Countryside Survey

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Countryside Survey – Environmental Change Network link

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Contents

Executive Summary

1. This component of the research programme for Countryside Survey (CS) in 2007 addressed the issue of year-to-year variability in vegetation: whether it was likely to influence Countryside Survey results and how it might relate to weather patterns.

2. The Environmental Change Network (ECN) is a collaborative, long-term UK monitoring programme, with the aim of detecting change in a wide range of environmental variables, using a series of intensively studied sites. Under standard protocols the vegetation of ECN sites is recorded every three years, starting in 1996. As part of the Countryside Survey in 1998 (some data also recorded in 1999) selected plots at ECN sites were also recorded in 1997 and 1998 so that, in combination with the prescribed 1996 and 1999 data, ECN vegetation data would be available to provide information on year to year variation in vegetation bracketing the CS recording year of 1998. For some of these plots, data were also available for 1994. As part of the 2007 Countryside Survey additional funding was provided to repeat the ECN vegetation monitoring in 2006 and 2007. In the intervening period some ECN sites had, despite lack of direct funding, attempted to continue with annual vegetation recording. In addition to the standard monitoring prescribed for 2002 and 2005, two sites have data for 2001 and four sites for 2003 and 2004. Thus ECN now has annual data on vegetation change since 1996.

3. Analysis of the ECN data has focused on year-to-year differences in numbers of species and the ecological characteristics of those species (using the systems of Grime and Ellenberg); these variables were the main reporting variables for the analysis of the main vegetation results from CS in 1998. The Countryside Vegetation System (CVS) was used for classifying the vegetation and stratifying the sampling and analysis.

3. Substantial year-to-year changes in CVS aggregate vegetation classes were found: 27% of the studied plots changed classification at some point. Between successive years 12% of plots changed and the rate of change increased with increasing interval between observations. At intervals comparable to the intervals between Countryside Surveys rates of change were similar to those for CS data. The least stable aggregate classes were tall grass/herb (AC II) (on average 36.5% of plots in each year change to other classes in successive years and 29.8% were previously classified as a different class) and upland wooded (AC VI) (31.5% of plots change to other classes in successive years and 25.3% were previously classified as a different class)

4. Of the variables studied, number of species was the most variable on a year to year basis. Strategy indices showed moderate levels of variability while the Ellenberg indices were substantially less variable.

5. In general ECN and CS findings were consistent with each other. There was one exception. The Ellenberg L (light) index showed a consistent, and significant, downward trend in the ECN data but no significant change in the CS data. This is shown to be a reflection of the greater proportion of lowland wooded plots in the ECN data, a vegetation class showing a substantial downward trend in this indicator.

6. Although there were substantial differences between years, and climate may well have been an important factor causing these, very few significant correlations between vegetation and weather variables were found In the ECN data. This is most likely to be due to the fact

that climatic effects may be persistent, subject to time-lags and caused by complex interactions between variables. Further investigation of these factors is needed.

7. An understanding of year-to-year changes in vegetation is informative in interpreting the results of Countryside Surveys. Year to year variability can be large enough to obscure or distort long-term changes and should be accounted for in the interpretation of CS and similar monitoring exercises. In the case of CS in 2007 it is unlikely that results, and in particular estimated changes, were affected markedly by the particular years in which surveys were carried out. One exception is the Ellenberg R score, change in which may have been underestimated by CS in 2007.

8. It is recommended that annual vegetation monitoring be continued at ECN sites with further developments to improve the coverage of vegetation types; in particular monitoring of the arable plots introduced at ECN sites for comparison with CS in 1998 should be reinstated.. More detailed analysis, should be carried out to improve understanding of the underlying mechanisms, particularly the link between vegetation properties and climate. Ultimately it should be possible to develop models of vegetation response to climate to help interpret the results of wider, intermittent monitoring programmes.

1. Introduction

Successive Countryside Surveys have carried out large-scale field surveys of British vegetation, using a stratified random sample of 1 km squares. The most recent survey (Carey *et al*, 2008)), was carried out in 2007 following previous surveys in 1978, 1984, 1990 and 1998. The component of the survey reported on here was designed to test whether year-to-year variation in vegetation are likely to affect Countryside Survey results. To do this additional monitoring work was carried out at Environmental Change Network (ECN) sites, where detailed records of climate, vegetation and other variables are available and where land management is relatively stable.

The Environmental Change Network (ECN) is a collaborative, long-term UK monitoring programme, with the aim of detecting change in a wide range of environmental variables, using a series of intensively studied sites. Under standard protocols the vegetation of ECN sites is recorded every three years, starting in 1996. As part of Countryside Survey in 1998 (some data recorded in 1999) selected plots at ECN sites were subject to additional monitoring so that, in combination with the prescribed 1996 and 1999 data, ECN vegetation data would be available to provide information on year to year variation in vegetation bracketing the CS recording year of 1998. An initial pilot study was carried out in the summer of 1997 funded by the DETR. This was essentially a repetition of the standard ECN vegetation survey carried out in 1996. The results are presented by Morecroft *et al.* (1997). In 1998 and 1999, two more surveys were carried out using the same plots and methodology. Additional plots were also set up to improve the coverage of different vegetation types, though linear features were not included in this contract.

As part of the CS in 2007 additional funding has also been provided to repeat, in 2006 and 2007, the ECN vegetation monitoring funded by CS in 1998. In the intervening period some ECN sites have, despite lack of dedicated funding, attempted to continue with annual vegetation recording. In addition to the standard monitoring prescribed for 2002 and 2005, two sites have data for 2001 and four sites for 2003 and 2004. Thus ECN now has annual data on vegetation change since 1996, albeit with gaps at some sites. All of the ECN vegetation data has been made available for analysis in this project.

The aims of this project were:

1. To repeat the vegetation monitoring undertaken at ECN sites for CS in 1998 using protocols compatible with CS monitoring.
2. To examine the relationship between annual fluctuations in vegetation at ECN sites and prevailing weather conditions.
3. To assess the extent to which vegetation monitoring in CS may be affected by year to year variations in vegetation and/or weather.
4. To review the protocols for vegetation monitoring at ECN sites with respect to applications in Countryside Surveys and to make recommendations for the long-term adoption of such monitoring as a standard requirement for ECN sites.

Earlier studies have shown that at least some plant communities can change on a year-to-year basis, influenced by the weather. One of the best examples of this is a study of road verges at Bibury, Gloucestershire, which have been monitored since 1958. Dunnett *et al*. (1998) reported changes in the relative abundance of different functional types, correlated with various measures of climate. In general terms, stress tolerant and ruderal (weedy) species increased in response to warm, dry weather during spring and summer whereas competitive, fast-growing species increased after wet conditions. Other studies showing year-to-year changes that can be attributed to climate include those by Herben *et al.* (1995), Collins *et al.* (1987) and van der Maarel (1985). It is important to determine whether such effects are widespread and whether they can influence the variables used to interpret Countryside Survey results, most of which have relatively stable values, based on the presence or absence of species, rather than, for example, biomass or cover.

A number of measures of vegetation characteristics (subsequently termed 'vegetation indices') have been selected for use in interpreting results from the Countryside Surveys (Bunce *et al*., 1998; Firbank *et al.* 2000; Carey *et al.* 2008) and the same variables are used in the analyses reported here. They include number of species per plot and scores of functional attributes according to the systems of Grime and Ellenberg. Grime (1979) proposed that plant 'strategies' could be characterised in terms of a triangular scheme reflecting the degree to which any species is adapted to disturbance (removal of material) or 'stress' (lack of resources). Three primary strategies were identified: *competitors*, plants adapted to low levels of disturbance and stress, *ruderals* which are adapted to high levels of disturbance and *stress tolerators*, which are adapted to low levels of resources. There are numerous intermediates and it is possible to score species according to how close they are to each of the three primary strategies. This was done for a large number of species by Grime, Hodgson & Hunt (1988) and can be expressed as C-radius, S- radius and R- radius, so for example, the higher its C-radius, the more strongly a species exhibits the attributes of a competitor. The Ellenberg system deals with adaptations to particular environmental conditions and scores species on a scale from approximately 1-9 (varying slightly with the property being scored) according to the habitats in which they are found, so for example a shade species would have a lower light (L) score than a species characteristic of open conditions. The system was original developed by Heinz Ellenberg for central Europe (e.g. Ellenberg, 1988), but has been adapted by Hill *et al.* (2000) to more accurately describe plant distributions in the British Isles. A shift in the mean value of CSR or Ellenberg scores should provide information on the nature of any change in the vegetation composition of different plots, sites or vegetation classes.

Data from the 1978 and 1990 Countryside Surveys were used to produce a statistical classification of vegetation, the Countryside Vegetation System (CVS) which has 100 classes of vegetation (Bunce *et al*, 1999). These vegetation classes are grouped together into eight aggregate classes (AC), which form one of the basic units for analysis of Countryside Survey results (Table 1.1). Aggregate vegetation classes formed the basis for selection of plots at ECN sites and were the basic stratification in analyses. Software (MAVIS) freely available from the CEH website (www.ceh-nerc.ac.uk) was used to classify ECN plots.

Table 1.1 Aggregate Vegetation Classes in the Countryside Vegetation System

I	Crops/weeds
II	Tall grass / herb
III	Fertile grassland
IV	Infertile grassland
V	Lowland wooded
VI	Upland wooded
VII	Moorland grass / mosaic
VIII	Heath / bog

2. Methods

Twelve ECN sites (Fig. 1, Table 2.1) were used in this study, representing a wide range of vegetation types, climatic conditions and land uses. The Snowdon and Cairngorms sites were not in the previous study for CS in 1998 because they joined the network later than the other sites. Table 2.2 shows the number of plots recorded by site and year. Between 11 and 25 plots were recorded at each site in 1998 under the CS contract, totaling 154 in all. Plots were mostly selected from existing ECN 'fine grain' vegetation monitoring plots (Sykes & Lane, 1996) to allow the time series to be extended by including records from earlier surveys, in particular the DETR funded pilot study in 1997 and the standard ECN recording in 1996. The number of plots recorded under the CS contract increases to 161 with the inclusion of Snowdon and the Cairngorms. The larger number of plots recorded in 1996 and the subsequent standard ECN vegetation recording years is clear. Three sites also had some records from 1994. The variable sampling effort in different years means that the number of observations made on individual plots are also very variable (Table 2.3). Plots observed only under the standard three year ECN monitoring cycle are recorded on four or fewer occasions, while plots selected for additional monitoring can have up to thirteen years of observations.

Table 2.1 ECN sites used for CS2007 study

Site	Sponsor / operator (owner)	Main habitats
Alice Holt	Forest Research	Broad leaved plantation woodland
Cairngorms	SNH & NERC/ CEH	Upland grassland and woodland
Drayton	DEFRA / ADAS	Mixed farmland
Glensaugh	Scottish Government/ MLURI	Upland grassland
Hillsborough	AFBI	Fertile pasture with some woodland
Moor House-Upper Teesdale	NERC/ CEH (Natural England)	Upland grassland and blanket bog
North Wyke	BBSRC/ North Wyke Research	Fertile pasture with some woodland
Porton	MOD/ DSTL	calcareous grassland with some woodland
Rothamsted	BBSRC/ Rothamsted Research	Arable farmland with some woodland
Snowdon	CCW & Welsh Assembly	Upland grassland
Sourhope	Scottish Government/ MLURI	Upland grassland
Wytham	NERC / CEH (Oxford Univ.)	Mixed broad-leaved woodland and mixed farmland

Selection of plots for annual recording was made on the basis of ensuring a good representation of different aggregate vegetation classes with the intention of having at least 15 plots of each aggregate class across as many ECN sites as possible. To enable this, some plots that had previously received a less detailed 'baseline' survey (Sykes & Lane, 1996) were included in 1997 and 1998. Table 2.4 summaries the aggregate class of all plots on all recording occasions. The first two categories have far fewer plots than the remainder. Aggregate Class I, Crops/ Weeds, is a habitat not normally recorded at ECN sites. Five completely new plots were set up for the 1998 study at each of the four ECN sites with arable land (Drayton, Porton, Rothamsted and Wytham). The protocol for setting up these new plots is included in Appendix 1. Unfortunately these plots were not revisited as part of the current project so that information on arable vegetation is very limited. Aggregate class II, Tall Grassland / Herb, was not sufficiently well represented amongst ECN plots to be thoroughly covered. This was anticipated, as it has the lowest area coverage of the Countryside Survey aggregate classes and occurs under land uses such as roadsides and field margins, which ECN monitoring was not designed to cover. Four plots from the 1997 survey were however kept within the recording programme and various other plots were classified as AC II in subsequent years. Four plots were unclassified by the classification software (Mavis) but each on one recording occasion only.

Figure 2.1 ECN sites used in analysis for Countryside Survey 2007 project

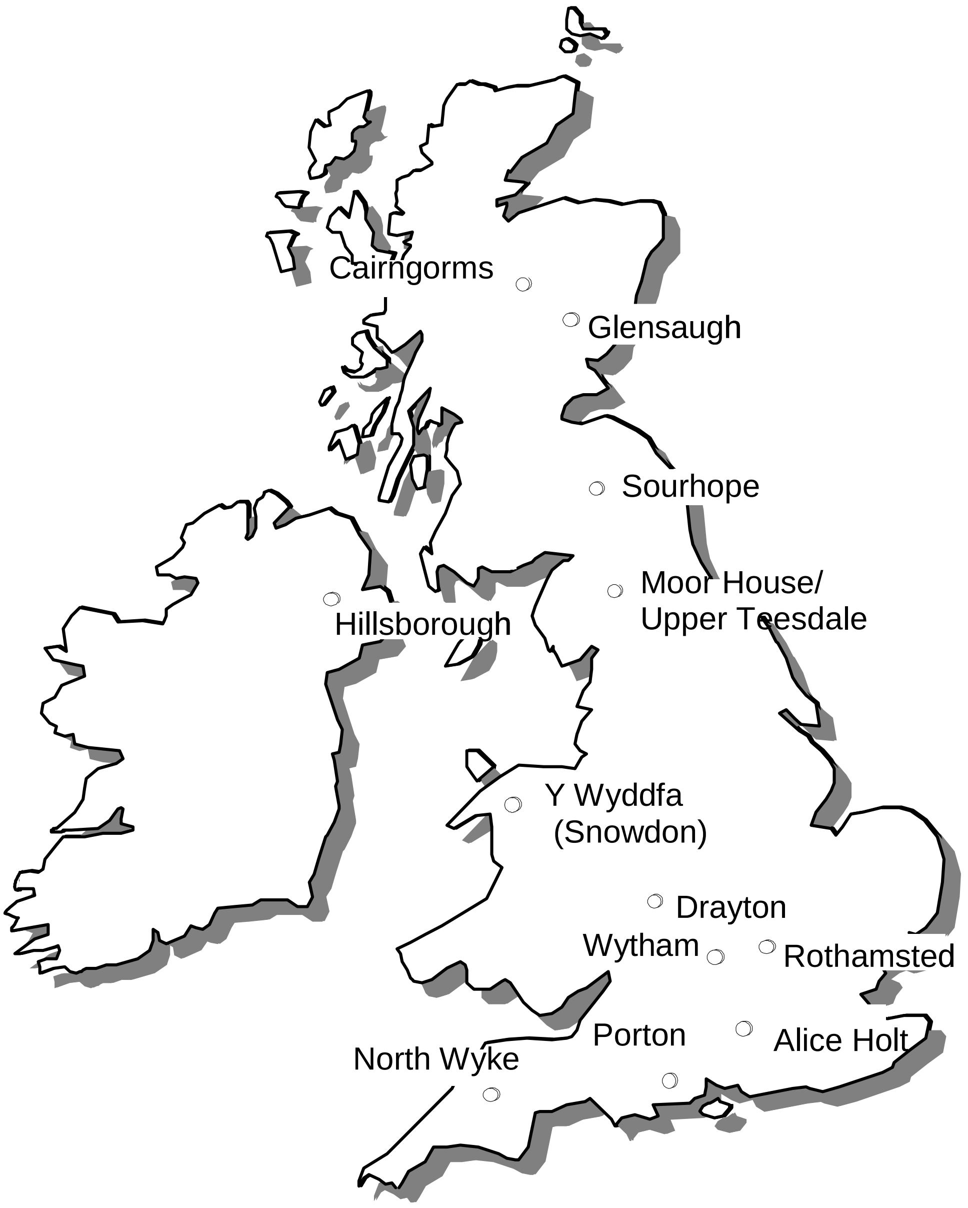


Table 2.2 Number of plots recorded each year by site

Year	**Alice Holt**	**Cairngorms**	**Drayton**	**Glensaugh**	**Hillsborough**	**Moor House/ Upper Teesdale**	**North Wyke**	**Porton Down**	**Rothamsted**	**Snowdon**	**Sourhope**	**Wytham**	**All sites**
1994			12				15					13	40
1996	49		12	14	24	45	19				18	13	194
1997	10		10	10	10	14	10	10	10		10	11	105
1998	15		17	14	12	25	11	17	15		11	17	154
1999	14		17	14	23	45	12	18	15	14	18	19	209
2000	14		17	14	12	18	11	8	14	4	11	17	140
2001						9						12	21
2002	50	12	12	14	23	45	17			18	18	15	224
2003			12		12						11	12	47
2004			12			24					11	16	63
2005	48	19	12	14	23	45	16	28			18	19	242
2006	14	14	12	14	12	24	11	13	8	14	11	14	161
2007	14	14	12	14	12	24	11	13	8	14	11	14	161
All	228	59	157	122	163	318	133	107	70	64	148	192	1761

Table 2.3 Number of years plots recorded by site

Number of years plot observed	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House/ Upper Teesdale	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham	All sites
1	9	2			1		7	19	1				39
2	9	3					2	1		4		2	21
3	25	5	5				16	3	5			3	62
4		9			11	20	1	1	2	14	7		65
5	1					1		2	2			2	8
6							7	7	6			2	22
7							4	3				1	8
8	5			4		6							15
9	9			10	2	3							24
10					10	7					1	2	20
11			2			8					10		20
12			10										10
13												10	10
All	58	19	17	14	24	45	37	36	16	18	18	22	324

Table 2.4 Vegetation type of plots recorded by site

Aggregate vegetation class	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House/ Upper Teesdale	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham	All sites
I Crops/weeds			16					9	14			11	50
II Tall grass / herb	5		29		25			4	4			16	83
III Fertile grassland			112		30		41		1			39	223
IV Infertile grassland	9			34	11	27	26	79			26	35	247
V Lowland wooded	100				68		51	14	51			84	368
VI Upland wooded	112	4		7	29	47	12				15	5	231
VII Moorland grass / mosaic				25		128	3			35	85		276
VIII Heath / bog	2	55		56		115				29	22		279
Unclassified						1		1				2	4
All classes	228	59	157	122	163	318	133	107	70	64	148	192	1761

The methodology was the ECN ‘fine grain’ vegetation monitoring protocol in which the presence of species is recorded in 10 randomly distributed 400 x 400 mm quadrats ('cells') within a larger 10 m x 10 m square plot. Plots and cells are permanently marked to ensure accurate relocation. The detailed methodology is described by Sykes & Lane (1996) and a comparison of the ECN and Countryside Survey methods is given by Morecroft *et al.* (1997). The method does differ from that of CS, which is not ideal for making comparisons, but it was adopted as it allowed a longer run of data to be analysed. Countryside Survey vegetation recording is based on species lists with cover estimates for a range of permanent plots located within randomly selected 1 km squares. Full details may be found in, for example Barr *et al.* (1993), but the different plot types are summarised in Appendix 2.

It is possible that Countryside Survey main plots are more stable than ECN fine grain plots as they cover a larger ground area and so may be less likely to be influenced by very localised changes: ECN fine grain plots cover 1.6 m^2 randomly spread over 100 m^2 whereas Countryside Survey main (X) plots cover 200 m^2. Habitat (Y) plots cover 4 m^2 and linear ones 10 m^2 so are more likely to show a similar degree of variability to ECN fine grain plots.

Analysis only included species used in the analysis of Countryside Survey results (Category 1 species) and likewise counted variable and taxonomically disputed species such as bramble (*Rubus fruticosus* agg.) as a single species.

Analyses have been undertaken for changes in the aggregate vegetation class between years and also for the following vegetation indices, which are also included in the analysis of the main CS results:

1. Number of species
2. Mean C radius
3. Mean S radius
4. Mean R radius
5. Mean Ellenberg R score (pH range)
6. Mean Ellenberg N score (soil fertility)
7. Mean Ellenberg W score (soil moisture)
8. Mean Ellenberg L score (light)

For the purposes of comparison of indices it is convenient to be able to assign a unique aggregate vegetation class to each plot, otherwise comparisons will involve different sets of plots. Each ECN plot has therefore been assigned an overall aggregate class, which is essentially the class to which it is most often assigned in year to year monitoring. Plots for which this is not possible, for example because they are assigned to different classes equally often, are assigned an aggregate class of 0. All results presented here in terms of aggregate classes, except those dealing with changes in aggregate class, are presented using this overall, and time invariant, aggregate class.

3 Results

3.1 Changes between aggregate vegetation class

Table 3.1shows the number of CS main (X) plots changing classification between surveys. Overall about a quarter or third of plots change aggregate class, the higher figure being for the longest interval. Aggregate class II is the least stable class and aggregate class VIII the most stable.

Table 3.1 Percentage of CS plots changing aggregate vegetation class between surveys.

Aggregate Class	1978-1990	1990-1998	1998-2007
I Crops/weeds	34.0	28.8	31.5
II Tall grass / herb	75.0	70.5	74.8
III Fertile grassland	51.6	35.3	29.1
IV Infertile grassland	35.9	21.6	22.3
V Lowland wooded	37.5	20.3	20.0
VI Upland wooded	43.4	28.5	29.7
VII Moorland grass/mosaic	40.0	23.7	27.7
VIII Heath / bog	20.9	16.4	7.6
All classes	36.6	28.0	26.4

27% of the ECN plots changed aggregate vegetation class at least once, with the probability of change depending on the interval between measurements (Table 3.2). At intervals similar to those between successive Countryside Surveys the change rate is comparable to that for CS main (X) plots. This strongly suggests that the ECN plots are similar in stability to those in CS and can therefore give a reasonable indication of the extent to which inter-annual variability affects vegetation classification in CS data.

Table 3.2 Relationship of change in aggregate vegetation class to interval between observations for ECN data

Years separation between observations	Number of comparisons	% of plots changing aggregate class
1	941	12.2
2	808	13.4
3	550	16.2
4	493	16.6
5	588	19
6	461	18
7	428	16.1
8	414	19.1
9	209	16.7
10	132	24.2
11	22	22.7

Table 3.3 summarises which changes between classes occurred for pairs of observations in consecutive years. The majority of plots (88%) do not change aggregate class. The changes between classes which do occur are not random, but tend to occur between similar aggregate classes. The largest number of changes were between upland wooded (AC VI) and moorland grass / mosaic (AC VII) and between upland wooded (AC VI) and lowland wooded (AC V). On a proportional basis the least stable aggregate classes are tall grass/herb (AC II) (36.5% of plots change to other classes and 29.8% were previously classified as a different class) and upland wooded (AC VI) (31.5% of plots change to other classes and 25.3% were previously classified as a different class). The most stable class was heath/bog (AC VIII). These findings are similar to those found in CS.

Table 3.3 Summary of changes in plot aggregate vegetation class between successive years for ECN data

	New Aggregate Class									**% changed from**
Initial Aggregate Class	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**All**	
I Crops/weeds	26								26	0.0
II Tall grass / herb	2	33	7	7	2	1			52	36.5
III Fertile grassland	2	5	123	4					134	8.2
IV Infertile grassland		5	6	119		1	6		137	13.1
V Lowland wooded		1			185	10			196	5.6
VI Upland wooded		3		1	10	74	18	2	108	31.5
VII Moorland grass / mosaic				4		13	131	2	150	12.7
VIII Heath / bog							3	135	138	2.2
All classes	30	47	136	135	197	99	158	139	941	
% changed to	13.3	29.8	9.6	11.9	6.1	25.3	17.1	2.9		

3.2 Vegetation indices: General

Table 3.4 gives the within-plot coefficients of variation for the summary vegetation indices used in the study. These quantify the year to year variation in individual plot values as a percentage of the mean value for each index. Species number showed the highest year to year variability of all the indices, having a coefficient of variation of 18% compared to 7-10% for CSR radii and 2-5% for Ellenberg indices. Crops/ Weeds (AC I) show the largest year to year variation in species number and CSR radii, followed by fertile grasslands (AC III), and lowland and upland woodlands (AC V & VI respectively); the other aggregate classes are more stable.

Table 3.4 Coefficients of variation (mean / standard deviation) for different vegetation indices and different vegetation classes

Aggregate Class	Number of species	C radius	S radius	R radius	Ellenberg R	Ellenberg N	Ellenberg W	Ellenberg L
I Crops/weeds	55.0	25.4	14.4	10.3	2.9	3.7	3.1	3.8
II Tall grass / herb	29.1	10.3	16.2	13.6	3.8	6.0	3.2	4.1
III Fertile grassland	29.7	12.4	12.4	10.4	2.8	4.8	3.7	2.1
IV Infertile grassland	10.6	5.1	4.8	4.7	2.0	3.9	2.4	1.3
V Lowland wooded	21.9	8.6	9.9	14.0	4.3	3.6	3.1	5.1
VI Upland wooded	27.2	8.2	8.8	12.7	6.5	7.3	3.3	3.6
VII Moorland grass / mosaic	10.9	4.3	3.2	5.3	3.8	4.5	2.2	1.0
VIII Heath / bog	19.3	6.3	4.1	6.9	6.3	6.2	2.2	1.5
All classes	18.2	8.3	7.0	9.8	4.0	4.8	2.8	2.7

3.3 Species number

Figure 3.1 and Table 3,5 present the change in number of species over time at ECN sites and Figure 3.2 and Table 3.6 present the same information broken down by aggregate vegetation class. Values are presented on a logarithmic scale to facilitate comparisons. The small amount of ECN vegetation data recorded in 2001 (not a specified ECN recording year or funded from outside sources) is reflected in the lack of a value for this year at most sites and is the cause of the larger fluctuations for this year in several aggregate classes. These are due to the paucity of data and should be disregarded.

No general overall trend is discernible but there are substantial differences between both sites and aggregate classes. Although substantial year to year variation is evident it is also clear that these changes are not just random fluctuations on a yearly time scale. Both sites and aggregate classes show persistent effects with fluctuations taking several years to complete. In the short term these could easily be mistaken for longer term trends. The fourteen year span of the data makes it evident, however, that such conclusions are not warranted.

The recording years for the 1998 CS (mostly 1998 but some plots recorded in 1999) can be seen to have low numbers of species compared to the other years, particularly in southern ECN sites. In contrast the most recent CS year, 2007, is reasonably average.

There is an interesting distinction in Figure 3.1 between the upland, mostly northern, sites which have higher species counts and a relatively flat pattern of change, and the lowland, predominantly southern, sites which have lower average counts and often a substantial dip in values around 1998 to 2001. This dip can also be seen in a number of the aggregate classes, notably the grassland classes, and is absent from the predominantly upland classes VII, Moorland, and VIII, Heath/Bog.

Fig. 3.1 Mean number of speciesper plot by year for each site.

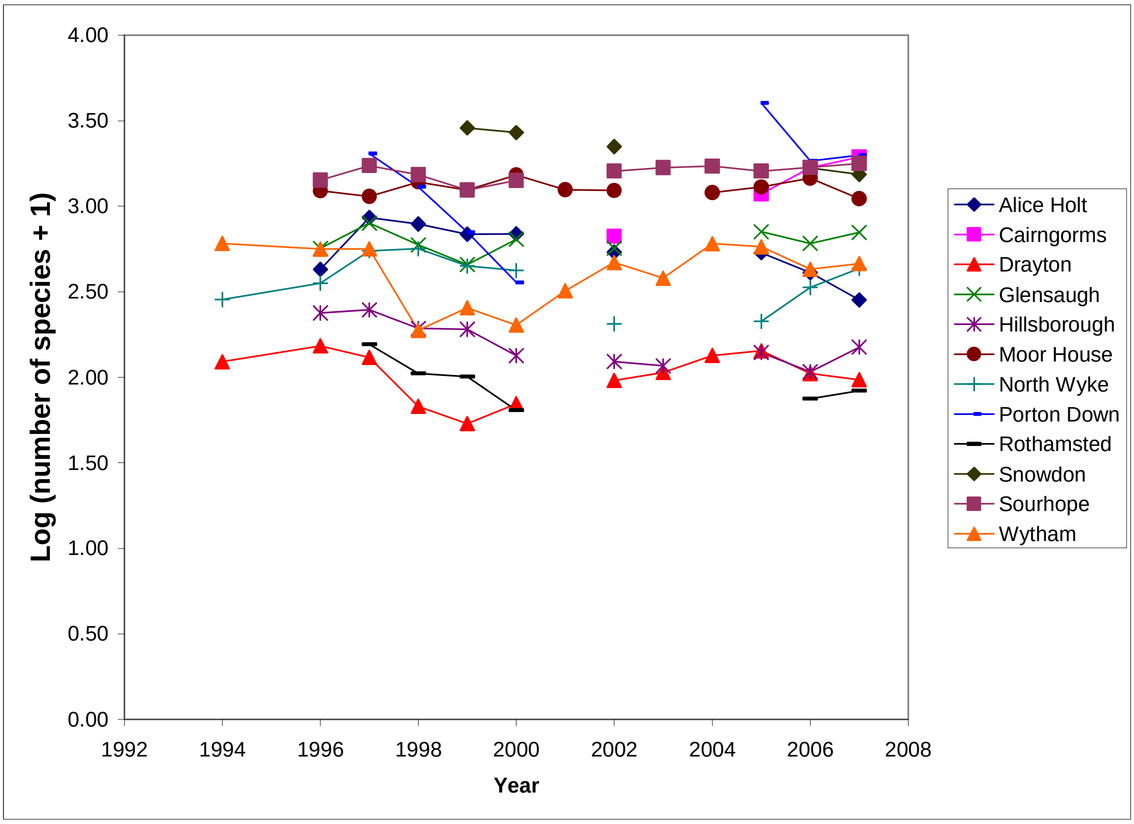


Fig. 3.2 Mean number of species per plot by year for aggregate vegetation classes

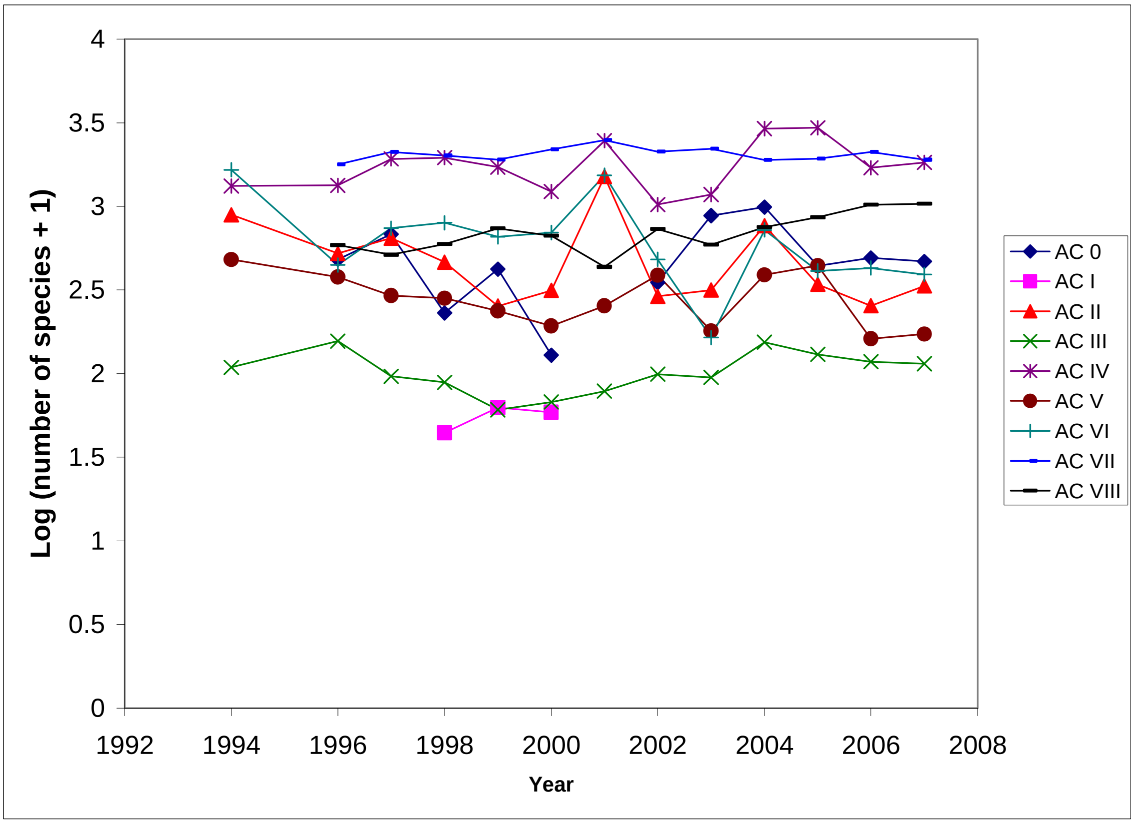


Table 3.5 Average number of species per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			7.75				12.07					17.23
1996	14.02		8.67	16.64	10.71	23.33	13.21				23.56	16.69
1997	18.70		8.90	19.10	10.40	22.07	15.20	32.40	8.60		26.40	17.55
1998	17.80		6.18	16.36	10.17	24.24	15.73	27.59	7.33		24.91	11.71
1999	16.86		5.41	14.86	9.52	23.38	15.08	23.78	7.20	31.14	22.17	13.53
2000	16.50		6.24	16.93	8.33	25.83	14.09	18.88	5.64	30.50	24.27	11.35
2001						25.33						13.92
2002	16.34	16.50	7.00	16.00	7.78	23.40	9.76			27.83	25.06	15.33
2003			7.08		7.25						26.09	14.17
2004			7.83			23.00					26.18	17.06
2005	16.60	21.11	8.42	17.29	8.09	23.53	9.94	38.89			24.94	16.84
2006	15.36	25.21	7.08	16.36	7.00	24.92	12.82	32.15	6.13	24.57	25.91	14.86
2007	13.00	27.00	6.67	17.21	8.25	21.75	13.91	34.23	6.25	23.86	26.27	15.86

Table 3.6 Average number of species per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		18.50	6.90	22.40	14.88	24.00		
1996		15.63	8.33	23.75	13.39	14.43	26.83	16.12
1997		16.43	6.64	29.00	12.06	18.20	28.73	14.50
1998	5.00	13.57	6.22	29.21	12.39	18.19	28.40	15.65
1999	6.41	11.50	5.32	27.37	11.46	17.00	27.59	18.06
2000	5.40	13.00	5.56	23.31	10.77	17.53	29.63	16.71
2001		23.00	5.67	29.00	11.50	28.00	33.25	13.00
2002		11.63	6.83	22.05	14.00	15.97	28.49	17.47
2003		11.80	6.40	24.50	9.73	8.50	29.14	15.00
2004		17.50	8.57	31.40	14.57	17.50	28.12	17.20
2005		13.67	7.75	34.09	15.17	14.86	27.72	18.36
2006		11.40	7.56	27.64	9.97	15.69	28.43	20.34
2007		12.00	7.44	28.92	10.00	14.56	27.00	20.66

3.4 Plant strategies

Figures 3.3 to 3.8 and Tables 3.7 to 3.12 present the change in plant strategy indices over time by site and aggregate vegetation class. As with number of species the small amount of ECN vegetation data recorded in 2001 is reflected in the lack of a value for this year at most sites and is the cause of the larger fluctuations for this year in several aggregate classes.

C (competitor) radius (Figures 3.3 & 3.4 and Tables 3.7 & 3.8) has relatively small site and aggregate class differences in overall mean value, though there is an impression that upland sites and the corresponding aggregate classes have lower values with the lowland sites showing a similar dip between 1998 and 2001 as was exhibited by number of species. There is little indication of any overall trend.

S (stress tolerator) radius (Figures 3.5 & 3.6 and Tables 3.9 & 3.10) has much greater site differences and smaller year to year variation than C radius. There is considerable structure shown in the figures with substantial differences between the upland and lowland sites. The former have higher values and flatter profiles. The latter have substantially lower values and a slight upward trend with little evidence of the dip found previously just prior to the millennium. Aggregate classes also show substantial structure. Classes VII and VIII have a much higher proportion of stress tolerant plants while the small amount of arable data (AC I, crops and weeds) shows that such habitats are very stress *in*tolerant. The lowland semi-natural habitats (AC II, tall grass and herb, and AC III, fertile grassland) also have few stress tolerators with the remaining classes intermediate between these and the upland classes.

R (ruderal) radius (Figures 3.7 & 3.8 and Tables 3.11 & 3.12) also has much greater site differences than C radius and comparable year to year variation, though less clear structure than S radius,. The lowland sites have higher values and there is a clear indication of an overall decrease in R radius, greatest for the lowland sites. Agricultural vegetation classes have the largest values, notably the AC I arable plots and the AC III fertile grasslands class. which also shows the greatest decline in value with time.

Fig. 3.3 Mean C radius of species in plot by year for each site.

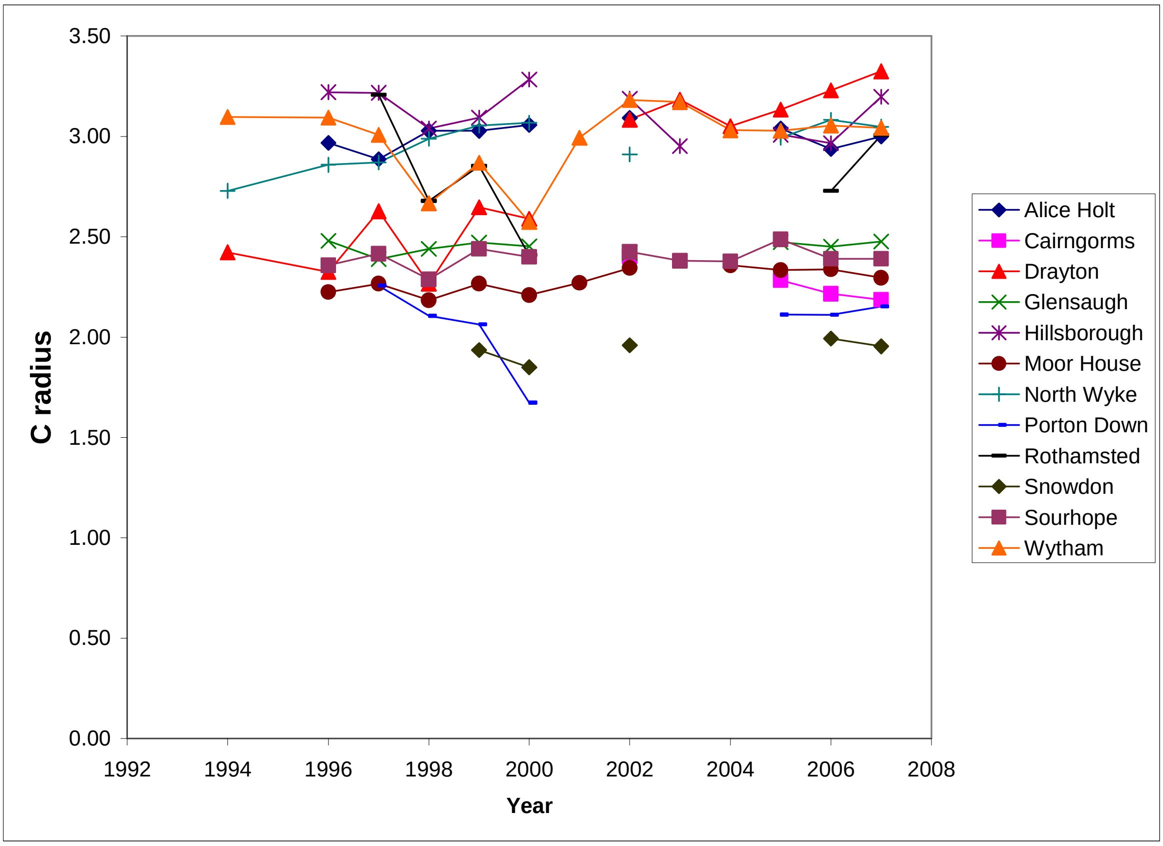


Fig. 3.4 Mean C radius of species in plot by year for aggregate vegetation classes

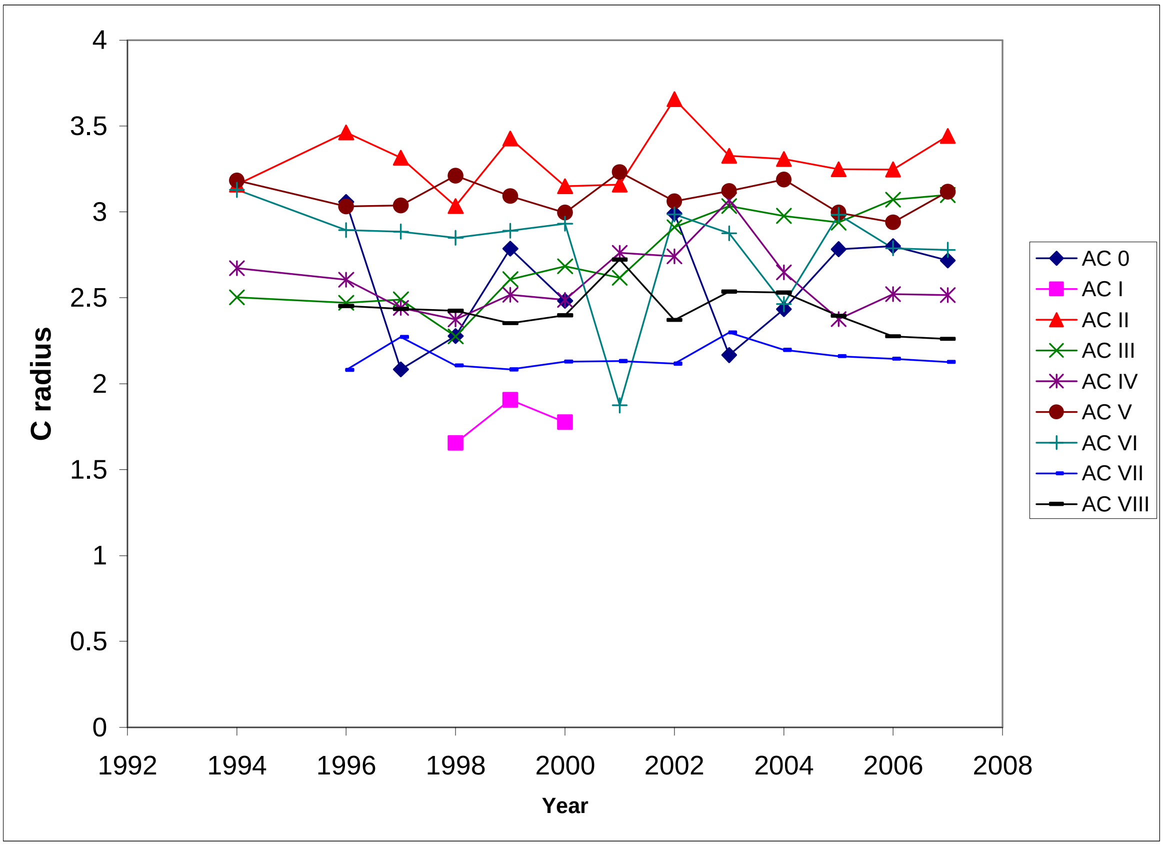


Table 3.7 Average C radius per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			2.42				2.73					3.10
1996	2.97		2.32	2.48	3.22	2.22	2.86				2.36	3.09
1997	2.89		2.63	2.39	3.22	2.27	2.87	2.26	3.21		2.42	3.01
1998	3.03		2.27	2.44	3.04	2.18	2.99	2.11	2.68		2.29	2.67
1999	3.03		2.65	2.47	3.09	2.27	3.05	2.06	2.85	1.94	2.44	2.87
2000	3.06		2.59	2.45	3.28	2.21	3.07	1.67	2.41	1.85	2.40	2.57
2001						2.27						2.99
2002	3.09	2.40	3.08	2.42	3.19	2.35	2.91			1.96	2.43	3.18
2003			3.18		2.95						2.38	3.17
2004			3.05			2.36					2.38	3.03
2005	3.04	2.28	3.13	2.47	3.01	2.33	2.99	2.11			2.49	3.03
2006	2.94	2.22	3.23	2.45	2.97	2.34	3.08	2.11	2.73	1.99	2.39	3.05
2007	3.00	2.19	3.32	2.48	3.20	2.30	3.05	2.15	3.01	1.95	2.39	3.04

Table 3.8 Average C radius per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		3.16	2.50	2.67	3.18	3.13		
1996		3.46	2.47	2.61	3.03	2.89	2.08	2.45
1997		3.32	2.49	2.44	3.04	2.88	2.27	2.44
1998	1.65	3.03	2.28	2.37	3.21	2.85	2.11	2.42
1999	1.91	3.43	2.61	2.52	3.09	2.89	2.08	2.35
2000	1.78	3.15	2.68	2.49	3.00	2.93	2.13	2.40
2001		3.16	2.62	2.76	3.23	1.87	2.13	2.72
2002		3.66	2.91	2.74	3.06	2.99	2.12	2.37
2003		3.33	3.03	3.07	3.12	2.88	2.30	2.54
2004		3.31	2.98	2.65	3.19	2.46	2.20	2.53
2005		3.25	2.94	2.38	3.00	2.98	2.16	2.40
2006		3.25	3.07	2.52	2.94	2.79	2.15	2.28
2007		3.44	3.10	2.52	3.12	2.78	2.13	2.26

Fig. 3.5 Mean S radius of species in plot by year for each site.

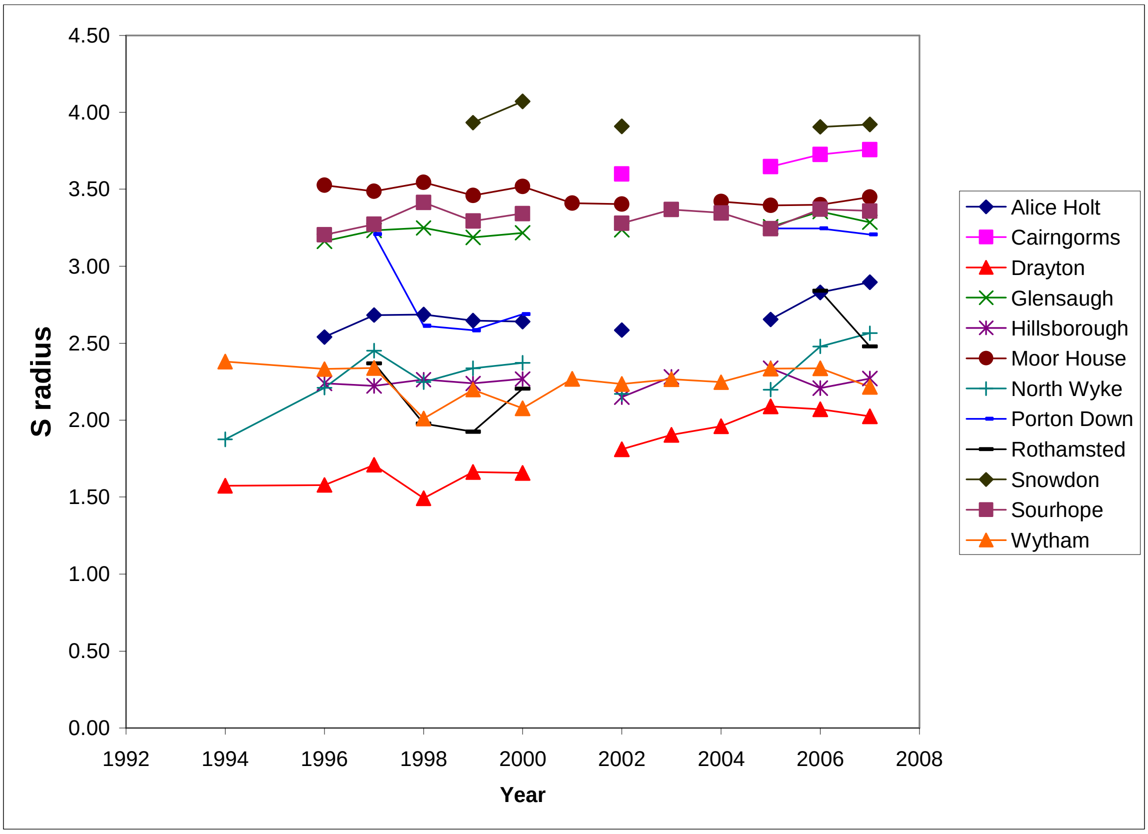


Fig. 3.6 Mean S radius of species in plot by year for aggregate vegetation classes

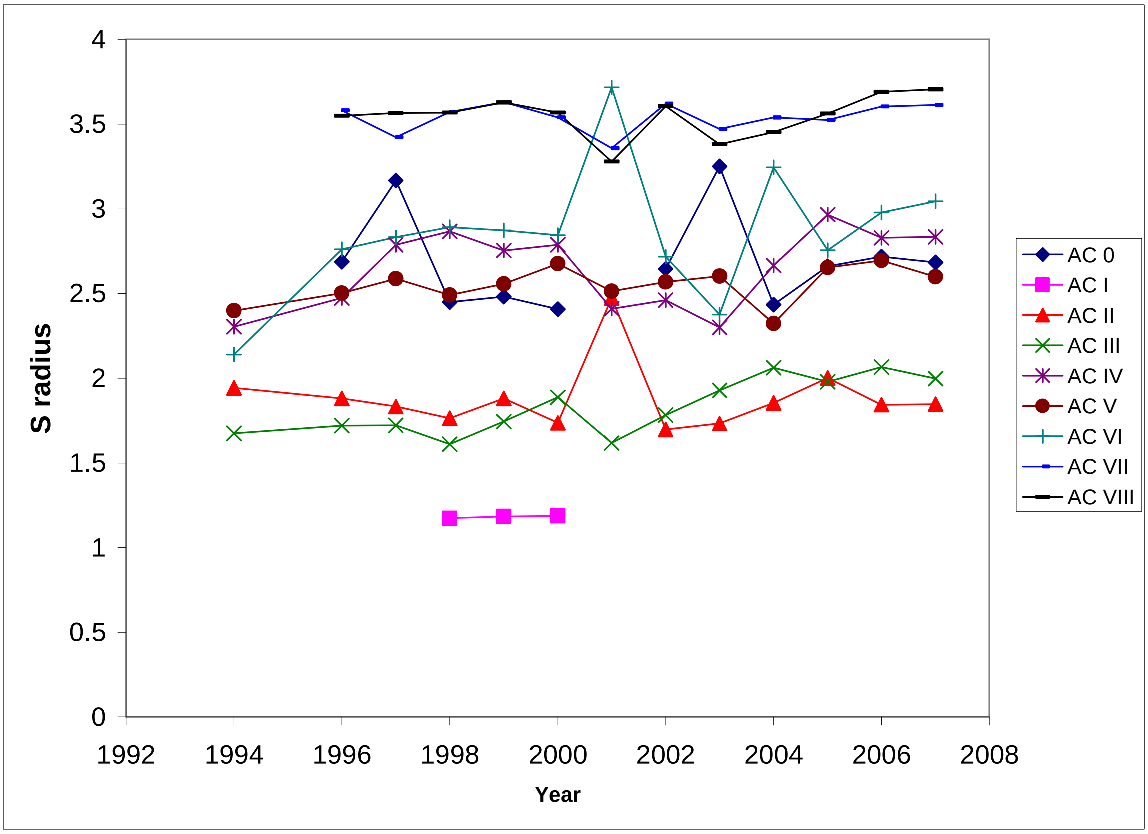


Table 3.9 Average S radius per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			1.57				1.88					2.38
1996	2.54		1.58	3.16	2.24	3.53	2.21				3.20	2.33
1997	2.68		1.71	3.23	2.22	3.49	2.45	3.21	2.37		3.27	2.34
1998	2.69		1.49	3.25	2.26	3.54	2.25	2.61	1.98		3.41	2.01
1999	2.65		1.66	3.19	2.24	3.46	2.34	2.58	1.93	3.93	3.29	2.20
2000	2.64		1.66	3.22	2.27	3.52	2.37	2.69	2.20	4.07	3.34	2.08
2001						3.41						2.27
2002	2.58	3.60	1.81	3.24	2.15	3.40	2.17			3.91	3.28	2.24
2003			1.90		2.28						3.37	2.27
2004			1.96			3.42					3.35	2.25
2005	2.65	3.65	2.09	3.26	2.34	3.39	2.20	3.24			3.25	2.33
2006	2.83	3.73	2.07	3.36	2.21	3.40	2.48	3.25	2.84	3.90	3.37	2.34
2007	2.90	3.76	2.02	3.29	2.27	3.45	2.56	3.21	2.48	3.92	3.36	2.22

Table 3.10 Average S radius per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		1.94	1.67	2.30	2.40	2.14		
1996		1.88	1.72	2.47	2.50	2.76	3.58	3.55
1997		1.83	1.72	2.79	2.59	2.83	3.42	3.56
1998	1.17	1.76	1.61	2.87	2.49	2.89	3.57	3.57
1999	1.18	1.88	1.74	2.75	2.56	2.87	3.63	3.63
2000	1.19	1.74	1.89	2.79	2.68	2.84	3.54	3.57
2001		2.47	1.62	2.41	2.51	3.72	3.36	3.28
2002		1.70	1.78	2.46	2.57	2.72	3.62	3.61
2003		1.73	1.93	2.30	2.60	2.38	3.47	3.38
2004		1.85	2.06	2.67	2.32	3.25	3.54	3.45
2005		2.00	1.98	2.97	2.65	2.76	3.52	3.56
2006		1.84	2.07	2.83	2.69	2.98	3.60	3.69
2007		1.85	2.00	2.83	2.60	3.04	3.61	3.71

Fig. 3.7 Mean R radius of species in plot by year for each site.

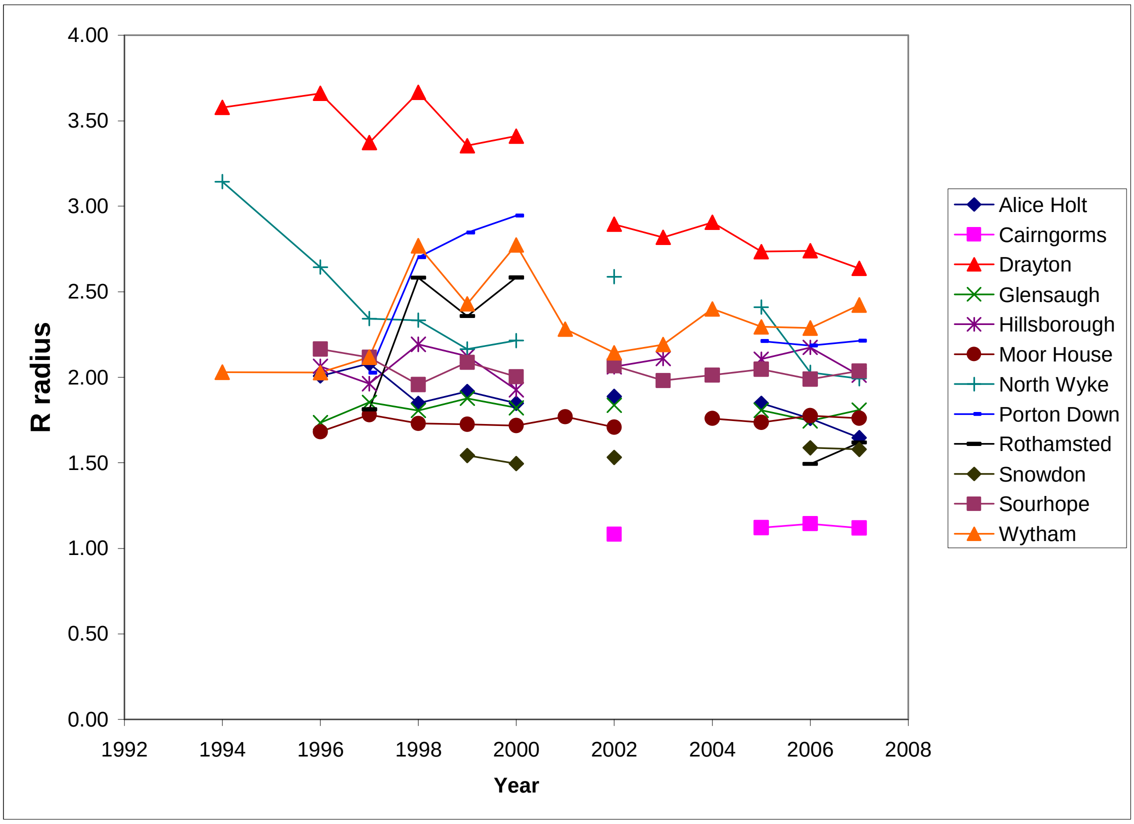


Fig. 3.8 Mean R radius of species in plot by year for aggregate vegetation classes

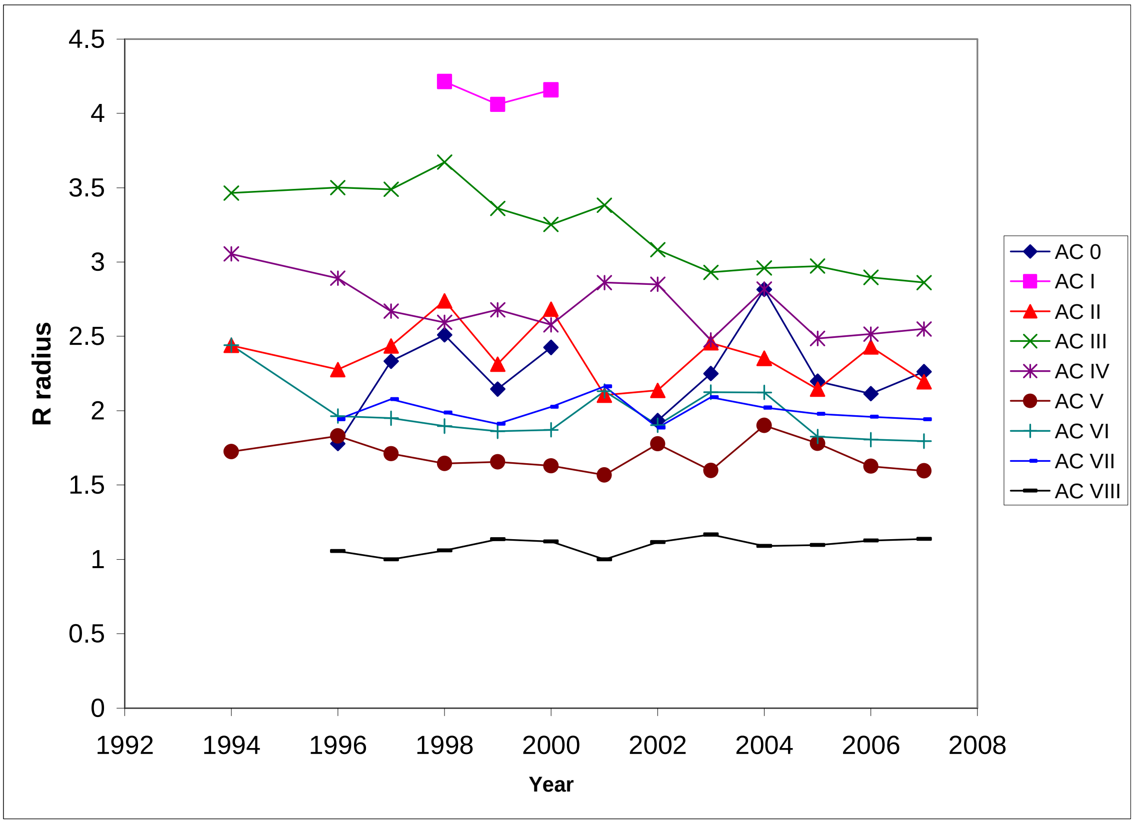


Table 3.11 Average R radius per plot, by site.

Year	Site Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			3.58				3.14					2.03
1996	2.01		3.66	1.74	2.06	1.68	2.64				2.17	2.03
1997	2.08		3.37	1.85	1.96	1.78	2.34	2.03	1.81		2.12	2.12
1998	1.85		3.67	1.81	2.19	1.73	2.33	2.70	2.58		1.96	2.77
1999	1.92		3.35	1.88	2.12	1.73	2.16	2.85	2.36	1.54	2.09	2.43
2000	1.85		3.41	1.82	1.93	1.72	2.22	2.94	2.58	1.50	2.00	2.77
2001						1.77						2.28
2002	1.89	1.08	2.90	1.84	2.06	1.71	2.59			1.53	2.07	2.14
2003			2.82		2.11						1.98	2.19
2004			2.91			1.76					2.01	2.40
2005	1.85	1.12	2.73	1.81	2.11	1.74	2.41	2.21			2.05	2.30
2006	1.76	1.14	2.74	1.74	2.17	1.78	2.03	2.19	1.49	1.59	1.99	2.29
2007	1.65	1.12	2.64	1.81	2.01	1.76	1.99	2.21	1.62	1.58	2.04	2.42

Table 3.12 Average R radius per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		2.44	3.46	3.06	1.73	2.44		
1996		2.28	3.50	2.89	1.83	1.96	1.94	1.05
1997		2.44	3.49	2.67	1.71	1.95	2.08	1.00
1998	4.21	2.74	3.67	2.59	1.65	1.90	1.99	1.06
1999	4.06	2.31	3.36	2.68	1.66	1.86	1.91	1.14
2000	4.16	2.68	3.25	2.58	1.63	1.87	2.03	1.12
2001		2.11	3.38	2.86	1.57	2.13	2.16	1.00
2002		2.14	3.08	2.85	1.78	1.90	1.89	1.12
2003		2.46	2.93	2.48	1.60	2.13	2.09	1.17
2004		2.35	2.96	2.82	1.90	2.12	2.02	1.09
2005		2.15	2.97	2.49	1.78	1.83	1.98	1.10
2006		2.43	2.90	2.52	1.63	1.81	1.96	1.13
2007		2.20	2.86	2.55	1.60	1.80	1.94	1.14

3.5 Ellenberg values

Figures 3.9 to 3.16 and Tables 3.13 to 3.20 present the change in plant strategy indices over time by site and aggregate vegetation class. As with previous results the small amount of ECN vegetation data recorded in 2001 is reflected in the lack of a value for this year at most sites and is the cause of the larger fluctuations for this year in several aggregate classes. However the year to year variation in Ellenberg values is, as described in 3.2 above, much smaller than for other vegetation indices and this is reflected in the much smoother graphical presentations.

The four Ellenberg indices fall into two types. Ellenberg R (pH) and N (fertility) show substantial differences in mean value across both sites and aggregate classes. Ellenberg W (wetness) and Ellenberg L (light) show much less geographical or habitat variability. None of the indices appear to show more than minor overall trends.

Ellenberg R and N values are much lower at upland sites than lowland and much lower in AC VIII (bog)

Fig. 3.9 Mean Ellenberg R of species in plot by year for each site.

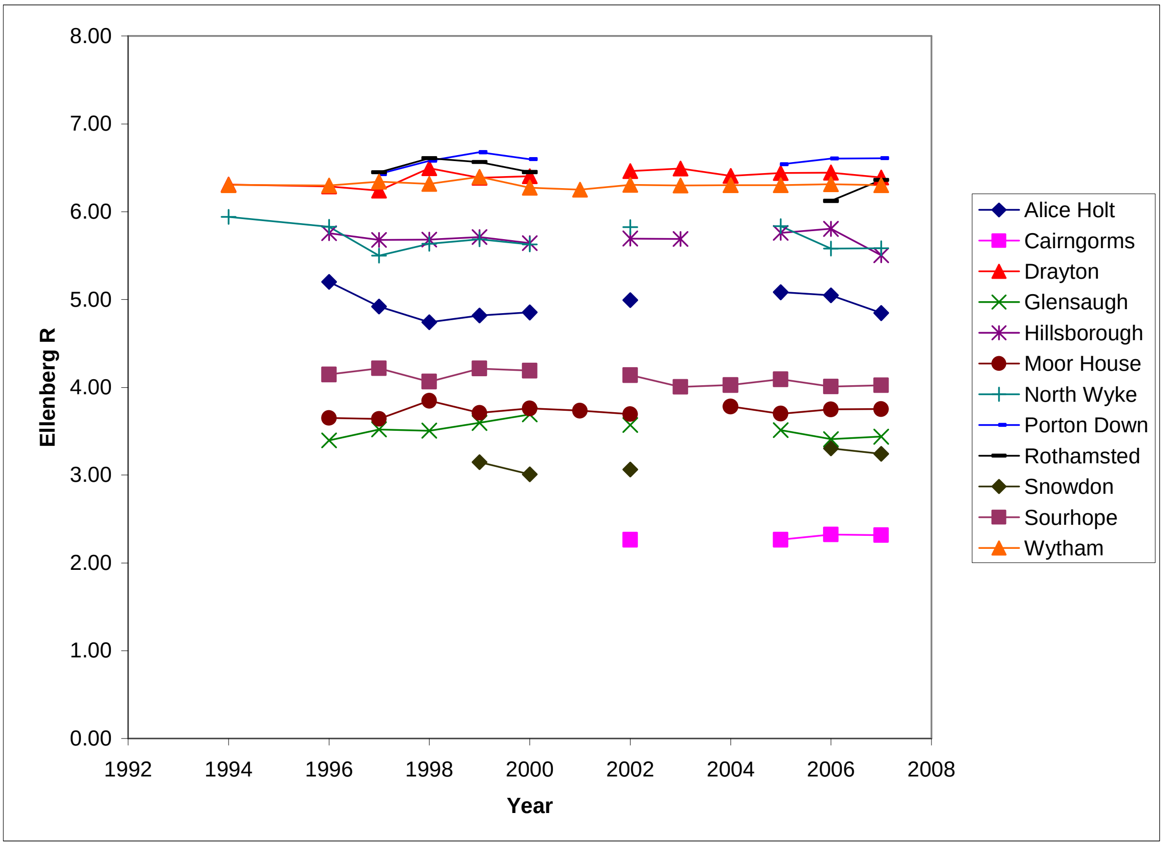


Fig. 3.10 Mean Ellenberg R of species in plot by year for aggregate vegetation classes

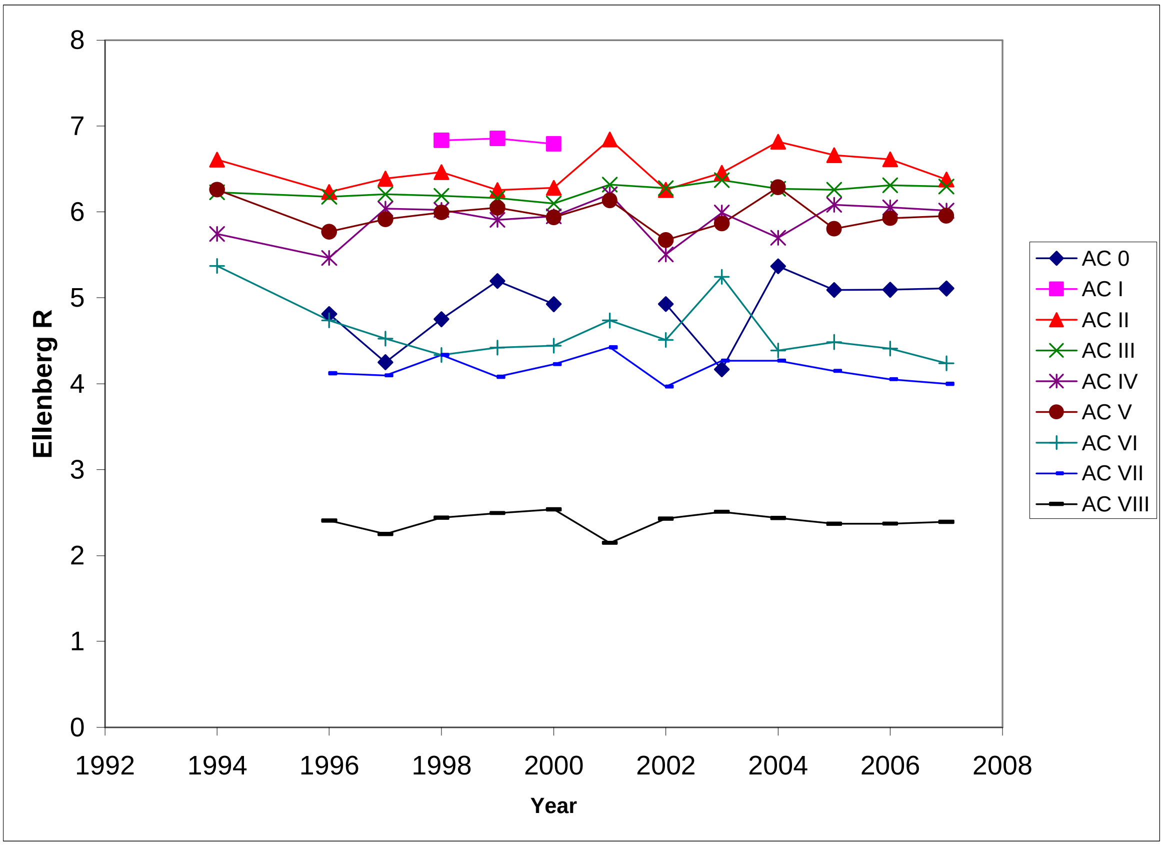


Table 3.13 Ellenberg R per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			6.31				5.94					6.30
1996	5.20		6.29	3.40	5.76	3.65	5.83				4.15	6.30
1997	4.92		6.24	3.52	5.68	3.64	5.50	6.43	6.45		4.22	6.34
1998	4.74		6.50	3.51	5.68	3.85	5.63	6.58	6.61		4.06	6.32
1999	4.82		6.39	3.59	5.71	3.71	5.69	6.67	6.57	3.15	4.22	6.40
2000	4.85		6.40	3.69	5.64	3.76	5.63	6.60	6.45	3.01	4.19	6.28
2001						3.73						6.25
2002	4.99	2.26	6.46	3.57	5.69	3.69	5.82			3.06	4.14	6.31
2003			6.49		5.69						4.01	6.30
2004			6.41			3.78					4.03	6.30
2005	5.08	2.26	6.44	3.51	5.76	3.70	5.83	6.54			4.09	6.30
2006	5.05	2.32	6.45	3.41	5.81	3.75	5.58	6.60	6.12	3.30	4.01	6.31
2007	4.85	2.32	6.39	3.44	5.50	3.75	5.58	6.61	6.36	3.24	4.02	6.30

Table 3.14 Average Ellenberg R per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		6.61	6.23	5.74	6.26	5.37		
1996		6.23	6.18	5.46	5.77	4.74	4.12	2.41
1997		6.39	6.21	6.04	5.91	4.52	4.10	2.25
1998	6.83	6.46	6.19	6.02	5.99	4.33	4.34	2.44
1999	6.85	6.26	6.16	5.91	6.05	4.42	4.08	2.49
2000	6.79	6.28	6.10	5.95	5.94	4.44	4.23	2.54
2001		6.84	6.32	6.20	6.13	4.74	4.42	2.15
2002		6.26	6.28	5.51	5.67	4.51	3.97	2.43
2003		6.46	6.37	5.99	5.86	5.24	4.27	2.51
2004		6.82	6.27	5.70	6.29	4.39	4.27	2.44
2005		6.66	6.26	6.08	5.80	4.49	4.15	2.37
2006		6.61	6.31	6.05	5.93	4.41	4.05	2.37
2007		6.38	6.29	6.01	5.95	4.24	4.00	2.39

Fig. 3.11 Mean Ellenberg N of species in plot by year for each site.

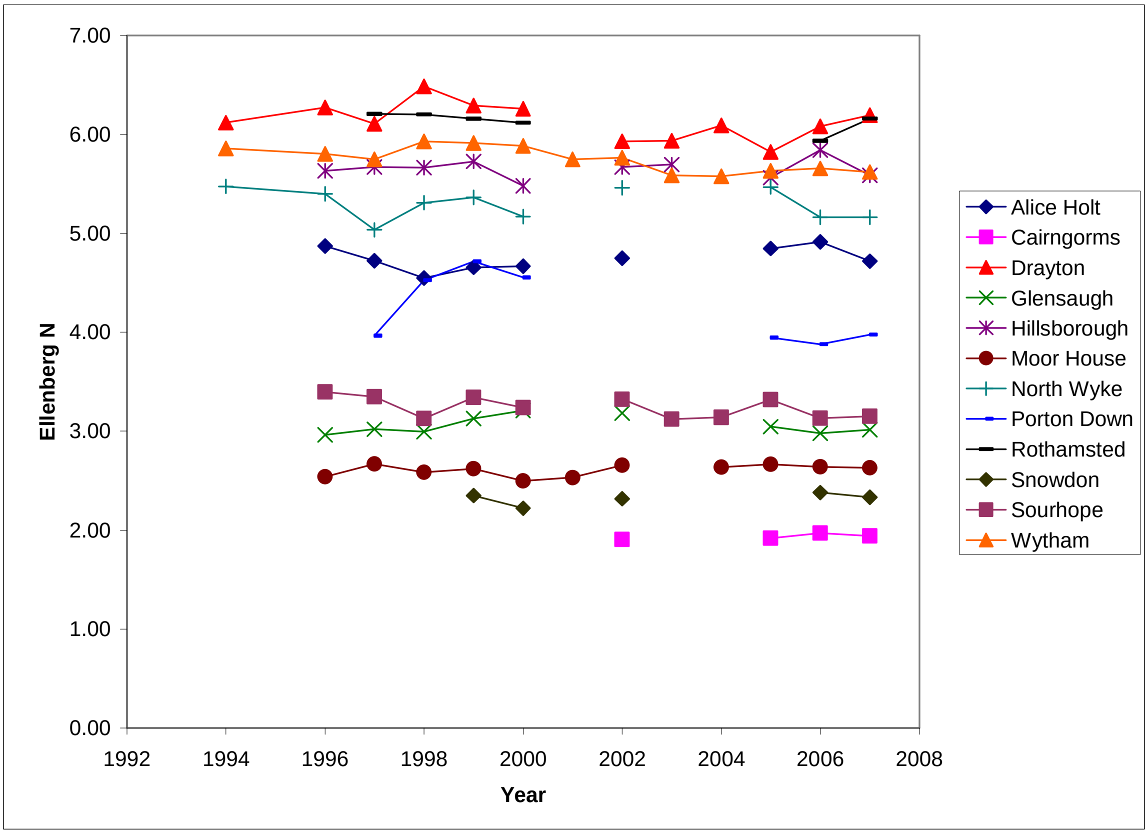


Fig. 3.12 Mean Ellenberg N of species in plot by year for aggregate vegetation classes

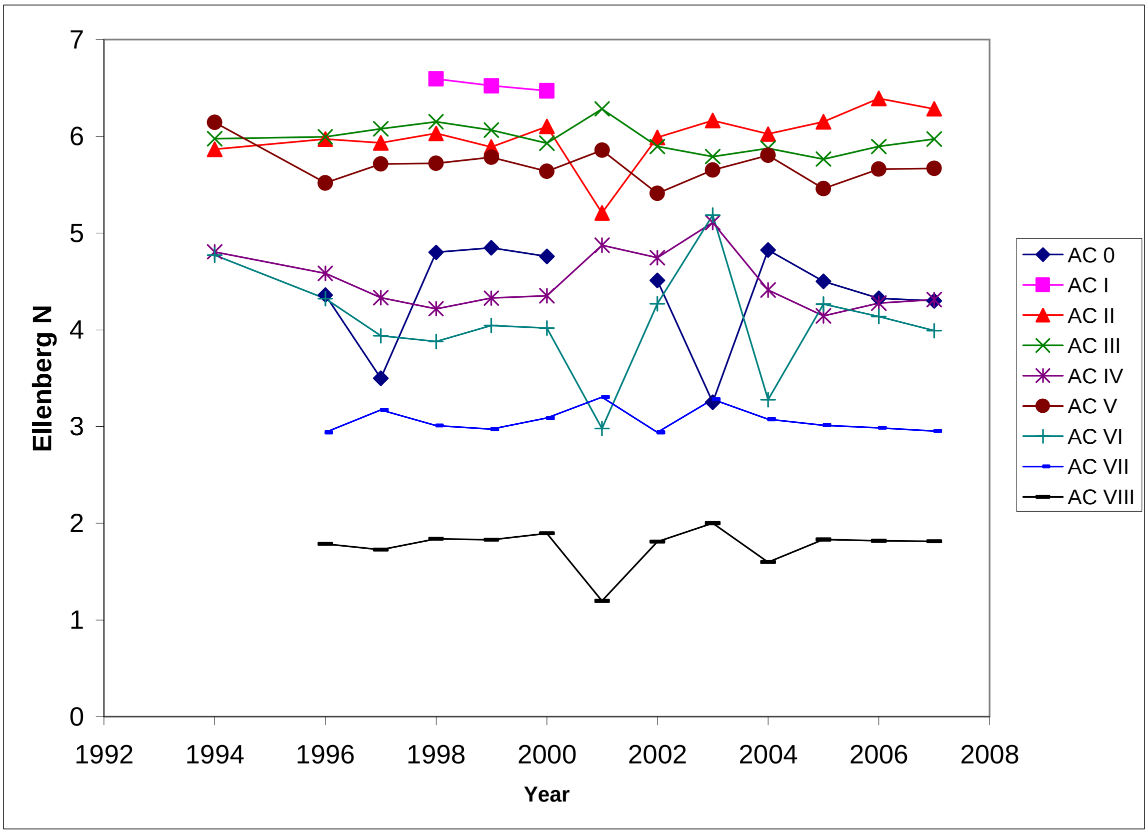


Table 3.15 Average Ellenberg N per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			6.12				5.47					5.86
1996	4.87		6.27	2.96	5.63	2.54	5.40				3.40	5.80
1997	4.72		6.11	3.02	5.67	2.67	5.03	3.96	6.21		3.35	5.75
1998	4.55		6.48	3.00	5.66	2.59	5.31	4.52	6.20		3.13	5.93
1999	4.65		6.29	3.13	5.73	2.62	5.36	4.71	6.16	2.35	3.34	5.91
2000	4.67		6.26	3.21	5.48	2.50	5.17	4.55	6.12	2.22	3.24	5.88
2001						2.53						5.75
2002	4.75	1.91	5.93	3.18	5.67	2.65	5.46			2.32	3.32	5.76
2003			5.93		5.69						3.12	5.59
2004			6.09			2.64					3.14	5.58
2005	4.84	1.92	5.82	3.05	5.56	2.66	5.47	3.94			3.32	5.63
2006	4.91	1.97	6.08	2.98	5.84	2.64	5.16	3.88	5.93	2.38	3.13	5.66
2007	4.72	1.94	6.19	3.01	5.58	2.63	5.16	3.97	6.16	2.33	3.15	5.62

Table 3.16 Average Ellenberg N per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		5.87	5.97	4.81	6.14	4.77		
1996		5.97	5.99	4.58	5.52	4.32	2.94	1.79
1997		5.93	6.08	4.33	5.72	3.94	3.17	1.73
1998	6.59	6.03	6.15	4.22	5.72	3.88	3.01	1.84
1999	6.52	5.89	6.06	4.33	5.79	4.04	2.97	1.83
2000	6.47	6.10	5.93	4.35	5.64	4.02	3.09	1.90
2001		5.21	6.28	4.87	5.86	2.98	3.31	1.20
2002		5.99	5.89	4.75	5.41	4.27	2.94	1.81
2003		6.16	5.79	5.11	5.65	5.19	3.28	2.00
2004		6.02	5.88	4.41	5.80	3.28	3.08	1.60
2005		6.15	5.77	4.14	5.46	4.27	3.01	1.83
2006		6.39	5.89	4.28	5.66	4.14	2.99	1.82
2007		6.28	5.97	4.31	5.67	3.99	2.96	1.81

Fig. 3.13 Mean Ellenberg wetness of species in plot by year for each site.

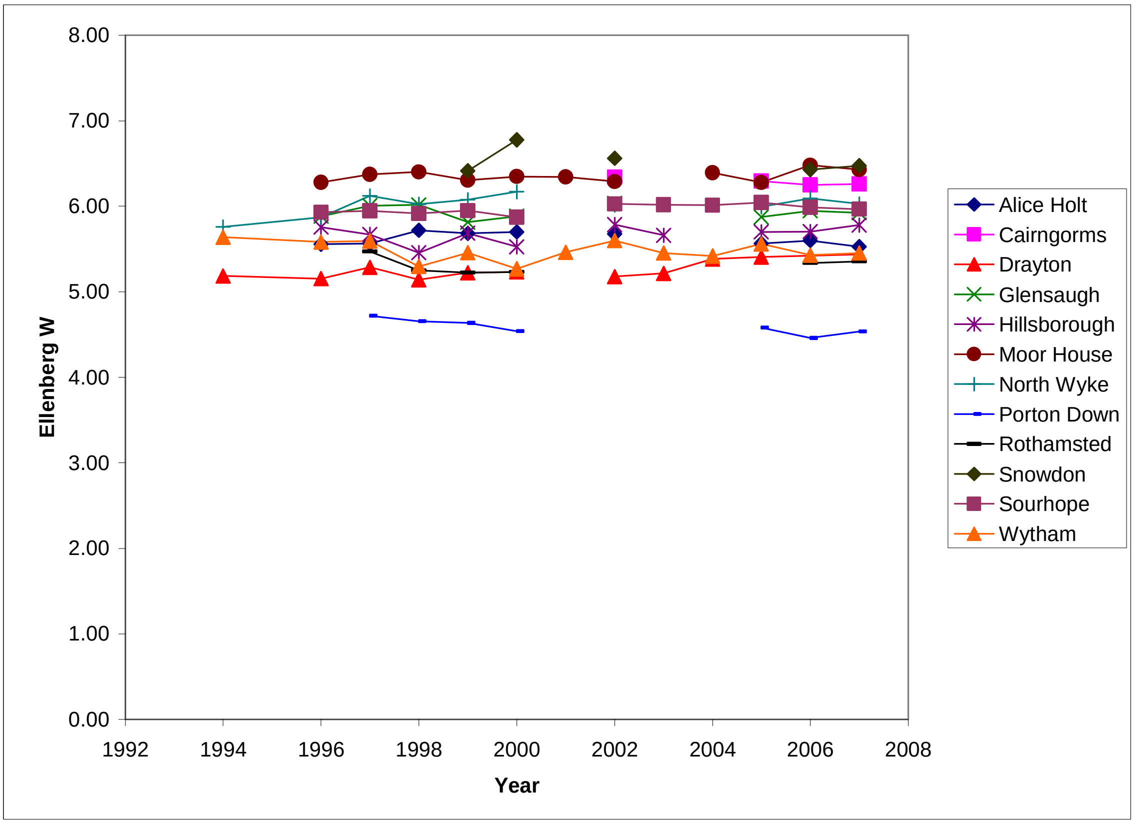


Fig. 3.14 Mean Ellenberg wetness of species in plot by year for aggregate vegetation classes

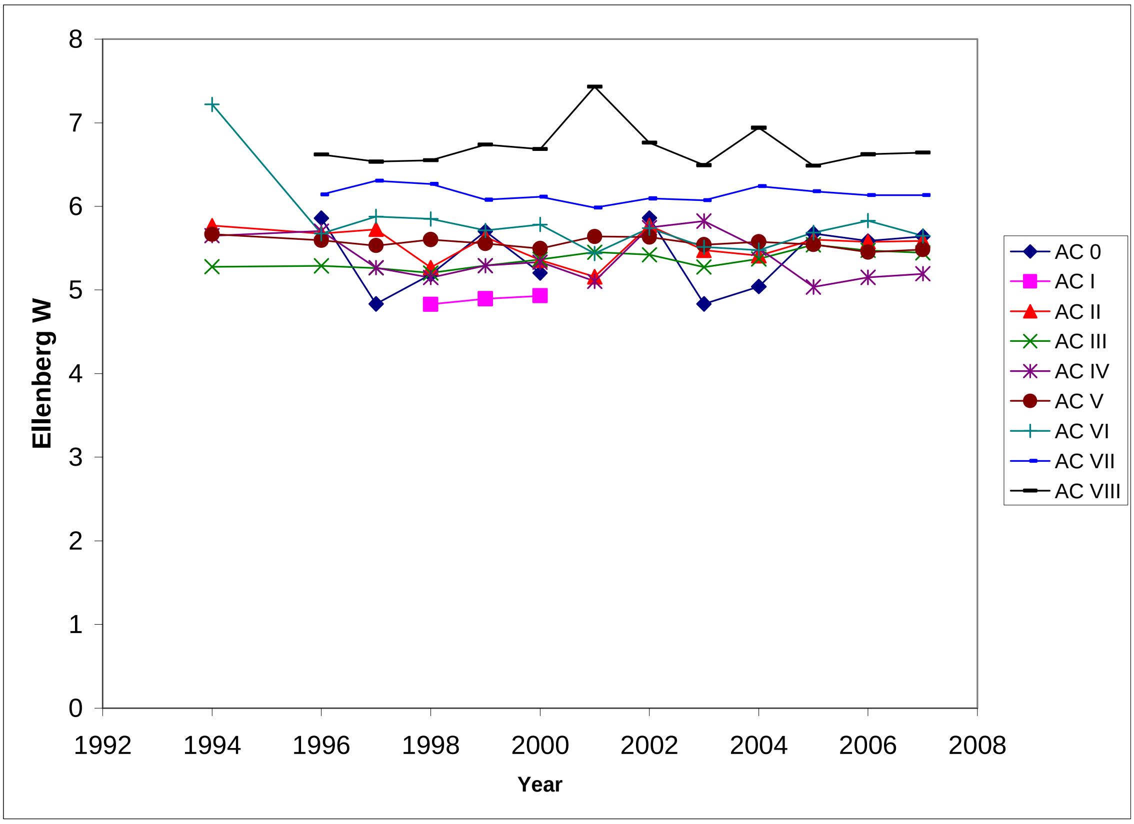


Table 3.17 Average Ellenberg W per plot, by site.

	Site											
Year	Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			5.19				5.76					5.64
1996	5.56		5.15	5.88	5.76	6.28	5.87				5.93	5.58
1997	5.56		5.29	6.01	5.67	6.37	6.12	4.72	5.47		5.95	5.59
1998	5.72		5.14	6.02	5.46	6.40	6.02	4.65	5.25		5.92	5.30
1999	5.68		5.22	5.81	5.68	6.31	6.08	4.64	5.23	6.41	5.95	5.46
2000	5.70		5.23	5.88	5.53	6.35	6.17	4.54	5.23	6.78	5.87	5.27
2001						6.34						5.46
2002	5.67	6.34	5.18	6.03	5.79	6.29	6.02			6.56	6.03	5.60
2003			5.22		5.66						6.02	5.45
2004			5.39			6.39					6.01	5.42
2005	5.56	6.29	5.41	5.87	5.70	6.28	5.99	4.58			6.05	5.56
2006	5.60	6.25	5.42	5.95	5.70	6.48	6.09	4.46	5.34	6.43	5.99	5.43
2007	5.53	6.26	5.43	5.92	5.78	6.43	6.03	4.53	5.35	6.48	5.97	5.45

Table 3.18 Average Ellenberg W per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		5.77	5.28	5.65	5.67	7.22		
1996		5.68	5.29	5.70	5.59	5.67	6.14	6.62
1997		5.73	5.26	5.27	5.53	5.88	6.31	6.53
1998	4.83	5.27	5.20	5.15	5.60	5.85	6.27	6.55
1999	4.90	5.63	5.29	5.29	5.56	5.71	6.08	6.74
2000	4.93	5.36	5.37	5.33	5.50	5.78	6.11	6.68
2001		5.16	5.45	5.10	5.64	5.44	5.98	7.43
2002		5.77	5.42	5.75	5.63	5.74	6.09	6.76
2003		5.47	5.27	5.82	5.54	5.51	6.07	6.49
2004		5.41	5.37	5.50	5.58	5.48	6.24	6.94
2005		5.60	5.54	5.04	5.54	5.69	6.18	6.49
2006		5.58	5.47	5.15	5.45	5.83	6.14	6.62
2007		5.59	5.44	5.19	5.48	5.65	6.13	6.64

Fig. 3.15 Mean Ellenberg light score of species in plot by year for each site.

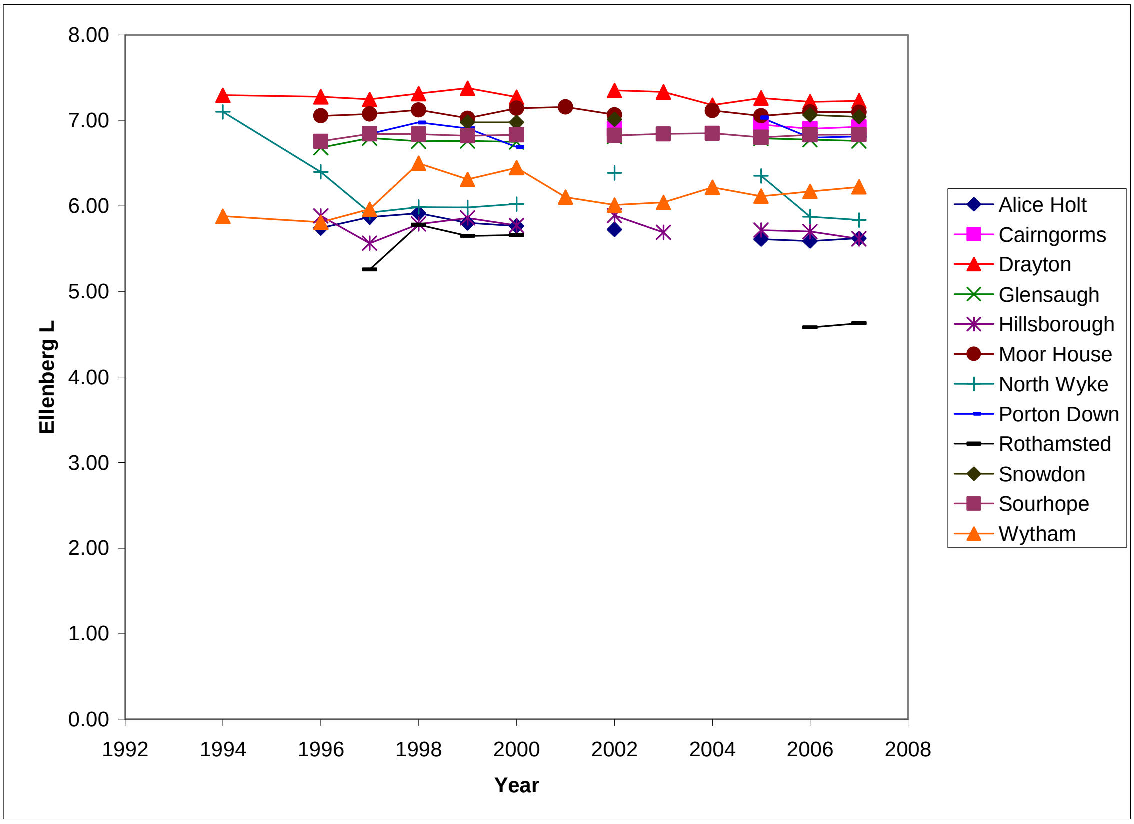


Fig. 3.16 Mean Ellenberg light score of species in plot by year for aggregate vegetation classes

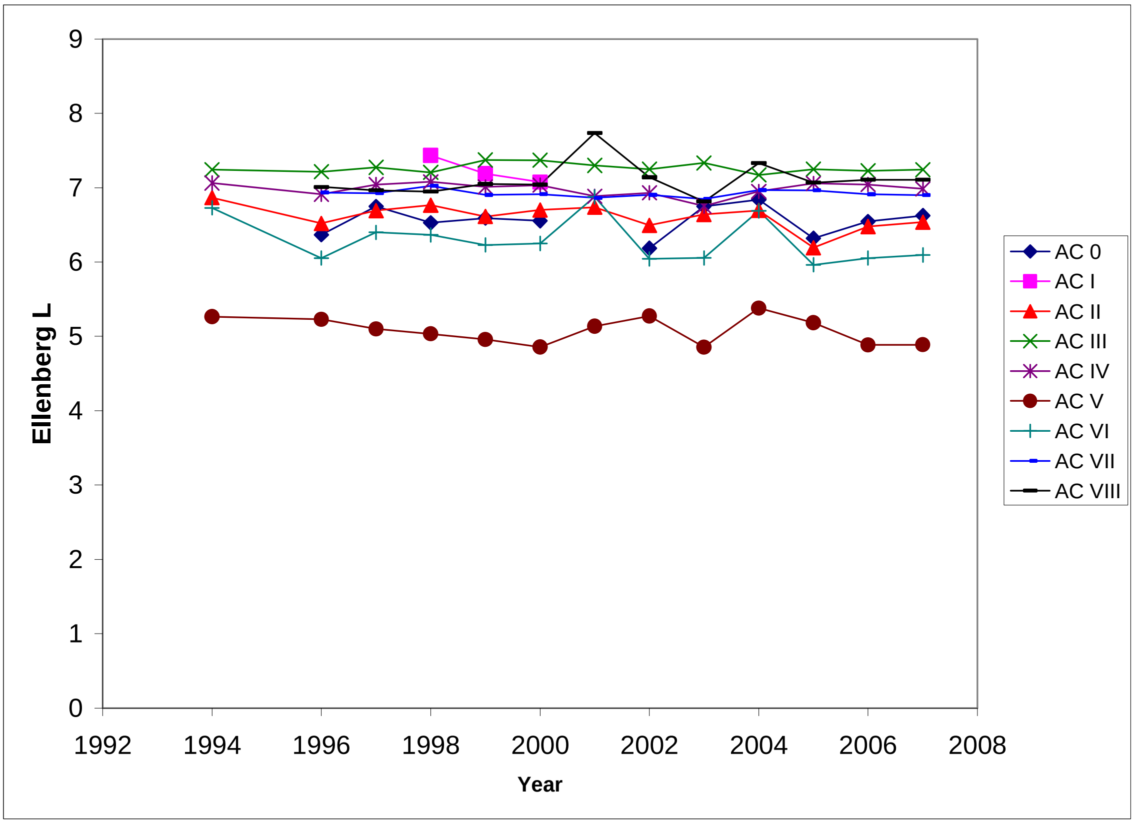


Table 3.19 Average Ellenberg L per plot, by site.

Year	Site Alice Holt	Cairngorms	Drayton	Glensaugh	Hillsborough	Moor House	North Wyke	Porton Down	Rothamsted	Snowdon	Sourhope	Wytham
1994			7.29				7.10					5.88
1996	5.74		7.28	6.68	5.89	7.05	6.40				6.76	5.81
1997	5.87		7.25	6.79	5.57	7.08	5.92	6.84	5.26		6.85	5.96
1998	5.92		7.32	6.76	5.79	7.13	5.99	6.98	5.78		6.84	6.50
1999	5.80		7.38	6.76	5.86	7.03	5.98	6.91	5.65	6.98	6.82	6.31
2000	5.77		7.27	6.75	5.77	7.14	6.02	6.69	5.66	6.98	6.83	6.45
2001						7.16						6.10
2002	5.73	6.90	7.35	6.81	5.89	7.07	6.39			7.01	6.83	6.01
2003			7.33		5.69						6.84	6.04
2004			7.18			7.12					6.85	6.22
2005	5.61	6.95	7.26	6.79	5.72	7.05	6.35	7.03			6.80	6.12
2006	5.59	6.90	7.22	6.78	5.70	7.10	5.88	6.80	4.58	7.07	6.83	6.17
2007	5.62	6.93	7.23	6.76	5.62	7.10	5.84	6.82	4.63	7.04	6.83	6.22

Table 3.20 Average Ellenberg L per plot, by aggregate vegetation class.

	Aggregate Classs							
Year	I	II	III	IV	V	VI	VII	VIII
1994		6.87	7.24	7.06	5.27	6.73		
1996		6.52	7.22	6.91	5.23	6.05	6.93	7.01
1997		6.69	7.28	7.04	5.10	6.40	6.93	6.97
1998	7.44	6.76	7.21	7.08	5.04	6.36	7.03	6.95
1999	7.19	6.61	7.37	7.01	4.96	6.23	6.90	7.05
2000	7.08	6.70	7.37	7.03	4.86	6.25	6.91	7.04
2001		6.74	7.30	6.89	5.14	6.88	6.86	7.74
2002		6.50	7.25	6.93	5.27	6.04	6.90	7.14
2003		6.64	7.33	6.75	4.85	6.06	6.85	6.82
2004		6.69	7.17	6.95	5.38	6.69	6.97	7.33
2005		6.19	7.25	7.06	5.18	5.96	6.97	7.07
2006		6.48	7.23	7.04	4.88	6.05	6.91	7.11
2007		6.54	7.24	6.99	4.89	6.10	6.90	7.11

3.6 Model fitting

The analyses reported above are exploratory and largely descriptive in nature. In this section more formal models are examined and their significance tested.

Temporal variation can be divided into two distinct components, systematic trend and random fluctuations. Both of these components can be further divided into a hierarchical series of spatially determined sub-components. Trend, for instance, may be exhibited at the national level, for sub-national regions, at the level of individual sites, or, in the case of ECN vegetation measurements, at the plot level. Each of these sub-components can be tested for significance. There could, for example, be significant trends at individual sites but no overall national trend or vice versa, a significant national trend with no significant differences in trend between sites. In a similar way random year-to-year fluctuations about trends can be subdivided into components of variation representing systematic effects at different spatial scales. Similar year-to-year fluctuations, for example, might occur consistently across the whole of the UK, or sub-regions of it. Alternatively there might be no consistent national pattern, with each site or plot varying independently and showing a different year-to-year pattern of fluctuations.

ECN was set up to provide detailed information on the interactions between drivers of environmental change and biological responses. Its sites were not randomly selected, as CS sites were, and hence, although this can be done using differential weighting, in general in is not particularly informative to use ECN data to estimate national or regional states or trends, as is done in CS. However, although there are not sufficient ECN terrestrial sites to accurately examine regional differences, there is a major division which can be examined. ECN sites naturally fall into two categories, upland and lowland. Since this division is one of the major determinants of the UK environment it is useful to take it into account in analysis.

One final aspect affecting temporal series is the question of persistence of effects. Ecosystems take time to change. The effects of a drought or particularly wet year, for example, can cause changes in vegetation that it may take several years to recover from. The degree of persistence of a change can be measured by the autocorrelation of a time series. High autocorrelation implies that the system is slow to change while low autocorrelation implies that the system changes quickly in response to external effects.

The analyses reported here examine each of these components of the data. All analyses were performed using the SAS statistical package (SAS Institute Inc., 2002). Initially a mixed model was used incorporating plot as a random effect, year of observation as a repeated measure and an autoregressive component of order one (AR1) to quantify persistence over time. Site and upland/lowland were included as fixed effects to reflect the non-random selection of ECN sites. Linear temporal trends were fitted at the UK (strictly speaking ECN), upland/lowland, site and plot levels. Linear trends were used because the time span of the ECN data was considered insufficient to accurately estimate more complex trends. Extraction of linear trends should be sufficient to prevent trends from biasing the estimation of year-to-year variation. Year-to-year variation about fitted trends was subdivided into national, upland/lowland and site level components. Plot level variation forms the residual variation of the model.

Model fitting proved to be computationally difficult. Restricted maximum likelihood (REML) and maximum likelihood (ML) methods sometimes failed to converge. Minimum variance quadratic unbiased estimation was therefore used instead since this did not suffer from the same convergence difficulties. In many instances, however, model fits appeared to be somewhat unstable and results considered unreliable. Investigation suggested that this was because the relatively short length of the ECN time series was insufficient to simultaneously estimate trend, year-to-year variation, and autocorrelation components within the context of such complex models. Autocorrelation estimates were particularly subject to instability, varying wildly with minor model changes. To overcome this problem a three stage procedure was adopted. First a linear trend was fitted to the data from each plot individually and the slopes of the fitted regression lines used to test for trends at ECN, upland/lowland and site level. Secondly random effect models with no autocorrelation component were fitted to the residuals from the regressions to test for significant year-to-year variation. Finally the residuals from these second stage models were tested for autocorrelation. This three stage procedure appeared to resolve the fitting problems

Table 3.21summarises the results. There were highly significant national (ECN) trends in R (ruderal) radius and Ellenberg light scores and the trends varied both between upland and lowland regions and from site to site. Although not significant at the ECN level there were significant differences in the trend in number of species at individual sites. Consistent, and significant year to year variation was found for most measurements but largely at the site, or upland/lowland level, rather than the national level. Similarly significant levels of autocorrelation were found for most measurements, though these were small and negative. The negativity is surprising, suggesting a “rebound” effect following disturbance. Given the instability of autocorrelation estimates from the full model, however, this finding should be treated with caution.

Table 3.21. Summary of results from model fitting.

Type of effect	**Scale**	**Number of species**	**C radius**	**S radius**	**R radius**	**Ellenbern R**	**Ellenberg N**	**Ellenbern W**	**Ellenberg L**
Linear temporal trend	National	0.126	0.122	0.765	0.007	0.750	0.473	0.308	0.039
	Upland/lowland	0.055	0.331	0.959	0.000	0.675	0.155	0.868	<.0001
	Site specific	0.000	0.078	0.092	0.000	0.106	0.188	0.241	0.004
Year to year variation	National	0.061	0.035	0.059	0.692	0.434	0.217	0.148	0.729
	Upland/lowland	0.004	0.170	0.011	0.510	0.002	0.002	0.326	0.829
	Site	0.000	<0.001	0.046	0.000	0.323	0.001	0.005	0.265
Autocorrelation		-0.07*	-0.15***	-0.04	-0.14***	-0.13***	-0.18***	-0.12***	-0.06

Except for autocorrelation values, which are correlation coefficients, values are the significance level of the indicated effect.
For autocorrelations * $p<0.05$, *** $p<0.001$. Significant values are highlighted. Each effect is conditional upon the incorporation of preceding effects.

3.7 Relationships with Climate

Five climatic variables were studied: mean temperature, mean maximum temperature, mean minimum temperature, mean 100 mm soil temperature and total precipitation. All of these variables can influence plant growth, reproduction and germination and are hypothetical explanations for the year to year differences in vegetation. Data were amalgamated into quarterly and yearly means or totals, to test the role of timing and duration of climatic conditions. For each vegetation index, relationships were examined with the climatic variables for (1) each of the five quarters up to and including the summer of the survey and for (2) the year ending with the *summer* of the survey and (3) the year ending with the *spring* of the survey year. The results for correlations with yearly data are shown in Table 3.23. One example of the correlations of a vegetation index, Ellenberg R values, with quarterly climate data is given in Table 3.24 and the complete set of correlations for quarterly climate means is given in Appendix 6.

In all there were 35 different climatic variables, analysed for each of the eight vegetation indices and for each aggregate class and for all classes combined, giving a total of 35*8*9 = 2520 tests/correlations. It is important, therefore, to be wary of the dangers of attaching too much importance to any single relationship, given so many comparisons. The total number of significant ($p<0.05$) results obtained was 132, close to the 126 (5%) that would be expected by chance alone (if the climate measurements were independent). On face value this suggests that *these* climate variables do not provide a good explanation of year to year variation in vegetation. The fact that climate measurements are not independent (e.g. maximum and minimum temperatures contribute to mean temperature), makes this all the more unlikely, as we would expect to see clusters of significant relationships with slightly different correlation coefficients.

A few patterns of significant relationships can, however, be discerned in the results and these are suggestive of real correlations. For example, the proportion of significant correlations for all aggregate classes combined, for which the data is greatest are higher than chance levels (22 out of 280 = 8%), and significant climate correlations with Ellenberg wetness (W) scores are almost all with rainfall.

The S-radius of aggregate class II (Tall grass and herb) was one of the few instance of a consistent series of climate relationships. It was found to be significantly, negatively correlated with all measures of temperature (mean, maximum and minimum air temperature and mean soil temperature) in the spring preceding the survey and also positively correlated with rainfall in the autumn preceding the survey.

For the annual climatic variables above chance levels of significant results were found for R radius. (16/90=18%). Negative correlations were found with mean and maximum temperature in both grassland aggregate classes and in all classes combined.

Such relationships need further investigation to confirm the suggested links. Although the present study is based on much more data, it is salutary to note that the postulated links from the previous study for CS in 1998 have not been confirmed in these analyses. Analysis of additional climate variables and non-linear relationships should also be undertaken. Overall, however, analyses so far suggest that climatic variation is not the primary cause of the observed annual fluctuations in vegetation indices.

Table 3.23 Correlation coefficients (r) between vegetation indices and aspects of climate in the preceding year - including and excluding the summer of survey. Significant (p<0.05) results are indicated by shading.

(a) Number of Species	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature including summer of survey	0.39	-0.33	-0.06	-0.12	0.01	-0.37	-0.08	0.17	-0.13
Temperature excluding summer of survey	-0.67	-0.25	0.10	-0.03	-0.13	-0.34	-0.12	0.20	-0.14
100 mm soil temp. incl. summer of survey	0.87	-0.24	-0.45	-0.06	-0.05	-0.19	-0.10	-0.01	-0.24
100 mm soil temp. excl. summer of survey	-0.76	-0.13	-0.12	-0.02	-0.19	-0.29	-0.12	-0.01	-0.27
Mean maximum temp incl. summer of survey	0.56	-0.23	0.03	0.01	0.23	-0.19	0.17	0.35	0.11
Mean maximum temp excl. summer of survey	-0.49	-0.23	0.34	0.06	-0.13	-0.24	0.05	0.46	0.09
Mean minimum temp incl. summer of survey	0.03	-0.21	-0.19	-0.06	0.05	-0.14	0.02	-0.07	-0.12
Mean minimum temp excl. summer of survey	-0.74	-0.17	-0.04	-0.01	-0.01	-0.16	0.03	0.00	-0.10
Rainfall incl. summer of survey	0.71	-0.24	-0.37	0.01	0.12	0.01	0.08	0.16	0.05
Rainfall excl. summer of survey	0.75	-0.28	-0.43	0.00	0.21	0.07	-0.06	0.27	0.05

(b) C- radius	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	0.47	0.37	0.60	0.24	0.22	0.30	0.25	-0.05	0.35
Temp. in year preceding summer of survey	-0.33	0.25	0.46	0.06	0.37	0.27	0.23	-0.08	0.25
100mm soil temp, yr to summer of survey	0.17	0.34	0.23	-0.08	0.25	0.18	-0.16	-0.08	0.15
100mm soil temp, yr preceding summer of survey	-0.72	0.13	0.19	-0.21	0.34	0.20	-0.15	-0.14	0.12
Mean maximum temp yr to summer of survey	0.72	0.18	0.58	0.42	0.00	0.09	0.16	-0.27	0.21
Mean max. temp yr preceding summer of survey	0.24	0.25	0.56	0.26	0.29	0.03	0.39	-0.15	0.28
Mean minimum temp yr to summer of survey	-0.20	0.21	0.38	0.17	0.07	0.24	0.15	0.16	0.19
Mean min. temp yr preceding summer of survey	-0.70	0.17	0.38	0.04	0.27	0.20	0.18	0.07	0.17
Rainfall yr to summer of survey	0.49	0.13	-0.02	0.10	0.16	-0.23	-0.02	-0.27	0.01
Rainfall yr preceding summer of survey	-0.16	0.07	-0.09	0.12	0.10	-0.18	-0.17	-0.15	-0.05

(c) S-radius	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	0.36	0.03	0.27	0.43	0.00	-0.06	0.15	-0.05	0.24
Temp. in year preceding summer of survey	-0.38	0.10	0.14	0.44	-0.12	0.00	0.03	0.00	0.13
100mm soil temp, yr to summer of survey	0.09	0.01	0.05	0.24	0.16	-0.04	0.09	0.15	0.20
100mm soil temp, yr preceding summer of survey	-0.66	0.10	0.05	0.28	-0.01	-0.06	0.02	0.19	0.10
Mean maximum temp yr to summer of survey	0.58	-0.05	0.46	0.22	0.02	-0.06	0.16	0.17	0.23
Mean max. temp yr preceding summer of survey	-0.15	0.07	0.32	0.43	-0.18	0.06	-0.06	0.04	0.23
Mean minimum temp yr to summer of survey	-0.15	0.13	0.06	0.00	0.03	-0.08	0.06	-0.17	0.07
Mean min. temp yr preceding summer of survey	-0.49	0.14	0.03	0.15	-0.02	0.05	-0.07	-0.10	0.07
Rainfall yr to summer of survey	0.62	-0.38	-0.03	0.25	0.18	0.30	0.08	0.20	0.16
Rainfall yr preceding summer of survey	0.20	-0.29	-0.06	0.12	0.22	0.22	0.07	0.06	0.04

(d) R- radius	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	-0.23	-0.37	-0.56	-0.46	-0.21	-0.13	-0.14	0.32	-0.32
Temp. in year preceding summer of survey	0.25	-0.32	-0.42	-0.34	-0.15	-0.15	0.01	0.41	-0.21
100mm soil temp, yr to summer of survey	-0.06	-0.35	-0.25	-0.19	-0.55	-0.01	-0.14	-0.28	-0.27
100mm soil temp, yr preceding summer of survey	0.63	-0.27	-0.21	-0.15	-0.32	-0.02	-0.08	-0.20	-0.16
Mean maximum temp yr to summer of survey	-0.62	-0.10	-0.54	-0.32	-0.04	-0.01	0.00	0.18	-0.22
Mean max. temp yr preceding summer of survey	-0.31	-0.27	-0.51	-0.37	-0.01	-0.01	0.18	0.43	-0.25
Mean minimum temp yr to summer of survey	0.35	-0.24	-0.35	-0.14	-0.13	0.02	-0.08	0.06	-0.16
Mean min. temp yr preceding summer of survey	0.68	-0.30	-0.34	-0.11	-0.18	-0.09	0.09	0.15	-0.14
Rainfall yr to summer of survey	-0.31	0.11	-0.04	-0.18	-0.43	-0.09	-0.01	0.22	-0.12
Rainfall yr preceding summer of survey	0.14	0.17	0.02	-0.12	-0.38	-0.06	-0.08	0.19	-0.02

Table 3.23 contd.

(e) Ellenberg L score	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	-0.42	-0.11	0.10	-0.30	-0.33	-0.08	0.45	-0.03	-0.13
Temp. in year preceding summer of survey	0.76	-0.16	-0.01	-0.27	-0.23	-0.16	0.36	-0.06	-0.08
100mm soil temp, yr to summer of survey	-0.56	-0.06	0.27	-0.12	-0.42	-0.17	0.38	-0.08	-0.23
100mm soil temp, yr preceding summer of survey	0.79	-0.20	0.00	-0.15	-0.29	-0.18	0.32	-0.08	-0.13
Mean maximum temp yr to summer of survey	-0.49	-0.09	0.12	0.07	-0.27	0.20	0.33	0.09	-0.02
Mean max. temp yr preceding summer of survey	0.62	-0.17	-0.04	-0.09	-0.19	0.14	0.30	0.14	-0.13
Mean minimum temp yr to summer of survey	-0.28	-0.03	0.24	-0.27	-0.30	-0.14	0.29	-0.02	-0.05
Mean min. temp yr preceding summer of survey	0.50	-0.20	0.09	-0.26	-0.26	-0.25	0.31	-0.09	-0.04
Rainfall yr to summer of survey	-0.92	0.42	0.36	-0.10	-0.45	0.23	-0.09	0.33	-0.09
Rainfall yr preceding summer of survey	-0.59	0.36	0.38	-0.07	-0.49	0.23	0.13	0.13	0.00

(f) Ellenberg N score	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	-0.57	0.09	-0.14	-0.15	-0.01	0.10	-0.20	0.26	-0.14
Temp. in year preceding summer of survey	0.56	0.10	0.00	-0.22	-0.04	0.06	-0.14	0.25	-0.10
100mm soil temp, yr to summer of survey	-0.38	0.07	0.04	0.18	-0.10	0.40	-0.23	-0.05	0.05
100mm soil temp, yr preceding summer of survey	0.87	0.13	0.11	0.08	-0.04	0.33	-0.23	0.02	0.07
Mean maximum temp yr to summer of survey	-0.76	0.07	-0.35	-0.05	-0.11	-0.32	0.09	0.02	-0.25
Mean max. temp yr preceding summer of survey	0.25	0.10	-0.14	-0.27	-0.11	-0.31	0.09	0.00	-0.21
Mean minimum temp yr to summer of survey	0.08	-0.13	-0.03	0.07	-0.09	0.22	-0.20	0.10	-0.06
Mean min. temp yr preceding summer of survey	0.69	-0.02	0.03	0.05	-0.11	0.19	-0.04	0.18	-0.05
Rainfall yr to summer of survey	-0.84	0.13	-0.09	-0.13	0.07	-0.16	0.08	-0.10	-0.03
Rainfall yr preceding summer of survey	-0.34	0.09	-0.09	-0.08	0.01	-0.18	0.11	0.04	0.02

(g) Ellenberg R score	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	-0.64	0.05	0.28	-0.31	0.06	-0.30	-0.03	0.10	-0.09
Temp. in year preceding summer of survey	-0.15	0.01	0.22	-0.27	0.04	-0.29	0.04	0.14	-0.10
100mm soil temp, yr to summer of survey	0.24	-0.01	-0.02	0.09	-0.04	-0.17	0.04	0.06	-0.05
100mm soil temp, yr preceding summer of survey	0.00	0.01	-0.02	0.06	0.03	-0.19	0.08	0.17	-0.04
Mean maximum temp yr to summer of survey	-0.22	0.13	0.17	-0.06	0.08	-0.24	0.14	0.00	0.03
Mean max. temp yr preceding summer of survey	-0.25	-0.03	0.32	-0.22	-0.03	-0.14	0.09	-0.07	-0.09
Mean minimum temp yr to summer of survey	-0.23	-0.20	0.18	-0.09	-0.15	-0.18	-0.08	-0.01	-0.06
Mean min. temp yr preceding summer of survey	-0.15	-0.08	0.16	-0.07	-0.05	-0.27	0.04	0.07	-0.06
Rainfall yr to summer of survey	-0.21	-0.15	-0.27	-0.11	0.07	-0.07	-0.11	0.14	-0.17
Rainfall yr preceding summer of survey	0.62	-0.11	-0.28	-0.09	0.04	-0.13	0.09	0.14	-0.04

(h) Ellenberg W score	aggregate class								
	I	II	III	IV	V	VI	VII	VIII	All
Temperature in year to summer of survey	0.33	-0.09	0.43	0.26	-0.10	0.08	0.49	-0.19	0.21
Temp. in year preceding summer of survey	-0.71	-0.21	0.32	0.19	-0.02	-0.01	0.26	-0.19	0.08
100mm soil temp, yr to summer of survey	0.37	-0.07	0.26	-0.03	-0.20	0.02	0.27	0.04	0.15
100mm soil temp, yr preceding summer of survey	-0.60	-0.23	0.25	-0.05	-0.08	0.10	0.19	0.02	0.10
Mean maximum temp yr to summer of survey	0.26	-0.06	0.45	0.23	0.01	0.08	0.27	-0.15	0.08
Mean max. temp yr preceding summer of survey	-0.62	-0.20	0.37	0.30	-0.05	0.12	0.38	-0.13	0.08
Mean minimum temp yr to summer of survey	0.53	-0.12	0.24	0.10	-0.04	0.09	0.30	0.04	0.17
Mean min. temp yr preceding summer of survey	-0.21	-0.16	0.23	0.03	-0.07	-0.04	0.09	-0.08	0.06
Rainfall yr to summer of survey	0.83	0.07	0.13	-0.12	-0.13	-0.40	0.03	0.30	0.05
Rainfall yr preceding summer of survey	0.37	-0.02	0.18	-0.15	-0.02	-0.36	-0.10	-0.02	-0.17

Table 3.24 Correlations (Pearson r) between Ellenberg R score and climate in 3 month periods. Previous Summer is the period June - August of the year before the survey. Autumn is September - November, Winter is December - February, Spring is March - May and Survey Summer is June - August in the period the survey took place. Significant (p<0.05) results are indicated by shading. Other variables analysed on this basis are given in Appendix 3

	aggregate class								
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**All**
Temperature previous Summer	-0.04	0.13	0.08	-0.04	-0.03	0.25	-0.05	0.19	-0.02
Temperature Autumn	0.14	-0.02	0.30	0.12	-0.01	0.05	0.16	-0.07	0.01
Temperature Winter	-0.02	0.04	-0.06	-0.29	0.12	-0.34	0.19	0.03	-0.08
Temperature Spring	-0.09	0.01	0.13	-0.15	0.17	-0.29	-0.07	-0.03	-0.02
Temperature survey Summer	-0.20	0.17	0.25	0.05	-0.07	0.11	-0.20	0.04	0.02
100 mm Soil temp. previous Summer	-0.07	-0.05	-0.07	0.15	-0.11	0.12	-0.02	-0.06	-0.13
100 mm Soil temp. Autumn	0.08	-0.05	0.46	0.10	-0.03	0.04	0.04	-0.43	-0.01
100 mm Soil temp. Winter	0.47	0.19	-0.18	-0.08	0.27	-0.11	0.05	0.43	0.12
100 mm Soil temp. Spring	0.34	-0.02	-0.08	0.02	-0.05	-0.26	0.01	-0.17	-0.09
100 mm Soil temp. survey Summer	0.04	0.02	0.01	0.22	-0.24	0.05	-0.13	-0.29	-0.12
Mean maximum temp. previous Summer	0.11	0.10	0.17	-0.03	-0.09	0.39	-0.08	0.00	0.00
Mean maximum temp. Autumn	0.35	0.17	0.27	-0.06	-0.15	-0.17	-0.28	0.23	0.06
Mean maximum temp. Winter	-0.12	0.03	-0.19	-0.37	0.19	-0.26	0.15	0.01	0.06
Mean maximum temp. Spring	-0.16	-0.06	0.17	0.11	0.16	-0.10	0.14	-0.13	0.03
Mean maximum temp. survey Summer	0.06	0.24	0.11	0.19	-0.02	0.06	-0.01	0.10	0.11
Mean minimum temp. previous Summer	-0.09	0.07	0.04	0.05	0.04	0.06	0.03	0.19	-0.03
Mean minimum temp. Autumn	0.02	0.02	-0.15	0.35	-0.02	0.08	0.16	-0.13	0.10
Mean minimum temp. Winter	0.35	0.05	-0.12	0.04	-0.08	-0.31	0.04	-0.05	-0.04
Mean minimum temp. Spring	0.00	-0.20	-0.02	-0.22	0.10	-0.23	-0.19	0.10	-0.01
Mean minimum temp. survey Summer	-0.27	-0.08	0.28	0.05	-0.17	0.15	-0.26	-0.02	-0.02
Rainfall previous Summer	0.35	0.13	0.02	-0.14	-0.10	-0.26	0.39	0.06	0.12
Rainfall Autumn	-0.43	0.08	-0.22	0.16	-0.02	-0.07	-0.07	0.36	0.03
Rainfall Winter	-0.02	-0.35	-0.17	0.00	0.04	-0.09	-0.17	0.20	-0.09
Rainfall Spring	-0.23	0.15	-0.40	0.01	0.07	-0.31	0.46	0.14	-0.12
Rainfall survey Summer	-0.53	-0.22	0.17	-0.20	-0.08	-0.11	0.00	0.01	-0.22

4. Discussion of ECN results

The results clearly show that vegetation did vary significantly from year to year and this variation was substantial in some vegetation types. This is an important finding, as it has not, with the exception of the CS in 1998 version of this study, been investigated before across such a wide range of sites and vegetation types. This study is also unusual in that it uses species presence/absence data at the plot level, which would be expected to be more stable than cover estimates or frequency measures within plots. There were differences between vegetation types and between sites, differences between sites largely reflecting which vegetation types were present at each.

The classification of a high proportion of the plots changed between years. Vegetation shows a continuous range of variation so it is not unexpected that the presence or absence of one or two species may be all that is required to move some plots from one class to another. However, the extent of the variation for a classification as coarse as the CS aggregate classes is surprising. Some classes are more prone to change than others, so for example, AC VI, Upland Wooded can grade into either Lowland Wooded (AC V) or Moorland grass / mosaics (AC VII) under different circumstances. Other classes such as heath / bog (AC VIII) have a more distinctive set of species and so are less sensitive to small changes in vegetation composition.

The level of variability of the vegetation indices within vegetation classes tends to parallel the degree of disturbance. Thus the most disturbed sites, the arable ones (AC I crops/ weeds), show the greatest variability for all of the vegetation indices; this is not surprising as cultivation allows a new species assemblage to develop each year. The differences between years, although large, tended not to be significant in AC I, because of large field to field variability. The fertile grasslands (AC III) are also relatively variable. They are not disturbed to the same degree as arable land but regular cutting or close grazing prevents a dense canopy persisting and poaching by livestock and vehicle tracks also create gaps in the sward. The number of species in these grasslands is small, so the presence or absence of a few weed species colonising short-term gaps may have a relatively large impact on the vegetation indices. This is especially true since our analysis (like most of those of the Countryside Surveys) was based on presence / absence rather than any measure of abundance within plots.

The changes in R and C radii suggest that the dip in species numbers in fertile grasslands(AC III) between approximately 1997 and 2000 reflects a shifting balance between ruderal species and the more competitive grasses, which dominate these grasslands, of which *Lolium perenne* is particularly important. This may be explained if gaps (which can be colonised by ruderals) were more common in the middle of the 1990s and closed over in later years. This may in turn reflect a recovery of soil water contents after the drought of 1995 and subsequent years. (Soil water content only returned to pre-drought levels in the summer of 1997 at Wytham; Morecroft *et al.*, 2000). In parallel studies an increased frequency of annuals was found *within* grassland plots at Drayton and Wytham in 1996 compared to 1994. It is notable that the biggest changes were found in 1999 following a very wet summer in 1998 and where records are available (Table 3.5) there do seem to have been fewer ruderal weeds in 1994 before the drought than 1996-1998, after it.

Woodlands of both 'upland' and 'lowland' types (aggregate classes V and VI) can be quite variable and some significant differences were found. Much of this variability is intrinsic to the system: woodland management causes dramatic changes in the physical environment of ground vegetation, but it is patchy and takes place at long time intervals; even in an unmanaged woodland, periodic tree fall can have similar effects. These processes are not synchronised across the ECN sites so it is surprising that significant year to year differences were found.

The predominantly upland vegetation types, VII and VIII, are relatively stable year-to-year. These sorts of vegetation are subject to little disturbance and maintain a close cover of stress tolerant species. Even where gaps do occur, a relatively small number of species adapted to what are typically damp, acidic conditions, can colonise them.

The most likely cause of year-to-year variations in vegetation across the range of sites in this study is differences in the weather, given that there were few other large scale perturbations which affected all sites. However, relatively few correlations with meteorological variables were found and those which were do not explain the most significant year to year changes. It is possible that climate is not the cause of the observed year to year fluctuations in vegetation indices, but it is hard to suggest any convincing alternative explanation. Unlike the situation at the time of the CS and ECN study the time series currently available are now long enough for the detection of climatic effects to be possible and it is surprising that more links were not found. A contributory factor may be that, since climatic variables are measured for each site as a whole and so must be related to summaries of the vegetation indices for each site, the power of detection is lower than for tests applied at the plot level. A more likely explanation is that climatic effects are complex, involving for example, long time lags, non-linear responses or interactions between variables. The persistence of effects, as evidenced by the medium term nature of year to year fluctuations, is also likely to play a part. Such effects require much more detailed and painstaking analyses to understand than have been feasible for this study.

Only two of the vegetation indices showed significant long term trends. There were downward trends in Grimes R radius and Ellenberg light score. The trend in R radius is substantial (Figures 3.7 and 3.8) but the trend in light score, though consistent enough to be significant, represents only a small change in relation to the mean level. This is clear from Figures 3.15 and 3.16.

5. Implications for Countryside Survey

The ECN results show that the Countryside Survey results must incorporate an element caused by year to year variations in vegetation, but how large is this element? Because ECN does not have annually recorded data going back to 1990 direct comparison is only possible for the changes between the two most recent surveys, in 1998 and 2007.

5.1 Changes in aggregate vegetation class classification

As described above changes in aggregate class of ECN plots ranged from 12% between successive years to 24% at intervals comparable to those between Countryside Surveys. Taking the former figure as reflecting random variation and the increase with the latter as reflecting more persistent change or long term trends, this might suggest that, up to a half of the changes in aggregate classes in CS could be the result of annual fluctuations. It is important however to look at the data for each vegetation class separately.

Table 5.1 gives matrices of change in aggregate class for CS between 1990 and 1998 and between 1998 and 2007 respectively . These are taken from the main report for CS in 2007 where a detailed analysis is provided. The two matrices are remarkably similar suggesting that the pattern of change has not altered markedly between the two periods. Table 3.2 is the comparable ECN table, though it should be remembered that this table shows change between successive years while the CS tables represent much longer intervals. With this proviso and noting that the overall level of change is twice as great in the CS tables, it is possible to see significant differences between the two studies.

Firstly the balance of plot types is very different between the two programmes. As pointed out above ECN has few arable plots and those it has were established specifically for the previous CS/ECN study. In addition there is a deficit of plots in AC IV (infertile grassland). The most notable difference, however is that ECN has a much greater proportion of AC V (lowland wooded plots) than CS. In terms of change between aggregate classes, it is notable that ECN plots in AC 3 (fertile grassland) and AC V are much more stable than those in CS. This may reflect the more stable management of ECN sites compared to the more general countryside. In addition, however, ECN plots in AC VI (upland wooded) appear to be less stable that those in CS showing the same proportion of turnover in a single year that CS plots show in a decade. We currently have no explanation for this.

Table 5.1 Changes in CS plot classification between aggregate vegetation classes. Data are from the main (X) plot type and all of Great Britain and are taken from the main report for CS in 2007 (Carey *et al*., 2008).

1990 to 1998

	New Aggregate Class									**% changed from**
Initial Aggregate Class	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**All**	
I Crops/weeds	296	65	55	5					421	29.7
II Tall grass / herb	56	41	27	5	3	2		1	135	69.6
III Fertile grassland	60	20	277	59			2		418	33.7
IV Infertile grassland	4	7	69	308		5	12		405	24.0
V Lowland wooded		4			63	9			76	17.1
VI Upland wooded		2		7	13	113	25	13	173	34.7
VII Moorland grass / mosaic				9		21	196	61	287	31.7
VIII Heath / bog						8	22	383	413	7.3
All classes	416	139	428	393	79	158	257	458	2328	
% changed to	28.8	70.5	35.3	21.6	20.3	28.5	23.7	16.4		

1998 to 2007

	New Aggregate Class									**% changed from**
Initial Aggregate Class	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**All**	
I Crops/weeds	257	52	21						330	22.1
II Tall grass / herb	41	30	22	5	7	3			108	72.2
III Fertile grassland	62	20	261	72			1		416	37.3
IV Infertile grassland	12	6	61	324		6	19		428	24.3
V Lowland wooded	2	7	2	1	48	13			73	34.2
VI Upland wooded	1	2	1	8	5	121	25	10	173	30.1
VII Moorland grass / mosaic		2		7		20	219	20	268	18.3
VIII Heath / bog						9	39	364	412	11.7
All classes	375	119	368	417	60	172	303	394	2208	
% changed to	31.5	74.8	29.1	22.3	20.0	29.7	27.7	7.6		

5.2 Changes in diversity

Overall comparison of Countryside Survey and ECN vegetation summaries is complicated by the pattern of observation/non-observation at ECN sites arising from the combination of standard ECN monitoring with funded additional monitoring around CS in 1998 and 2007 and with voluntary effort in intervening years. Simply averaging the available data in each year would induce bias from the varying mix of sites/plots over time. To overcome this problem statistical models (technically mixed models with allowance for the hierarchical nature of ECN data (plots within sites) via a random site effect and an autoregressive AR(1) component) were fitted to the data and used to estimate the annual levels of each vegetation index for the ECN network as a whole. This procedure produces estimated values from which the bias arising from the varying site mix has been removed. The results of these analyses are presented in Figures 5.1 and 5.2. A further complication is that, although the set of ECN sites cover a wide range of habitats and locations across GB and were chosen to do so, they do not form a representative sample of GB. Thus the average level of any vegetation index over the complete set of ECN sites should not be expected to be the same as the representative national estimates from Countryside Survey. To facilitate comparison, therefore, the results in Figures 5.1 and 5.2 are presented with separate scales for CS and ECN data. The two scales in each graph have different initial values but care has been taken to ensure that the intervals on the two scales are the same so that variation and change estimates are on equal footing for both sets of data and can be directly compared.

The first graph in Figure 5. superimposes the average number of species found in the last three Countryside Surveys on the estimated ECN annual values from 1994 to 2007 and a linear trendline fitted to the ECN data. It is clear both that the results from the two sets of data are compatible and that there has been little change in diversity over the studied period. Interestingly the ECN data suggest that a dip in species number may have occurred between the 1998 and 2007 Countryside Surveys. For the actual CS years, however the ECN data confirm that the CS change results are unlikely to have been biased by the specific conditions in the survey years.

5.3 Changes in plant strategy indices

The remaining three charts in Figure 5.1 compare the CS and ECN data for the plant strategy indices. The ECN data show the significant decline in R radius over the studied period with the compensating, though not significant, increases in C and S radii. The CS results are broadly in line with this conclusion, although there is a suggestion that CS results may give smaller values for both the decline in R radius and the increases in C and S scores. In particular the small CS confidence intervals for C radius suggest that the difference in the change in C radius between ECN and CS is larger than could be accounted for by chance although the lack of significance of the trend in C radius at ECN sites makes it clear that this is not the case. For none of the three indices is there a suggestion that the CS results may be affected to any great extent by the particular years in which they took place.

5.4 Changes in Ellenberg indices

Figure 5.2 shows comparisons between the ECN and CS results for the four Ellenberg indices. It should be noted that the scales on these charts have been chosen to facilitate the comparison of the two datasets and that the actual changes and trends shown are in reality extremely small. Figures 3,9 to 3.12 provide useful comparative references here.

As with the previous indices the CS and ECN data provide similar conclusions and there is little or no suggestion that the CS results are affected by or arise from unusual conditions in the actual survey years. The R, N and W scores show remarkable consistency between the

ECN trends and the CS changes, possibly a reflection of the lesser year to year variation in Ellenberg values compared to the other vegetation indices. The Countryside Survey N and W scores for 1998 and 2007 lie almost on the fitted ECN trendline and very close to the actual ECN estimates for those years. The R score results are particularly interesting. The ECN and CS results are extremely close while the 2007 ECN value is substantially below the fitted trendline. This suggests that the CS estimate of change in Ellenberg R from 1998 to 2007 may be an underestimate of the actual change that has occurred.

Only for Ellenberg L score is there a discrepancy between the ECN and CS results. The ECN data shown a consistent and sustained decline in Ellenberg L between 1998 and 2007 which is not reflected in the CS results. Furthermore the relatively small CS confidence intervals make it unlikely that this discrepancy is just an effect of random variation. Since changes in L score are often mediated through the balance between woodland and other vegetation this may reflect a difference in or changes to the proportions of woodlands at ECN and CS sites. In this context it is notable in comparison of Tables 3.2 and 5.1 that ECN sites overall have a much higher proportion of AC V (lowland wooded) plots than CS and that Table 3.20 shows these plots to have a substantial decline in Ellenberg L score. Table 5.2 gives the estimated trends (change in score per annum) for Ellenberg light score within each aggregate vegetation class. There is a decreasing trend in classes I-VI and an increasing trend in classes VII and VIII. Over all plots combined there is a significant average decline. However the largest significant negative trend is for class V, lowland wooded, the class that is substantially over-represented in ECN in comparison to CS. When the individual class trends are combined in proportion to their representation in the CS data (Table 5.1) the overall trend is not significant, in agreement with the CS findings.

Table 5.2 Relationship between Ellenberg light score and year of observation

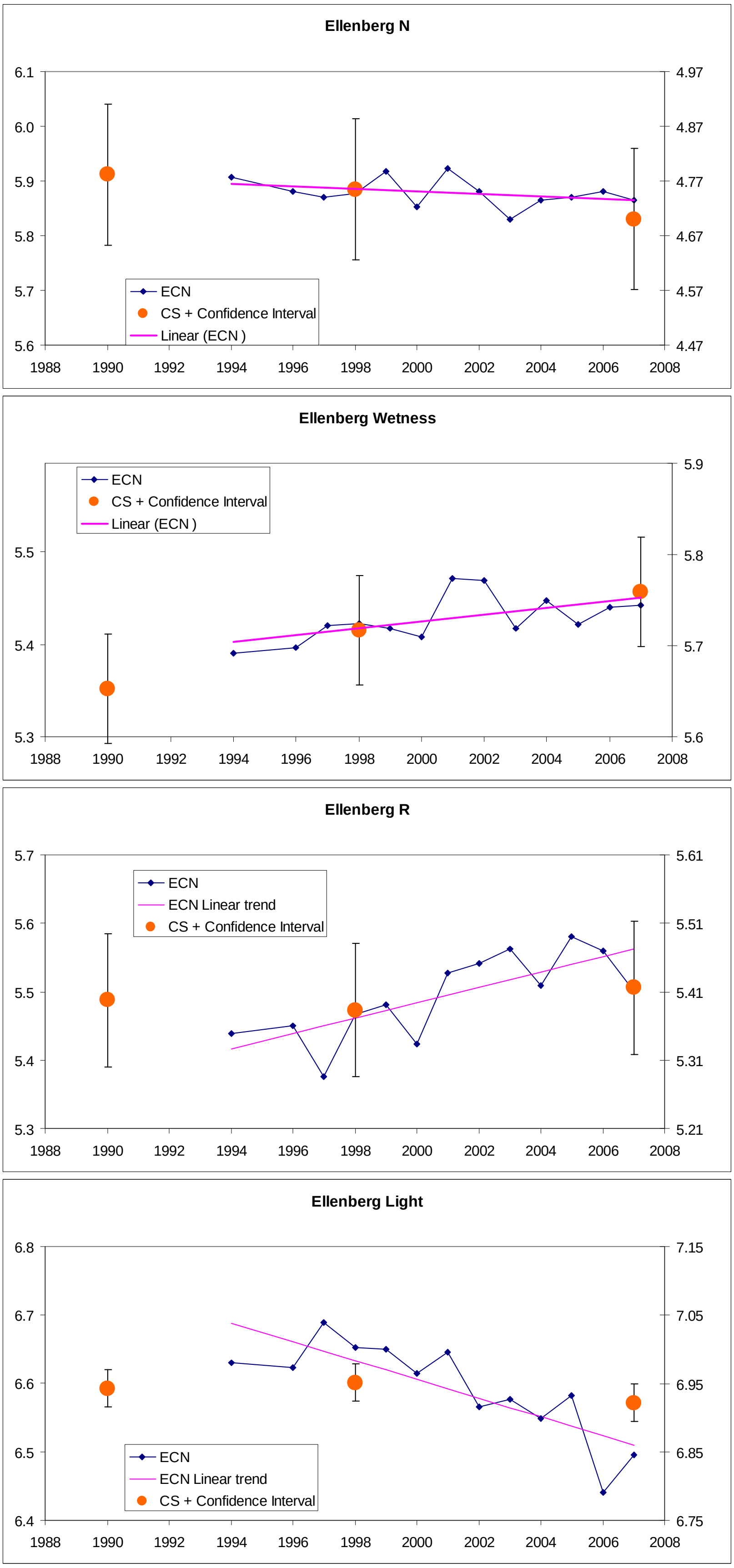
Aggregate vegetation class		Regression slope	SE	N	t	p
I	Crops/weeds	-	-	0	-	-
II	Tall grass / herb	-0.0471	0.0254	9	-1.86	0.100
III	Fertile grassland	-0.0045	0.0044	21	-1.01	0.324
IV	Infertile grassland	-0.0052	0.0023	30	-2.24	0.033
V	Lowland wooded	-0.0217	0.0100	37	-2.17	0.037
VI	Upland wooded	-0.0065	0.0096	20	-0.68	0.504
VII	Moorland grass / mosaic	0.0034	0.0018	38	1.88	0.068
VIII	Heath / bog	0.0132	0.0034	39	3.90	0.000
No dominant class		-0.0246	0.0179	8	-1.38	0.212
All classes		-0.0057	0.0026	202	-2.19	0.030
Classes II-VIII, CS weighting		-0.0033	0.0024	194	-1.37	0.172

5.5 Overall conclusions

Overall therefore the results of this study indicate that the findings of CS in 2007 with regard to vegetation are robust to random annual fluctuations in vegetation composition and properties. With one exception ECN and CS results are remarkably consistent. The exception, a discrepancy in the findings for Ellenberg L, arises from the differing mix of vegetation types at ECN and CS sites.

Fig. 5.1 Comparison of number of species and plant strategy indices for 1990 to 2007 in CS data with ECN annual data from 1994 to 2007. Error bars for CS data are confidence intervals.

Fig. 5.2 Comparison of Ellenberg indices in 1990 to 2007 for CS data with ECN annual data from 1994 to 2007. Error bars for CS data are confidence intervals.



6. Recommendations

This study has quantified year to year changes in vegetation and shown that, although they are in general large enough to influence the results of the Countryside Surveys, the survey years of 1998 and 2007 were not extreme or exceptional enough to suggest that such influences play more than a minor role. The exception to this conclusion is the Ellenberg R score where ECN results suggest that 2007 values were low in terms of recent trends and that this might have led to an underestimate of change from CS. Only further data will distinguish, however, between the possibilities that the 2007 Ellenberg R values represent the most recent fluctuation about a consistent trend or that they are the beginning of a change in trend.

This study has not, however, been able to identify substantial correlations with climate or accurately quantify their impact. This is no longer, as was concluded in the previous ECN/CS study, likely to be because ECN does not have long enough time series but is more likely to be due to the complex nature and temporal persistence of climate vegetation interaction. Further analyses will be undertaken by ECN to understand such interactions but additional data would certainly help with this. It is therefore important that annual monitoring of vegetation continues, both to provide additional data and to make it possible to allow for variation in weather conditions in interpreting the results of future large-scale, but intermittent, monitoring exercises. This is all the more important in the context of climate change as periods of extreme weather such as droughts will probably become more frequent (Hulme & Jenkins, 1998). Yearly vegetation monitoring would also greatly enhance understanding of the mechanisms underlying vegetation changes.

Is ECN monitoring a suitable basis for such a study? The fact that this study could detect significant differences between years, discriminate between different vegetation types and show a general correspondence between ECN and CS results indicates that the method used was fit for its intended purpose. The very detailed information available for each ECN site makes these sites particularly well suited for an ongoing study of annual vegetation changes. As well as the extensive climate data, information on soil type and properties, hydrology and animal populations could all be invaluable additions for interpreting vegetation data. Large-scale changes in management are unusual at most ECN sites and where management practices do change, records are normally kept. This means that in some respects ECN plots can act as 'controls' against which to judge land use change in the wider countryside. Personal contact is often important in understanding site - specific changes and locally based ECN site managers can normally answer detailed questions about site history and management. Future analysis should take advantage of this wealth of background knowledge to gain a fuller understanding of the processes taking place at the plot scale. This study also benefited from using locally based staff to locate and mark permanent plots in advance of the surveyors' visits. Further advantages of using ECN sites for a study of this sort include the wide geographical range of locations and the existing time series for vegetation data, which this project has contributed to. Annual vegetation monitoring would also add value to ECN monitoring itself.

It is unfortunate that the specialist arable plots established for the CS2000 study were not monitored for for this study and it is recommended that they be re-established for any future continuation of this work. The low number of plots in aggregate vegetation class II is a cause of concern as it makes it unlikely that significant differences or relationships to climate will be detected for this class. Any future recording programme should aim to establish new plots, to address this deficit. Including the newer ECN sites in Snowdonia and the Cairngorms, has improved coverage at the upper end of the range of altitudes. Although analysis suggests that the results of ECN and CS monitoring methods are comparable further study to confirm this is desirable. This could be done relatively easily by superimposing a Countryside Survey design plot onto each ECN plot and recording both for a few years.

It is therefore recommend that the current monitoring programme be continued and extended in the following ways:

1. Continue annual monitoring of plots that were chosen for the CS studies up to at least the next main Countryside Survey and preferably indefinitely.
2. Develop analysis further to better understand processes and eventually enable the effects of climate on inter-annual variability in vegetation to be modelled.
3. Set up additional plots in vegetation of aggregate class II and reinstate the arable plots used for the CS/ECN study in 1998.
4. Record vegetation in a sample of plots using both Countryside Survey and ECN methods.

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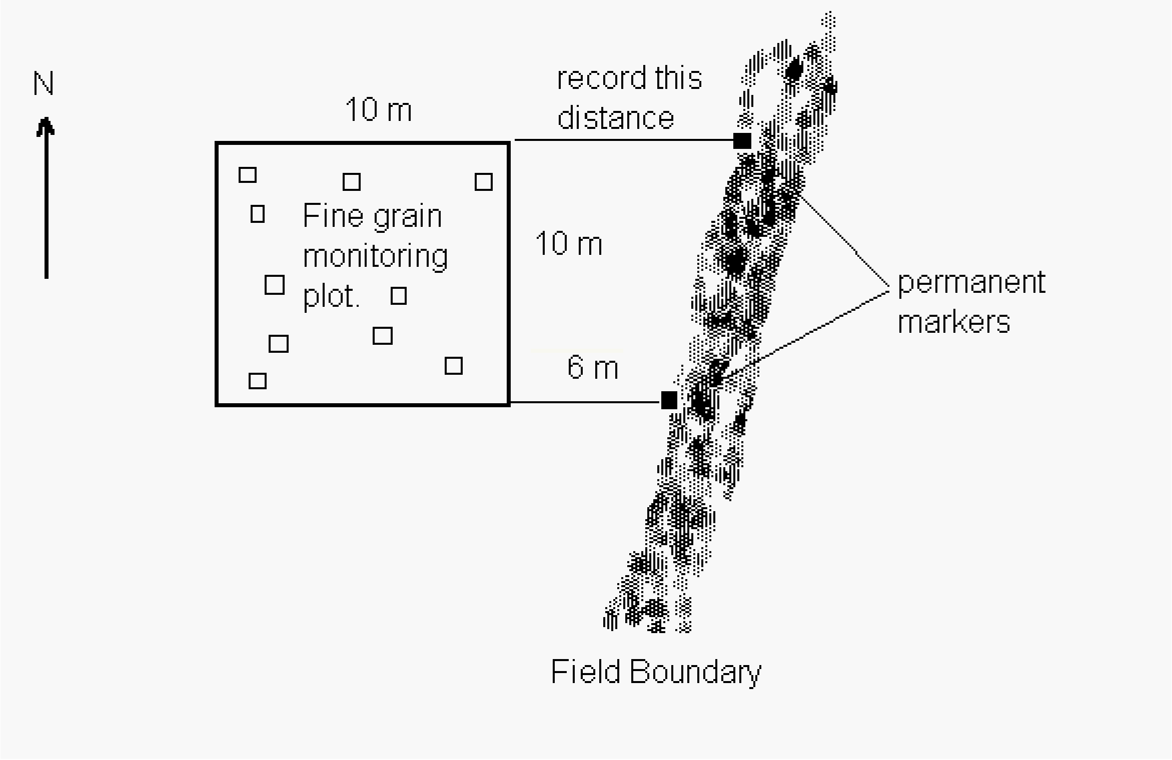
Appendix 1 Protocol for setting up arable vegetation plots - instructions sent to ECN site managers

ECN Annual Vegetation Recording Project 1998
Protocol for establishment of fine grain monitoring plots on arable land.

We have been asked to include arable plots in this assessment in order to help interpret results from the Countryside Survey. This protocol has been drawn up to ensure compatibility with this methodology as well as ECN, hence for example, plots are established at the edge of fields.

Five plots should be established on arable land at each suitable ECN site. Plots should include a range of crops typical of the site, but not grass leys, extreme experimental treatments, or unorthodox crops; plots should normally be in different fields. Once a field has been chosen a random point along its boundary should be selected. The plot should be located such that the nearest corner is 6 m from this point on the boundary, where a permanent marker should be placed (Fig. 1). The nearest corner should be due North, South, East or West of the boundary point. A second marker should be placed in the boundary due North, South, East or West of the second closest corner and the distance between the marker and plot corner recorded. Which corner (NE, SE, SW, NW) is closest to each permanent marker should also be noted, together with the location of the marker with respect to an easily identified landmark (e.g. gate, building, tree). Plot information (grid reference etc.) for arable plots should be recorded in the same way as for other ECN plots.

Figure 1. Diagram to illustrate position of plot relative to field boundary



Because herbicide usage will affect which arable weeds are present, records of herbicide treatment should be kept (see Table 1). It would be helpful to have records from the present growing season onwards.

Table 1 EXAMPLE PROFORMA FOR USE IN ARABLE CROPS

HERBICIDE USAGE RECORD			
ECN SITE		FIELD NAME/No.	
RECORDER	CROP	VARIETY	DATE SOWN
DATE	**PRODUCT**	**Active ingredient**	**Rate per ha**

This work will be repeated next year using the same permanent plots. It is possible that the monitoring may be continued in subsequent years. Inevitably crops will vary from year to year and this will confound interpretation of results; in the long term this should become less important as crops return to the original fields. In the short term extra plots may be established next year in order to track trends in common crops such as wheat.

Appendix 2 Summary of vegetation monitoring plots in the Countryside Survey.

Name	**Area and shape**	**Location**	**Years for which comparisons can be made**
Main	200 m^2 square	random but not on linear features	1978, 1990, 1998, 2007
Habitat	4 m^2 square	random from semi-natural habitats not included in main plots	1990, 1998, 2007
Boundary	10 x 1m linear	nearest field boundary to main plot	1990, 1998, 2007
Hedge	10 x 1m linear	random	1978, 1990, 1998, 2007
Streamside	10 x 1m linear	random + selected	1978, 1990, 1998, 2007
Roadside	10 x 1m linear	random + selected	1978, 1990, 1998, 2007

Appendix 3. Complete Table 3.7 Description in partial Table 3.7 above

(a) number of species	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	-0.77	-0.04	0.62	0.06	-0.42	-0.22	-0.07	0.37	0.05
Temperature Autumn	0.77	-0.02	0.18	0.04	-0.02	-0.07	0.23	0.29	0.17
Temperature Winter	-0.25	-0.31	-0.29	-0.07	0.14	-0.24	-0.04	0.13	-0.14
Temperature Spring	0.65	-0.21	-0.28	-0.05	0.23	-0.19	-0.13	-0.12	-0.09
Temperature survey Summer	0.68	0.09	0.29	-0.10	-0.03	-0.06	0.08	0.20	0.19
100 mm Soil temp. previous Summer	-0.74	0.15	0.38	-0.13	-0.43	-0.24	0.06	0.19	0.00
100 mm Soil temp. Autumn	0.74	-0.10	0.10	0.15	0.05	0.09	0.07	0.12	0.19
100 mm Soil temp. Winter	-0.09	-0.27	-0.12	-0.06	0.05	-0.23	-0.15	-0.09	-0.30
100 mm Soil temp. Spring	0.91	-0.02	-0.49	-0.02	0.21	-0.06	-0.06	-0.08	-0.03
100 mm Soil temp. survey Summer	0.82	0.10	-0.16	-0.22	-0.02	0.14	0.10	0.15	0.16
Mean maximum temp. previous Summer	-0.71	-0.01	0.72	0.03	-0.48	-0.11	-0.04	0.35	0.14
Mean maximum temp. Autumn	0.84	0.11	0.10	-0.05	0.21	-0.15	-0.15	0.25	0.16
Mean maximum temp. Winter	0.08	-0.23	-0.23	-0.10	0.17	-0.24	-0.13	-0.03	-0.20
Mean maximum temp. Spring	0.67	-0.11	-0.11	0.14	0.33	-0.16	0.12	0.12	0.15
Mean maximum temp. survey Summer	0.86	0.09	0.28	-0.04	0.02	0.05	0.12	0.15	0.16
Mean minimum temp. previous Summer	-0.77	0.00	0.54	-0.01	-0.18	-0.16	-0.03	0.24	0.08
Mean minimum temp. Autumn	0.63	0.02	-0.04	0.06	-0.04	0.10	0.23	0.25	0.08
Mean minimum temp. Winter	-0.72	-0.11	-0.23	0.04	0.36	-0.07	0.18	0.14	0.09
Mean minimum temp. Spring	0.78	-0.12	-0.33	-0.13	0.09	-0.24	-0.29	-0.18	-0.25
Mean minimum temp. survey Summer	0.45	0.03	0.28	-0.13	-0.03	-0.03	-0.08	0.07	0.08
Rainfall previous Summer	-0.40	-0.12	-0.37	-0.02	0.47	0.12	-0.06	0.30	0.07
Rainfall Autumn	-0.87	-0.05	-0.29	0.21	0.03	0.04	0.39	0.06	0.10
Rainfall Winter	0.56	-0.17	-0.21	0.15	0.08	0.05	0.03	0.15	0.07
Rainfall Spring	-0.78	-0.12	-0.26	0.00	0.02	-0.18	-0.18	0.39	-0.11
Rainfall survey Summer	0.49	0.08	-0.14	0.02	0.04	-0.05	0.27	-0.02	0.09

(b) C- radius	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	-0.49	-0.07	0.11	-0.09	0.1	0.03	0.2	-0.12	0.04
Temperature Autumn	0.51	0.09	0.42	0.51	-0.21	0.01	0.28	0	0.16
Temperature Winter	0.08	0.2	0.28	0.05	0.36	0.24	0.19	-0.07	0.12
Temperature Spring	0.52	0.44	0.24	0.05	0.35	0.27	0.12	0.03	0.25
Temperature survey Summer	0.37	-0.02	0.24	0.28	-0.34	-0.03	0.1	-0.02	0.13
100 mm Soil temp. previous Summer	-0.75	-0.21	-0.09	-0.45	0.02	0.07	-0.17	-0.06	-0.04
100 mm Soil temp. Autumn	0.63	0.22	0.22	0.22	-0.18	0.11	0.11	0.23	0.17
100 mm Soil temp. Winter	-0.52	0.19	0.3	-0.04	0.38	0.05	-0.16	-0.16	0.1
100 mm Soil temp. Spring	-0.04	0.32	-0.02	-0.03	0.3	0.26	0.09	0.02	0.12
100 mm Soil temp. survey Summer	0.45	0.01	-0.04	-0.03	-0.25	-0.05	-0.16	0.09	0.02
Mean maximum temp. previous Summer	-0.64	0.01	0.16	-0.06	-0.1	-0.3	0.12	-0.05	0.11
Mean maximum temp. Autumn	0.5	0.13	0.3	0.17	-0.28	0.24	-0.07	-0.19	0.14
Mean maximum temp. Winter	0.42	0.1	0.09	-0.02	0.38	0.32	0.15	0.16	0.01
Mean maximum temp. Spring	0.81	0.26	0.4	0.19	0.2	0.09	0.18	-0.14	0.26
Mean maximum temp. survey Summer	0.27	-0.08	0.22	0.17	-0.36	-0.17	-0.22	-0.21	0.01
Mean minimum temp. previous Summer	-0.54	-0.05	0.21	-0.02	0.13	0.22	0.21	-0.02	0.13
Mean minimum temp. Autumn	0.17	-0.1	0.03	0.31	-0.28	-0.15	0.02	0.08	-0.1
Mean minimum temp. Winter	-0.57	-0.06	0.16	0.08	0.16	0.03	0.15	-0.11	-0.06
Mean minimum temp. Spring	0.27	0.23	0.01	-0.11	0.21	0.42	-0.11	0.1	0.11
Mean minimum temp. survey Summer	0.2	-0.01	0.3	0.29	-0.27	0.22	0.08	0.16	0.16
Rainfall previous Summer	-0.56	0.17	0.08	0.2	0.25	0.23	-0.1	0.06	0.01
Rainfall Autumn	-0.41	-0.38	-0.02	-0.11	-0.1	-0.13	-0.47	-0.28	-0.17
Rainfall Winter	0.34	0.01	0.02	-0.05	0.31	-0.19	-0.21	-0.21	-0.03
Rainfall Spring	-0.62	-0.37	-0.07	-0.01	-0.08	0.25	-0.24	-0.19	-0.15
Rainfall survey Summer	0.56	0.22	0.21	0.13	0.32	0.16	0.31	-0.13	0.2

(c) S-radius	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	-0.51	0.12	0.11	0.25	-0.01	-0.22	-0.10	0.04	0.11
Temperature Autumn	0.43	0.24	0.25	-0.09	0.15	-0.02	-0.09	-0.11	0.29
Temperature Winter	-0.06	-0.02	0.05	0.33	-0.16	-0.01	0.08	-0.01	-0.03
Temperature Spring	0.44	-0.54	0.02	0.21	-0.18	-0.08	0.16	-0.02	0.01
Temperature survey Summer	0.38	0.16	0.20	-0.05	0.18	-0.10	0.09	-0.04	0.25
100 mm Soil temp. previous Summer	-0.58	0.08	0.01	0.10	-0.12	-0.34	-0.04	0.20	0.07
100 mm Soil temp. Autumn	0.65	0.01	0.13	-0.09	0.37	-0.01	-0.02	-0.17	0.28
100 mm Soil temp. Winter	-0.31	0.07	0.17	0.24	-0.01	0.00	0.05	0.07	0.00
100 mm Soil temp. Spring	0.46	-0.50	-0.11	0.12	-0.10	-0.05	0.08	0.07	0.02
100 mm Soil temp. survey Summer	0.48	0.08	-0.07	-0.05	0.18	-0.04	0.13	0.08	0.24
Mean maximum temp. previous Summer	-0.73	0.16	0.21	0.19	0.03	0.00	-0.16	0.02	0.23
Mean maximum temp. Autumn	0.27	0.04	0.25	-0.21	0.16	-0.16	0.20	0.19	0.19
Mean maximum temp. Winter	0.20	-0.10	-0.02	0.21	-0.31	-0.17	0.15	-0.22	-0.28
Mean maximum temp. Spring	0.64	-0.43	0.23	0.17	-0.07	-0.07	0.10	0.13	0.18
Mean maximum temp. survey Summer	0.44	0.17	0.30	-0.14	0.17	0.04	0.15	0.19	0.19
Mean minimum temp. previous Summer	-0.37	-0.13	0.19	0.15	0.02	-0.27	-0.13	-0.03	0.12
Mean minimum temp. Autumn	0.27	0.31	0.08	-0.38	0.09	0.01	-0.03	-0.14	0.04
Mean minimum temp. Winter	-0.57	0.04	-0.01	-0.01	0.01	0.14	-0.08	0.10	-0.03
Mean minimum temp. Spring	0.63	-0.41	-0.12	0.05	-0.13	-0.32	0.32	-0.05	-0.15
Mean minimum temp. survey Summer	0.12	0.26	0.17	-0.22	-0.03	-0.31	0.19	-0.16	0.13
Rainfall previous Summer	-0.55	-0.07	-0.03	0.01	-0.04	-0.05	0.01	-0.12	-0.07
Rainfall Autumn	-0.31	0.47	-0.07	-0.16	0.13	0.07	0.39	0.30	0.04
Rainfall Winter	0.43	-0.02	-0.21	0.14	-0.03	0.26	0.21	0.18	0.08
Rainfall Spring	-0.35	0.38	-0.06	0.04	0.30	-0.03	0.10	0.14	0.05
Rainfall survey Summer	0.58	-0.25	0.02	0.30	-0.12	0.13	-0.01	0.14	0.19

(d) R- radius	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	0.38	0.03	-0.12	-0.20	0.00	0.14	0.18	0.35	-0.07
Temperature Autumn	-0.43	-0.17	-0.33	-0.36	-0.07	0.03	0.16	0.19	-0.24
Temperature Winter	-0.16	-0.24	-0.26	-0.19	-0.12	-0.17	-0.05	0.27	-0.06
Temperature Spring	-0.42	-0.17	-0.24	-0.06	-0.08	-0.07	-0.17	0.03	-0.15
Temperature survey Summer	-0.18	-0.02	-0.21	-0.20	0.01	0.12	-0.10	-0.03	-0.19
100 mm Soil temp. previous Summer	0.70	0.12	0.03	0.19	0.13	0.11	0.10	-0.38	-0.03
100 mm Soil temp. Autumn	-0.56	-0.24	-0.18	-0.26	-0.34	-0.18	0.10	-0.29	-0.29
100 mm Soil temp. Winter	0.37	-0.31	-0.30	-0.24	-0.30	0.07	-0.19	0.14	-0.07
100 mm Soil temp. Spring	0.12	-0.19	-0.02	0.10	-0.19	-0.11	-0.05	-0.24	-0.11
100 mm Soil temp. survey Summer	-0.32	0.02	0.06	0.14	-0.24	-0.03	-0.06	-0.51	-0.21
Mean maximum temp. previous Summer	0.53	-0.09	-0.16	-0.14	0.08	0.15	0.15	0.24	-0.17
Mean maximum temp. Autumn	-0.49	-0.18	-0.27	0.06	0.12	-0.08	-0.19	0.17	-0.15
Mean maximum temp. Winter	-0.44	-0.08	-0.07	-0.07	0.06	-0.07	-0.12	0.38	0.16
Mean maximum temp. Spring	-0.69	-0.04	-0.40	-0.06	-0.01	0.03	0.03	0.02	-0.24
Mean maximum temp. survey Summer	-0.12	0.00	-0.19	-0.01	0.06	0.04	-0.12	-0.15	-0.09
Mean minimum temp. previous Summer	0.45	0.13	-0.23	-0.14	-0.06	0.13	0.20	0.22	-0.14
Mean minimum temp. Autumn	-0.04	-0.06	0.02	-0.05	0.05	0.05	0.07	-0.06	0.03
Mean minimum temp. Winter	0.36	-0.13	-0.14	0.08	-0.09	-0.16	0.12	-0.06	0.06
Mean minimum temp. Spring	-0.15	0.07	-0.04	0.01	-0.02	0.03	-0.39	0.02	0.00
Mean minimum temp. survey Summer	0.01	0.03	-0.28	-0.12	0.16	0.23	-0.21	-0.03	-0.16
Rainfall previous Summer	0.40	-0.13	-0.08	-0.04	-0.12	0.02	-0.05	0.18	0.02
Rainfall Autumn	0.41	0.08	-0.02	0.08	-0.01	0.07	-0.31	0.13	0.07
Rainfall Winter	-0.23	0.00	-0.03	-0.04	-0.28	-0.03	-0.13	0.08	-0.03
Rainfall Spring	0.60	0.08	0.05	-0.12	-0.29	-0.42	-0.06	0.10	0.02
Rainfall survey Summer	-0.34	-0.10	-0.17	-0.20	-0.19	-0.02	0.13	0.21	-0.21

(e) Ellenberg L scores	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	0.84	-0.06	-0.28	0.11	-0.15	-0.06	0.12	-0.09	-0.17
Temperature Autumn	-0.75	-0.22	-0.22	-0.13	-0.15	-0.21	0.14	0.11	-0.27
Temperature Winter	0.49	-0.11	0.14	-0.15	-0.16	0.09	0.39	-0.02	0.11
Temperature Spring	-0.41	0.25	0.16	-0.07	-0.04	0.10	0.35	-0.07	0.02
Temperature survey Summer	-0.81	-0.13	-0.16	0.03	-0.03	-0.10	0.06	0.01	-0.23
100 mm Soil temp. previous Summer	0.63	-0.06	-0.32	0.07	-0.04	0.26	-0.05	-0.20	-0.18
100 mm Soil temp. Autumn	-0.86	-0.22	-0.03	-0.11	-0.27	-0.41	0.29	-0.10	-0.35
100 mm Soil temp. Winter	0.54	-0.26	0.12	-0.06	-0.32	-0.13	0.22	0.09	0.05
100 mm Soil temp. Spring	-0.76	0.09	0.18	0.00	0.07	0.11	0.31	-0.06	-0.02
100 mm Soil temp. survey Summer	-0.84	0.03	0.11	0.12	-0.08	0.08	0.09	-0.15	-0.34
Mean maximum temp. previous Summer	0.76	-0.17	-0.31	0.09	-0.09	0.10	-0.14	0.07	-0.27
Mean maximum temp. Autumn	-0.45	-0.18	-0.19	-0.09	0.13	-0.34	0.16	-0.51	-0.14
Mean maximum temp. Winter	0.15	-0.06	0.21	-0.07	0.01	0.09	0.37	-0.10	0.27
Mean maximum temp. Spring	-0.75	0.14	0.15	0.18	-0.11	0.22	0.36	0.08	-0.07
Mean maximum temp. survey Summer	-0.85	-0.23	-0.16	0.11	-0.01	-0.09	-0.10	-0.01	-0.10
Mean minimum temp. previous Summer	0.70	0.07	-0.17	0.02	-0.26	-0.13	0.26	-0.19	-0.21
Mean minimum temp. Autumn	-0.74	-0.29	-0.07	0.07	-0.07	-0.01	-0.01	0.22	-0.03
Mean minimum temp. Winter	0.77	-0.35	-0.06	-0.04	0.00	-0.02	0.20	0.00	0.14
Mean minimum temp. Spring	-0.74	0.49	0.20	-0.16	-0.06	0.04	0.36	-0.26	0.09
Mean minimum temp. survey Summer	-0.60	0.04	0.06	-0.02	-0.09	-0.04	0.13	0.00	-0.21
Rainfall previous Summer	0.81	-0.08	0.23	-0.10	-0.08	-0.09	0.46	-0.22	0.08
Rainfall Autumn	0.46	-0.34	-0.26	0.12	-0.05	0.03	-0.35	0.13	0.11
Rainfall Winter	-0.80	0.12	0.05	-0.03	-0.32	0.09	-0.05	0.33	0.00
Rainfall Spring	0.43	-0.37	-0.08	-0.07	-0.31	-0.01	0.47	-0.34	0.00
Rainfall survey Summer	-0.65	0.23	0.12	-0.30	0.00	-0.13	0.03	0.14	-0.14

(f) Ellenberg N scores	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	0.73	0.13	-0.11	-0.23	-0.12	0.28	-0.06	0.22	-0.03
Temperature Autumn	-0.66	-0.13	0.04	0.25	-0.09	-0.02	0.19	0.05	-0.08
Temperature Winter	0.14	0.05	0.03	-0.21	0.01	-0.15	-0.02	0.16	-0.08
Temperature Spring	-0.65	0.18	-0.14	0.03	0.22	-0.02	-0.16	0.07	-0.02
Temperature survey Summer	-0.63	-0.11	-0.19	0.09	-0.10	0.18	-0.09	0.09	-0.08
100 mm Soil temp. previous Summer	0.79	0.08	0.05	-0.13	-0.03	0.14	-0.08	-0.21	-0.01
100 mm Soil temp. Autumn	-0.84	0.04	-0.02	0.33	-0.03	0.28	-0.01	-0.25	-0.05
100 mm Soil temp. Winter	0.40	0.16	-0.04	0.08	0.01	0.28	-0.22	0.30	0.09
100 mm Soil temp. Spring	-0.65	0.17	0.07	0.09	0.08	0.00	-0.06	-0.18	0.03
100 mm Soil temp. survey Summer	-0.73	-0.19	-0.04	0.17	-0.21	0.25	-0.09	-0.33	-0.11
Mean maximum temp. previous Summer	0.92	0.15	-0.16	-0.23	-0.14	0.07	0.04	-0.01	-0.07
Mean maximum temp. Autumn	-0.51	0.14	-0.10	0.18	-0.20	-0.04	-0.34	0.42	-0.08
Mean maximum temp. Winter	-0.23	0.00	-0.01	-0.27	0.04	-0.25	-0.09	0.20	0.01
Mean maximum temp. Spring	-0.85	0.12	-0.40	0.11	0.08	-0.15	0.09	-0.13	-0.22
Mean maximum temp. survey Summer	-0.69	-0.02	-0.24	0.13	-0.17	-0.03	0.04	0.03	-0.12
Mean minimum temp. previous Summer	0.62	0.21	-0.23	0.00	-0.05	0.32	0.02	0.26	-0.01
Mean minimum temp. Autumn	-0.47	-0.20	0.16	0.34	-0.08	-0.12	0.10	-0.16	0.06
Mean minimum temp. Winter	0.82	-0.07	0.12	0.11	-0.22	-0.07	0.11	-0.01	-0.05
Mean minimum temp. Spring	-0.81	-0.02	-0.11	-0.03	0.24	0.18	-0.49	0.23	0.06
Mean minimum temp. survey Summer	-0.33	-0.25	-0.22	0.09	-0.07	0.22	-0.30	0.04	-0.06
Rainfall previous Summer	0.69	0.07	0.02	0.05	-0.20	-0.11	0.11	0.21	0.05
Rainfall Autumn	0.54	-0.23	-0.03	0.04	-0.10	-0.10	-0.20	-0.01	-0.08
Rainfall Winter	-0.59	-0.16	0.02	-0.14	-0.02	-0.16	-0.15	-0.17	-0.10
Rainfall Spring	0.59	-0.13	0.18	0.01	-0.10	-0.05	0.05	0.27	-0.03
Rainfall survey Summer	-0.77	0.05	0.12	-0.09	0.06	-0.02	0.01	-0.10	-0.09

(g) Ellenberg R scores (same as Table 3.11)	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	-0.04	0.13	0.08	-0.04	-0.03	0.25	-0.05	0.19	-0.02
Temperature Autumn	0.14	-0.02	0.30	0.12	-0.01	0.05	0.16	-0.07	0.01
Temperature Winter	-0.02	0.04	-0.06	-0.29	0.12	-0.34	0.19	0.03	-0.08
Temperature Spring	-0.09	0.01	0.13	-0.15	0.17	-0.29	-0.07	-0.03	-0.02
Temperature survey Summer	-0.20	0.17	0.25	0.05	-0.07	0.11	-0.20	0.04	0.02
100 mm Soil temp. previous Summer	-0.07	-0.05	-0.07	0.15	-0.11	0.12	-0.02	-0.06	-0.13
100 mm Soil temp. Autumn	0.08	-0.05	0.46	0.10	-0.03	0.04	0.04	-0.43	-0.01
100 mm Soil temp. Winter	0.47	0.19	-0.18	-0.08	0.27	-0.11	0.05	0.43	0.12
100 mm Soil temp. Spring	0.34	-0.02	-0.08	0.02	-0.05	-0.26	0.01	-0.17	-0.09
100 mm Soil temp. survey Summer	0.04	0.02	0.01	0.22	-0.24	0.05	-0.13	-0.29	-0.12
Mean maximum temp. previous Summer	0.11	0.10	0.17	-0.03	-0.09	0.39	-0.08	0.00	0.00
Mean maximum temp. Autumn	0.35	0.17	0.27	-0.06	-0.15	-0.17	-0.28	0.23	0.06
Mean maximum temp. Winter	-0.12	0.03	-0.19	-0.37	0.19	-0.26	0.15	0.01	0.06
Mean maximum temp. Spring	-0.16	-0.06	0.17	0.11	0.16	-0.10	0.14	-0.13	0.03
Mean maximum temp. survey Summer	0.06	0.24	0.11	0.19	-0.02	0.06	-0.01	0.10	0.11
Mean minimum temp. previous Summer	-0.09	0.07	0.04	0.05	0.04	0.06	0.03	0.19	-0.03
Mean minimum temp. Autumn	0.02	0.02	-0.15	0.35	-0.02	0.08	0.16	-0.13	0.10
Mean minimum temp. Winter	0.35	0.05	-0.12	0.04	-0.08	-0.31	0.04	-0.05	-0.04
Mean minimum temp. Spring	0.00	-0.20	-0.02	-0.22	0.10	-0.23	-0.19	0.10	-0.01
Mean minimum temp. survey Summer	-0.27	-0.08	0.28	0.05	-0.17	0.15	-0.26	-0.02	-0.02
Rainfall previous Summer	0.35	0.13	0.02	-0.14	-0.10	-0.26	0.39	0.06	0.12
Rainfall Autumn	-0.43	0.08	-0.22	0.16	-0.02	-0.07	-0.07	0.36	0.03
Rainfall Winter	-0.02	-0.35	-0.17	0.00	0.04	-0.09	-0.17	0.20	-0.09
Rainfall Spring	-0.23	0.15	-0.40	0.01	0.07	-0.31	0.46	0.14	-0.12
Rainfall survey Summer	-0.53	-0.22	0.17	-0.20	-0.08	-0.11	0.00	0.01	-0.22

(h) Ellenberg W scores	**aggregate class**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**All**
Temperature previous Summer	-0.72	-0.38	0.09	0.02	-0.28	-0.11	0.07	-0.25	-0.10
Temperature Autumn	0.62	0.07	0.39	0.23	-0.22	0.28	0.14	-0.09	0.19
Temperature Winter	-0.65	-0.10	0.31	0.17	0.19	0.03	0.20	-0.18	0.06
Temperature Spring	0.09	0.30	0.16	0.08	0.16	-0.07	0.30	-0.04	0.20
Temperature survey Summer	0.78	0.02	0.07	0.09	-0.28	0.19	0.34	-0.13	0.15
100 mm Soil temp. previous Summer	-0.38	-0.29	0.08	-0.14	-0.11	0.08	-0.22	-0.02	-0.01
100 mm Soil temp. Autumn	0.71	0.38	0.02	0.12	-0.27	0.11	0.07	-0.03	0.20
100 mm Soil temp. Winter	-0.80	-0.21	0.35	0.05	-0.02	0.12	0.30	-0.02	0.04
100 mm Soil temp. Spring	0.43	0.37	0.07	-0.07	0.14	-0.12	0.18	0.06	0.23
100 mm Soil temp. survey Summer	0.71	0.15	-0.11	-0.16	-0.28	-0.06	0.02	0.03	0.09
Mean maximum temp. previous Summer	-0.52	-0.22	0.06	-0.04	-0.42	0.11	0.08	-0.07	-0.06
Mean maximum temp. Autumn	0.14	0.23	0.36	0.12	-0.12	0.10	-0.09	-0.47	0.15
Mean maximum temp. Winter	-0.37	-0.08	0.08	0.23	0.31	0.09	0.12	-0.24	-0.10
Mean maximum temp. Spring	0.62	0.29	0.34	0.01	-0.03	-0.13	0.23	0.01	0.18
Mean maximum temp. survey Summer	0.69	0.01	0.11	-0.08	-0.19	0.09	-0.10	-0.08	-0.04
Mean minimum temp. previous Summer	-0.57	-0.24	0.26	0.07	-0.31	-0.28	-0.01	-0.33	-0.05
Mean minimum temp. Autumn	0.73	-0.04	0.06	-0.06	0.01	0.33	-0.06	0.23	0.05
Mean minimum temp. Winter	-0.62	-0.03	0.34	-0.09	0.18	0.05	0.01	-0.01	0.05
Mean minimum temp. Spring	0.44	0.16	-0.07	0.12	0.17	0.01	0.35	-0.09	0.10
Mean minimum temp. survey Summer	0.71	-0.19	0.12	0.16	-0.08	0.14	0.41	-0.04	0.24
Rainfall previous Summer	-0.92	-0.03	0.24	0.12	0.34	-0.19	-0.13	-0.45	-0.24
Rainfall Autumn	-0.09	-0.37	0.00	-0.15	0.25	0.15	-0.09	0.28	0.13
Rainfall Winter	0.83	-0.03	-0.01	-0.20	0.09	-0.30	0.05	0.41	0.09
Rainfall Spring	-0.11	-0.36	0.22	-0.24	0.00	0.10	-0.30	-0.49	-0.26
Rainfall survey Summer	0.55	0.18	0.10	0.37	-0.05	-0.25	0.20	0.21	0.32

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The Countryside Survey partnership has endeavoured to ensure that the results presented in this report are quality assured and accurate. Data has been collected to estimate the stock, change, extent and/or quality of the reported parameters. However, the complex nature of the experimental design means that results can not necessarily be extrapolated and/or interpolated beyond their intended use without reference to the original data.

For further information on Countryside Survey see *www.countrysidesurvey.org.uk*

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