sites which would allow this problem to be quantified. As there are also good data for other environmental variables, it is also possible to start looking at the causes of such variation. Should field experimentation become necessary, ECN sites are also well placed to carry out this work, as most have staff based on site.

In order to illustrate what an ongoing annual vegetation monitoring system might show, which intermittent Countryside Surveys do not, we will present a theoretical example. Consider the situation in woodlands when there is an unusually strong gale: trees may be blown down causing gaps to open up in the canopy. In such cases, the soil disturbance and increased solar radiation levels at the forest floor allows new species to colonise and there is a temporary increase in diversity for a few years until the forest canopy re-establishes itself. A dataset such as that in Figure 8(a) might be collected by an annual vegetation monitoring scheme over a 15 year period. During this time 2 Countryside Surveys are likely to have taken place, but a significant increase (Fig. 8b), decrease (Fig 8c) or no change (Fig. 8d) result might have been found, depending on when the data were collected. This is of course an extreme case to illustrate a point, but more subtle year to year variations in the environment could have a similar effect and would more easily go unnoticed.

In an example like this there would also be substantial local variability. By using ECN sites locally based staff would have noted the impact of the storm in general terms making it possible to identify the maximum wind speed and duration of the storm at each site. Correlations between the extent of the changes and various environmental parameters could be derived from the network as a whole. For example, was the maximum windspeed a good predictor of damage by itself or was it modified by previous exposure to high winds? Did warmer sites show a quicker response in terms of species number than cooler ones? Did soil water content play any role? All of these could be investigated using ECN data.

Figure 8 Example dataset to illustrate changes in vegetation during an 18 year period



7 Recommendations for future work

1. Annual vegetation monitoring should be incorporated into the basic ECN programme at all sites. Without such an annual vegetation monitoring scheme, the interpretation of Countryside Survey results would be severely constrained.

2. The existing ECN 'fine grain' monitoring protocol can be used for this purpose - it has been shown to have the capacity to detect changes and allows comparisons with existing data. It is particularly important that this additional monitoring should start next year (1998) in order to identify any peculiarities in the year in which the next Countryside Survey takes place.

3. The ECN fine grain method could be applied to all CS90 vegetation types with the possible exception those types which are particularly sensitive to trampling, such as some of the mires. In these types of vegetation, annual monitoring is not recommended because it could result in long-term damage and be a direct cause of vegetation change.

4. There should be an increase in the number of plots to properly study under-represented vegetation types. In particular tall grassland / herb, upland wooded and heath / bog systems need further replication. In order to adequately sample tall grasslands it may be necessary to establish some linear plots at field margins. Sufficient extra plots can be established at ECN sites, once new sites at Snowdon and (probably) Cairngorms are included.

5. Arable systems should be included. This would require establishment of approximately 20 new plots across a number of ECN sites. At least 5 ECN sites are suitable for this.

6. A straightforward repeat of this year's work programme would cost a similar amount and yield useful data. Extra resources would be required to meet increased data analysis and reporting requirements as well as any additional fieldwork to address points 4 and 5 above.

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