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The Butterfly Monitoring Scheme

Progress Report for 2000/2001

25 year anniversary report

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SUMMARY

1. This report reviews the national Butterfly Monitoring Scheme (BMS) for the 2000 season and marks the twenty-fifth year of monitoring since the scheme started in 1976.

2. The scheme continues to be run by Mr Nick Greatorex-Davies at the Centre for Ecology and Hydrology (CEH, formerly ITE), Monks Wood. Mr David Roy gives technical assistance with database management and programming and is also involved in writing research papers using BMS data. The BMS is jointly funded by the Joint Nature Conservation Committee (JNCC) and by CEH. Dr Dorian Moss, Head of the Environmental Information Centre at Monks Wood, has overall responsibility for management of the BMS.

3. In 2000 there were 129 sites and 134 transects in the BMS. Usable datasets were received from 116 transects in 2000 including 9 Environmental Change Network (ECN) transects. Eleven transects at eight new sites were added to the scheme in 2000, of these, six transects at three sites are on intensive farmland. Three transects at three sites were lost from the scheme, all are long-running transects and it remains a priority to find new recorders for these.

4. Transect Walker, the new recording software that was developed for Butterfly Conservation for transect walkers to record their data, became available in August. The software was sent to 28 BMS recorders covering 34 transects. However as it was sent out so late in the season, data in electronic form was received for 15 transects only. An additional 15 BMS recorders covering an additional 18 transects have requested the software for 2001. An updated version will be sent to all these recorders in May 2001. JNCC have provided significant funding for further development of the software in 2001.

5. Recorders provided habitat information using the new classification (based on the European Nature Information System, EUNIS) for nearly 50 transects.

6. The BMS website is due for a substantial update during the spring and summer of 2001.

7. Changes in abundance of species are examined. The year 2000 showed a slight improvement on the preceding two years and was a little above average for butterflies when compared with data from the other 24 years of the scheme. Of 34 species for which collated indices were calculated, 21 showed increases and 13 declines. Unlike 1999 the magnitude of the increases was generally greater than the declines.

8. For the second year running the **Ringle**t butterfly produced its ***highest collated index*** since the BMS began. The **Green Hairstreak** and the **Comma** also produced their ***highest collated indices*** of the scheme Other species that produced relatively high indices include **Orange Tip**, **Peacock, Speckled Wood**, **Marbled White** and **Meadow Brown**. There was a further decline in the spring index of the **Holly Blue** but a surprising upturn in the summer generation.

9. The **Small Heath** produced its ***lowest collated index*** of the series. This butterfly has declined significantly at many monitored sites in England and Wales over the monitoring period. Other low collated indices were produced by the **Dingy Skipper** (this butterfly has shown a steady decline on monitored sites over the monitoring period) and the **Small Tortoiseshell** (though an increase from last years all series low). After two years of increase the **Wall Brown** increased again in the first generation but dropped to another low index in the second generation.

10. 2000 was a good year for migrant butterflies with the highest numbers of **Clouded Yellows** recorded on transect since 1983. The **Painted Lady** also had its second best year of the scheme, but numbers still did not compare with the exceptional year of 1996. The **Red Admiral** had a well above average year.

11. Recent and forthcoming publications using data from the BMS are listed.

12. Appendix 1 contains graphs showing annual fluctuations in the all-sites collated indices of 34 species from 1976-2000.

13. Appendix II shows the revised habitat classification being used for recording transect site and section habitat details. It is based on the European Nature Information System (EUNIS) and adapted for butterfly transects by Butterfly Conservation in consultation with CEH.

1 INTRODUCTION

The purpose of this report is to review the Butterfly Monitoring Scheme (BMS) and to summarise the results of the scheme for the year 2000, with the particular aim of providing information on the long and short term changes and trends in butterfly abundance.

1.1 ORIGINS, ORGANISATION AND AIMS OF THE BMS

The BMS was launched in 1976 by Dr Ernie Pollard based at the Institute of Terrestrial Ecology (ITE) at Monks Wood. The scheme was initially financed jointly by the Nature Conservancy Council (NCC) and ITE. Since 1991 it has been jointly financed by the Joint Nature Conservation Committee (JNCC) (acting on behalf of the statutory conservation agencies (successors of NCC): English Nature, Countryside Council for Wales, Scottish Natural Heritage and the Environment and Heritage Service Northern Ireland), and ITE (now the Centre for Ecology and Hydrology (CEH)).

Dr Dorian Moss, Head of the Environmental Information Centre at Monks Wood, currently has overall responsibility for the management of the BMS. The scheme has been run by Mr Nick Greatorex-Davies since the beginning of 1995 when he took over from Mrs Tina Yates. Mr David Roy provides technical assistance with database management and programming. Dr Ernie Pollard retired from active involvement in the scheme in 1998 (apart from walking a transect as part of the scheme) but is still available for advice when required.

The primary aims of the scheme are to provide information at regional and national levels on changes in the abundance of butterfly species, to detect trends which may indicate changes in their status and to provide a reliable long-term reference against which population changes in species studied on individual sites, or in other countries, can be monitored. It also aims to monitor changes at individual sites and, by comparison with results elsewhere, to assess the impact of local factors such as habitat change caused by management. The scheme also provides information on aspects of the population ecology and phenology of individual species, both in relation to the effect of environmental changes (including climate change) and as a contribution to basic knowledge.

1.2 SITES FROM WHICH THE BMS RECEIVES DATA

The year 2000 was the 25th year of the BMS. Currently 134 transects at 129 sites throughout the United Kingdom are part of, or contribute to, the BMS. At least some data were received from 119 BMS and 11 Environmental Change Network (ECN) transects. Of these, 116 transects provided sufficient data to produce annual site index values for at least some species. Forty transects (11 more than in 1999) produced sufficient data for annual indices to be calculated for all the species recorded, and a further 19 sites (four less than in 1999) sufficient for indices for all but one or two species.

The ECN was set up in 1993 with funding from the Department of the Environment (now Department of the Environment, Transport and the Regions) in conjunction with a number of research organisations (including CEH) to monitor changes in the environment, particularly in relation to climate change. Butterfly monitoring is just one part of this programme. ECN transects are not managed as part of the BMS, but data from most of the ECN sites are now used together with the BMS data to calculate the annual all-sites collated indices. Two of the BMS transects are now also ECN transects, making a total of 13 ECN transects. Within the rest of this report BMS and ECN transects will simply be referred to as BMS transects because all potentially contribute to the scheme in providing data for the calculation of the collated annual indices.

1.3 SITES LOST AND GAINED FROM THE BMS IN 2000

Sites lost

Three transects were lost to the scheme in 2000 because, for various reasons, the recorders are unable to continue recording. All are long running transects and as such are particularly important sites to the BMS. **Waterperry Wood** has been in the BMS since 1976, **Weeting Heath** since 1977 and **Shabbington Wood** since 1984. Efforts to find new recorders for these transects have so far been unsuccessful, but finding new recorders remains a priority. **Ben Lawers** in the Highlands has been in the BMS since 1977 and may also be lost to the scheme, though monitoring may continue to cover the flight period of the Mountain Ringlet.

As in 1999 three transects failed to produce any data at all, and may also be lost to the scheme, but it is still hoped that data will continue to be gathered in future years at these sites.

Sites gained

Eleven new transects at eight sites were brought into the scheme in 2000. Most of these have already been running a number of years and it is intended that the additional data will eventually be added to the BMS database. Criteria for bringing new sites into the BMS include the following: to replace sites lost to the scheme; to improve geographical coverage; to improve coverage of scarce species; to improve the coverage of biotopes under-represented by the scheme (e.g. this year several farmland transects have been brought into the scheme); transects that are being well monitored and which already have several years of data and which are likely to be continued for the foreseeable future.

Three transects in Scotland

Creag Meagaidh is an upland site in Highland that has populations of Small Pearl-bordered Fritillary, Dark Green Fritillary, Scotch Argus and Large Heath. A separate transect is walked at the site for the Mountain Ringlet. **Callendar Wood** in Falkirk is a mixed ancient semi-natural and plantation woodland with some unimproved grassland. The site is owned by Forest Enterprise. **St. Abb's Head** is a coastal site owned by the National Trust for Scotland. Butterfly species recorded on the transect include Northern Brown Argus and Grayling.

Two coastal transects - Wales and Suffolk

Great Orme's Head is on the north coast of North Wales. The transect here has been operating for several years and is run by Conwy Borough Council. Great Orme is a large rocky limestone promontory much of which is covered by herb-rich limestone grassland. The site supports large populations of the Silver-studded Blue and Grayling butterflies. **North Warren** is situated on the Suffolk coast. The site is owned, and the transect operated, by the RSPB and already has 10 years of data. It has strong populations of Green Hairstreak and Grayling.

Six Farmland transects, two at each of three sites

At all three sites some areas, notably field boundaries, are managed under the Countryside Stewardship Scheme (operated by the Ministry of Agriculture Fisheries and Food). All provide excellent opportunities to monitor butterflies on a range of farmland habitats which will prove a valuable addition to the few farmland transects that already contribute to the BMS.

Grange Farm (known to RSPB members as Hope Farm) is an intensively managed arable farm in Cambridgeshire which was purchased by the RSPB late in 1999 for the purpose of trialing, demonstrating and advocating new farmland management techniques that favour farmland birds. The farm will continue to be farmed as a commercial enterprise. **Loddington Farm** in Leicestershire is a primarily arable farm owned since 1992 by the Allerton Research and Educational Trust who work in partnership with the Game Conservancy to carry out research into, and to demonstrate, the integration of game and wildlife

conservation with profitable farming. Two transects have been operated here since 1997. At **Writtle (Agricultural) College** in Essex one transect is on arable land and the other on primarily pasture land. The land is owned by the college. Two transects have been operated here since 1996.

2 THE DEVELOPMENT OF NEW FEATURES OF THE BMS

2.1 TRANSECT WALKER – BUTTERFLY TRANSECT RECORDING SOFTWARE

In August 2000 Butterfly Conservation (BC) launched its new butterfly transect recording software, *Transect Walker* (TW). Copies of TW were immediately sent out to 28 BMS recorders covering 34 transects, all of whom had responded positively to a request sent out to recorders earlier in the season asking which recorders would be willing to trial the software in 2000. Electronic data were received from 15 of these sites in October and November, the software having arrived too late in the season for all these recorders to be able to use it. The transfer of data from individual copies of TW to the BMS ORACLE database proved to be very simple and has eliminated the data input stage at Monks Wood for those sites whose recorders submitted their data in this way. TW is also being widely used by BC transect recorders and so far about 300 copies have issued to them.

Apart from providing a good medium for the input of butterfly transect data electronically, TW also enables the recorder to record a wealth of other information on the transect. In addition graphs and summary tables can be produced of the data, including species histograms showing changes in annual indices over a series of years. The software also calculates estimates for missing weeks, where appropriate, according to a set of built in rules based on the criteria used for the BMS.

TW is written in the programming language Delphi and can run as a stand alone piece of software on almost any computer, not requiring the user to have a particular application installed on their computer.

Recorders are still encouraged to use the paper field recording form while walking their transect(s) (rather than a notebook or Dictaphone) as data are likely to be recorded more accurately on the standard form and errors are more likely to be avoided in the transcription of data to the electronic form.

An updated version of TW, where problems (‘bugs’) associated with the earlier version have been rectified and some new features added, is due to be completed and available for recorders by May 2001. Copies will be sent to all those recorders who already have TW and to all who have requested TW more recently (another 15 BMS recorders covering an additional 18 transects have so far requested TW).

Some extra funding has been provided by JNCC for the year 2001 for further development of Transect Walker so that some of the major additional features that have been recommended by users can be added. In the meantime the recently updated version of TW (and indeed the first version) is perfectly adequate for recorders to digitise their data.

BC also commissioned the production of some additional software for their regional transect co-ordinators. This allows for data to be passed on to local BC transect co-ordinators who can then analyse and summarise the data for local transects and feed back this information to recorders in their region. We shall be receiving a copy at Monks Wood to trial.

2.2 HABITAT RECORDING

A standardised habitat classification was issued to recorders in 2000 for recording habitat details at site and section level. This classification is based on the European Nature Information System (EUNIS) habitat classification (successor to CORINE habitats classification (Devillers *et al*. 1991)) developed at CEH and was adapted for use on butterfly transects by Butterfly Conservation in consultation with CEH. The habitat classification is also included in the Transect Walker software. Through its use we expect that information will be provided that will significantly enhance the usefulness of BMS data in enabling analysis of butterfly data at the habitat level.

Recorders were asked to record habitat details of their transects section by section, using this classification, during the 2000 season. Habitat details for nearly 50 sites were sent in after the 2000 season. We hope that recorders will provide an annual update of habitat details so that changes are recorded.

For 2001 the habitat recording forms have been modified. It is clear that for the transect habitat information to be of most use, habitats need to be recorded at two levels. Firstly the habitat within the recording 'box' needs to be recorded (i.e. the 5m area the recorder records in (or whatever fixed area is recorded)), and secondly the adjacent habitat on either side of the transect.

2.3 WORKING IN PARTNERSHIP WITH BUTTERFLY CONSERVATION ON BUTTERFLY MONITORING

As many of you will be aware, we (including our partners JNCC) have been seeking to work more closely with the charity Butterfly Conservation (BC) with regards to butterfly monitoring. Outside of the national BMS there are probably in excess of 400 butterfly transects being walked, many of these by BC members (as are some within the BMS). An increasing number of these transects are being recorded to a standard where the data are entirely compatible with those in the BMS and some of them cover areas, species and habitats under-represented by the BMS. After discussions with BC it is clear that there would much to be gained by working closely together and we have agreed to collaborate on butterfly monitoring. There is still much to be worked out in terms of the practicalities of how this working together will operate and how it will be formalised, but we intend to make significant progress on this in 2001. This is excellent news and we are very excited about the prospects of what can be achieved. This collaboration should result in a much strengthened scheme that will greatly increase the scientific and conservation value of butterfly monitoring in the UK.

2.4 BMS WEBSITE http://www.bms.ceh.ac.uk/

No further improvements have been made to the BMS website since it was launched early in 2000. However a major overhaul of the site is planned during the spring and summer of 2001.

The website currently includes information on the background, history and aims of the scheme, sites in the scheme, availability of data, some examples of the type of use to which the BMS data has been put, and a bibliography of publications relating to the BMS or which make use of BMS data.

Apart from making information about the BMS available on the internet and increasing the profile of the BMS, another purpose of the website will be to provide on-line access to summary BMS data, particularly to the species, all-sites and regional collated indices.

3 SUMMARY OF THE 2000 SEASON

3.1 SUMMARY OF THE WEATHER IN 2000 AND SOME APPARENT EFFECTS ON BUTTERFLIES

For the fourth year in succession the year began with several very mild months (Table 1 and Figure 1). April was cool and, like 1998, was exceptionally wet. Although there was not the same amount of flooding in parts of the UK as there was in 1998, it was the wettest April since records began more than 340 years ago! As in previous years, and associated with the milder than normal weather, there were a quite a few reports of hibernating species of butterfly seen on the wing or basking in weak sunshine in the early months of the year (Bowles 2000), well before the start of the transect recording season. In January and February nearly 50% of reports were of Red Admiral. In March the other hibernating species were more in evidence and there were a few reports of several other spring species, especially Speckled Wood and Holly Blue.

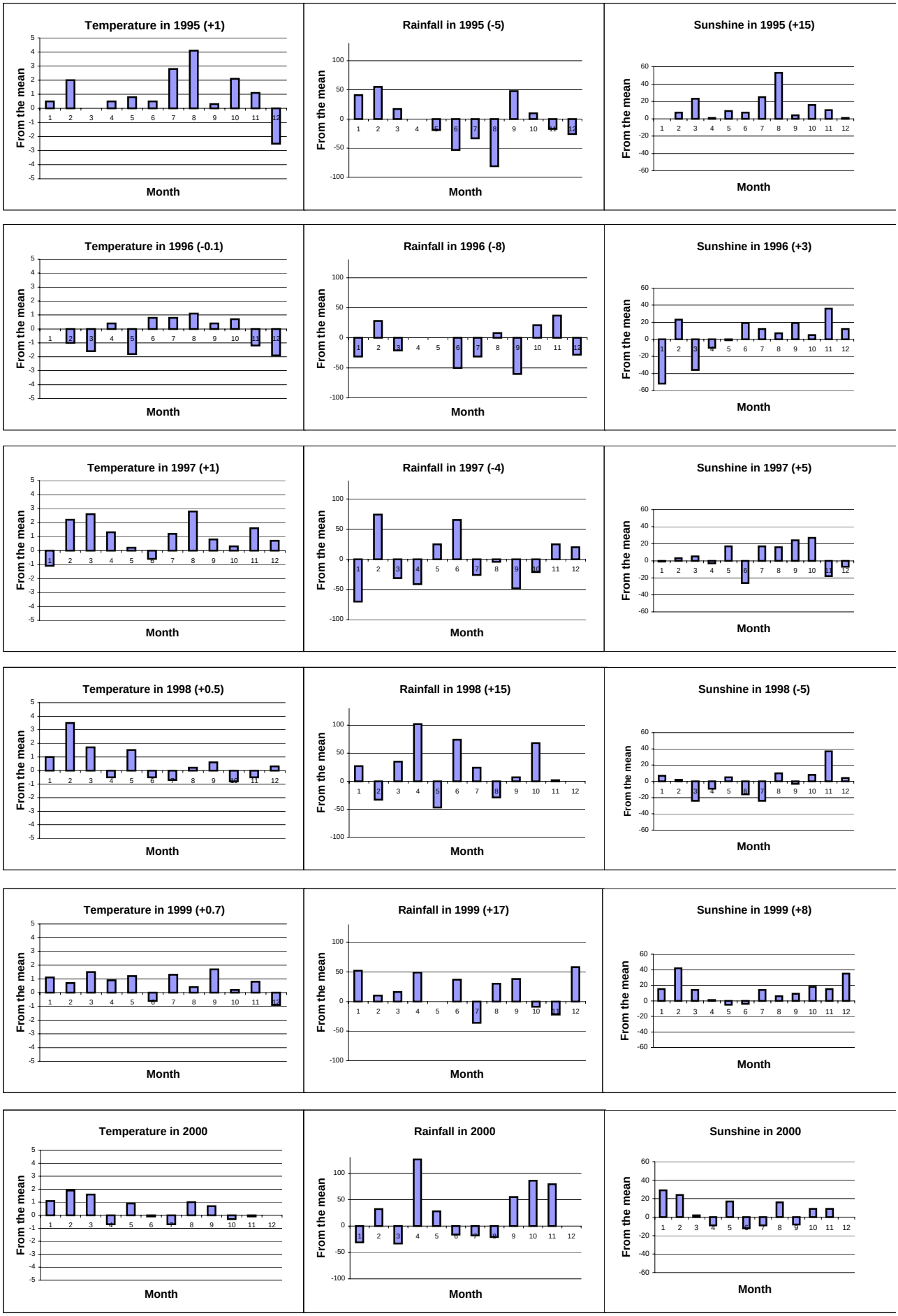
May was mild and sunny but rather wet. June and July were relatively dry but not particularly warm though north-west Scotland experienced a very warm dry sunny spell early in the period. August saw a considerable improvement being warmer, dryer and sunnier than average and butterflies responded well to this.

Table 1. Summary of UK weather in 1999/2000

1999	Daytime Temp (^{0}C)	Rainfall (%)	Sunshine (%)	Brief description
September	+1.7	+38	+9	Wet and very warm
October	+0.2	-9	+18	Very sunny in England, rather mild and dry
November	+0.8	-22	+15	Mild, sunny and rather dry
December	-0.9	+58	+35	Cold, sunny and very wet
2000				
January	+1.1	-31	+29	Mild, sunny and dry
February	+1.9	+32	+24	Mild, wet and sunny
March	+1.6	-33	+2	Mild and dry
April	-0.7	+126	-9	Cold and very wet
May	+0.9	+28	+17	Warm, sunny and wet
June	-0.1	-16	-12	Warm in the south, cool in the north
July	-0.7	-18	-9	Cool in the east, dry in Scotland
August	+1.0	-21	+16	Warm, dry and sunny
September	+0.7	+55	-8	Wet, but mild

Table 1 shows a summary of UK weather in 1999/2000 and is taken from a weather summary provided by Dr M. Hulme of the University of East Anglia on the internet at website: http://www.cru.uea.ac.uk/~mikeh. The information is also published in *The Guardian* newspaper. The summary is for the UK as a whole and so will not necessarily describe weather in particular regions precisely. [Anomalies are with respect to the 1951-80 average]

Figure 1. United Kingdom monthly mean temperatures, rainfall and sunshine 1995-2000, showing departures from the 1951-1980 averages (data from: http://www.cru.uea.ac.uk/~mikeh).



3.2 REVIEW OF CHANGES IN INDICES

The year 2000 showed a slight improvement on 1999 for butterflies on BMS sites (Figure 8, page 26) and so was a better than average year. Details are summarised in Table 2 on page 13 and Table 9 on pages and 24 and 25. Of the 33 species (plus univoltine Common Blue) for which all-sites collated indices have been produced, there were 21 increases and 13 decreases [*]. More details will also be found in the section titled "Species accounts" starting on page 27. Unlike 1999 the magnitude of the increases was generally greater than the declines.

Little change
Eight species showed little change from 1999 (<10%), these were **Large Skipper**, **Small Copper**, **White Admiral**, (which showed a slight increase), **Meadow Brown**, (which remained unchanged) **Large White**, **Green-veined White**, **Silver-washed Fritillary**, and **Marbled White** (which all showed a slight decrease).

Increases
Three species produced their ***highest collated index*** since the scheme began, the **Ringlet**, for the second year running with a >20% increase, the **Green Hairstreak**, also with a >20% increase, and the **Comma** with a greater than 50% increase.

The first generation indices for the **Large White**, **Green-veined White** and the **Small White** all showed an improvement on their 1999 index. The **Green-veined White** did especially well, with a >200% increase to produce one of the highest indices of the series. However all three species showed a small drop in their second generation index.

The **Pearl-bordered Fritillary** and **Small Pearl-bordered Fritillary** both showed increases, however the number of sites that contributed to the collated index was very small in both cases. The **Small Tortoiseshell**, increased slightly, but the collated index still remains very low. Other species which increased included the **Grizzled Skipper**, **Brimstone**, **Orange Tip**, **Brown Argus**, **Peacock** and **Hedge Brown**.

Decreases
The biggest decrease was shown by the spring generation of the **Holly Blue** which dropped by 75% to it's lowest first generation level since 1995. However there was a surprising increase (nearly 80%) in the second generation, whereas a further decline from 1999 might have been expected judging by the pattern of previous cycles of this species. The **Small Heath** produced its ***lowest collated index*** of the series (the only species to do so in 2000) with a decrease of about 20%. This species has shown a long-term decline over the monitoring period with significant declines at many sites (Map 18). After three successive increases the **Grayling** also dropped by almost 20% to produce an about average index (but remaining higher than in 1998). After signs of a possible recovery, with two years of increases from the "all-time" low of 1998, the **Wall Brown** index disappointingly dropped by 26% in the second generation, however the first generation index was the highest since 1993. After generally steadily increasing for many years the **Chalkhill Blue** suffered it's biggest drop since 1980, of >40%. Following the substantial increase in 1999, the index of the bivoltine **Common Blue** dropped by >20% and was the lowest since 1986. Smaller decreases occurred for the **Small / Essex Skipper, Dingy Skipper**, **Small White** and **Dark Green Fritillary**.

[*] Unless otherwise stated comments throughout this section refer to the second generation or summer/autumn flight period of multivoltine (two or more generations per year) species and those with a spring and summer/autumn flight periods.

Good year for migrants

2000 was a good year for the commoner migrant species. The **Painted Lady** showed the biggest increase of all species (>700%) and provided the second highest index for this species since the scheme began, with only the exceptional year of 1996 being higher. The **Clouded Yellow** was recorded at many sites with similar numbers being recorded as in the good year of 1983, which itself is thought to have been the best Clouded Yellow year since 1947. [1] It was a well above average year for the **Red Admiral** too, with a >50% increase on the 1999 index.

[1] No collated index is calculated for the Clouded Yellow because in some years none are recorded at all on transects contributing to the BMS.

3.3 TABULAR SUMMARY OF CHANGES 1999 TO 2000

Details of the above changes are summarised in Table 2 on page 13, with further details in Table 9 on pages 24 and 25.

In the last column of Table 2 (Trend in all-sites [collated] index), significant trends are identified using simple regressions of $\log_{10}$ all-sites collated index on years (for method see Pollard & Moss 1995). The figure gives the degree of slope (trend) of the regression line, positive or negative. Asterisks indicate the degree of statistical significance of trend: * P <0.05, ** P<0.01; *** P< 0.001. It should be noted that simple regression results may give rather too many significant results with population data (Diggle, 1990), so these figures should be treated with caution. Nevertheless they do give an indication as to how the different species are faring on monitored sites. Particular caution needs to be exercised in looking at the results for species for which relatively few sites are used for the calculation of all-sites collated indices such as Common Blue (northern univoltine), Chalkhill Blue, Small Pearl-bordered and Pearl-bordered Fritillaries. The very big fluctuations in the index for the Holly Blue may make testing for a trend of relatively little value.

Table 2. Summary of changes 1999 / 2000.

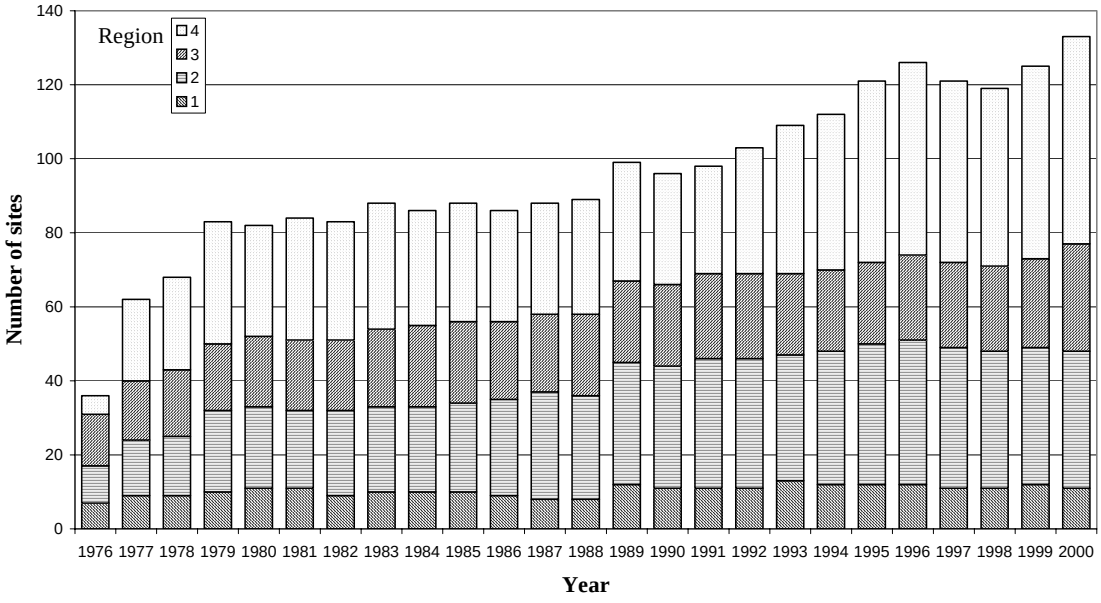
SPECIES	1999 all-sites index	2000 all-sites index	% change Down	% change Up	% of the mean all-sites index	Rank order of 25 years 1999	Rank order of 25 years 2000	Lowest / highest all-sites index	Comments	Trend in all-sites index
Small Skipper	192	169	12		81	14	15			0.008
Large Skipper	143	151		6	84	19	17			0.004
Dingy Skipper	16	14	12		52	18	22			-0.0161 ***
Grizzled Skipper	28	31		11	63	19	18			-0.009
Brimstone 1 (Spring)	98	114		16	115	12	8			0.007
Brimstone 2 (Summer/Autumn)	68	103		51	92	24	10			-0.001
Large White 1 (1st generation)	32	48		50		15	13			-0.01
Large White 2 (2nd generation)	91	86	5		67	18	19			0.011
Small White 1	10	31		210		24	19			-0.029 ***
Small White 2	74	62	16		57	18	21			0.002
Green-veined White 1	90	171		90		22	4			0.0002
Green-veined White 2	377	352	7		128	7	8			0.013 **
Orange Tip	115	151		31	125	14	4	Highest since 1993		0.005
Green Hairstreak	174	213		22	165	4	**1**	**HIGHEST EVER**		0.013 **
Small Copper 1	40	59		48		18	12			0.001
Small Copper 2	58	59		2	70	15	14			0.012
Common Blue 1	27	46		70		22	16			0.003
Common Blue 2	85	67	21		73	13	14			0.018 *
Common Blue (univoltine)	13	8	38		32	18 of 23	23 of 24	Lowest since 1986		-0.022 **
Brown Argus 1	60	86		43		15	6			0.009
Brown Argus 2	92	113		23	130	8	6			0.013
Chalkhill Blue	139	78	44		94	4	10	Lowest since 1990	Biggest drop since 1980	0.025 ***
Holly Blue 1	301	76	75			11	14	Lowest since 1995		0.02
Holly Blue 2	64	113		77	42	14	10		Surprising upturn	0.043 *
White Admiral	21	22		5	56	20	19			-0.003
Red Admiral	90	136		51	160	8	4			0.033 ***
Painted Lady	241	1957		712	188	12	2	2nd highest index		0.037
Small Tortoiseshell	43	48		12	39	24	22		Highest ever in 1997	-0.004
Peacock 1	239	312		31		3	3			0.022
Peacock 2	187	218		17	123	9	4			0.017 **
Comma	217	327		51	191	9	**1**	**HIGHEST EVER**		0.029 ***
Small Pearl-bordered Fritillary	11	22		100	48	24	22			-0.012 *
Pearl-bordered Fritillary	1.5	2.5		67	12	24	22		Collated indices from 4 sites only	-0.039 ***
Dark Green Fritillary	48	41	15		63	19	20	Lowest since 1990	Highest ever in 1997	-0.001
Silver-washed Fritillary	54	50	7		93	8	12			0.016 ***
Wall Brown 1	17	21		24		19	16	Highest since 1993		-0.019 *
Wall Brown 2	27	20	26		40	14	20			-0.02 *
Speckled Wood	263	296		13	181	2	2	Highest since 1992		0.028 ***
Marbled White	323	293	9		154	3	5			0.02 ***
Grayling	78	63	19		94	6	13			-0.013 **
Hedge Brown	110	128		16	118	10	6			0.006
Meadow Brown	161	161		0	124	6	5			0.01 **
Small Heath	26	21	19		41	23	**25**	**LOWEST EVER**		-0.017 ***
Ringlet	511	629		23	179	**1**	**1**	**HIGHEST EVER**	Previous highest last year	0.033 ***

4 SITES CONTRIBUTING DATA TO THE BMS IN 2000

4.1 THE NUMBER OF SITES CONTRIBUTING DATA TO THE BMS

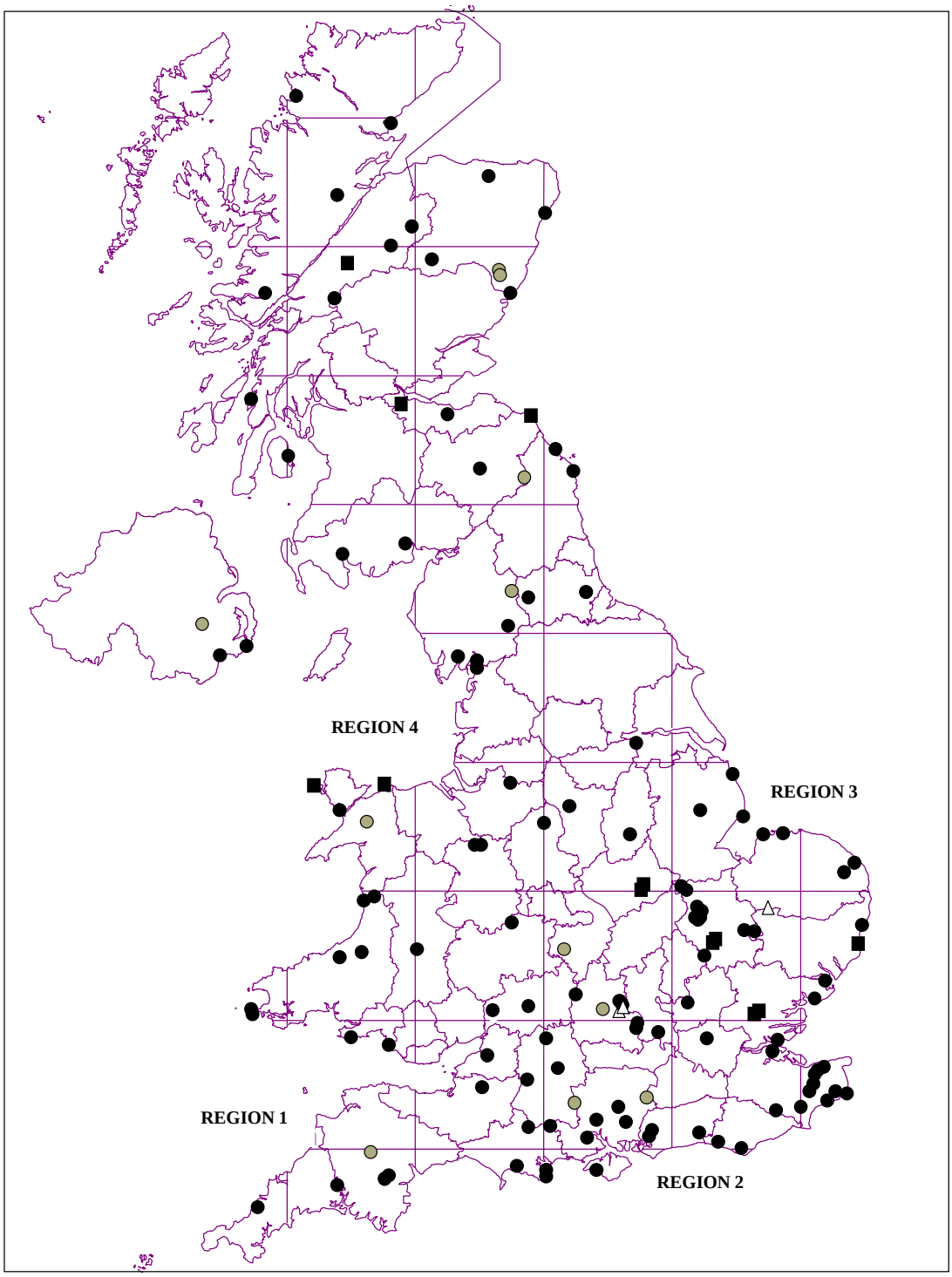
The BMS was officially launched in 1976 with just 36 sites contributing to the scheme. However three years of trials preceded this when data were being gathered to test the methodology. Seven sites still in the BMS, which were monitored during this period as part of this process, have data going back to 1974. The number of sites contributing to the BMS (Figure 2) has gradually increased over the years with at least one site being added to the scheme in most years. In 2000, 131 of the 134 transects currently part of the BMS submitted at least some data to the scheme for. A further three transects at three sites remain in the scheme, though no data have been received from them for 2000. The distribution of the sites currently part of, or contributing to, the BMS is shown on Map 1 on page 15.

Figure 2. Number of sites contributing data to scheme



THE CURRENT UK DISTRIBUTION OF BMS SITES

Map 1. BMS and ECN sites in 2000, (BMS = black circles, BMS new sites = black squares, ECN = grey circles, BMS sites lost from scheme = open triangles), showing county boundaries (*not* Vice-counties) and the four BMS regions.



4.2 THE TYPES OF SITES CONTRIBUTING DATA TO THE BMS

Most BMS transects on nature reserves

The original aim of the BMS was, quite simply, to provide objective information on changes in the abundance of butterflies, not just common species but also scarce and rare ones. The Nature Conservancy Council provided substantial support for the BMS from its beginning in 1976 and many of the early recorders were wardens of National Nature Reserves (NNRs). Several British butterfly species have a high proportion of their populations on NNRs and other protected land. Because of these factors it was inevitable that most of the transects in the BMS would be on nature reserves. This predominance of transects on nature reserves has continued to the present day and many transects added to the scheme in recent years have also been on nature reserves. This is not least because most of those wishing to carry out butterfly transects are interested in the conservation of butterflies, particularly the rarer species. There is less interest amongst recorders in carrying out transects on non reserve sites in the wider countryside where relatively few species of conservation interest are found. However where opportunities arise, we are trying to improve the representation of the wider countryside amongst BMS transects and in 2000 several farmland transects were added to the scheme (see page 4).

Management responsibility for sites

Table 3 shows who has management responsibility for the sites where BMS transects are carried out. In the majority of cases these organisations (and a few individuals) also own the land, but in some cases the land is leased from a separate land owner such as a private estate or another organisation, or there is a management agreement with the land owner. In most cases staff of these organisations carry out, or are responsible for the

Table 3. The management responsibility for 132 BMS / ECN sites (includes the three sites where transects were lost to the BMS in 2000: Weeting Heath (WT), Shabbington Wood and Waterperry Wood (FE)). Numbers in brackets refer to the sites where BMS transects also became ECN transects. These figures are also included in the figures in the BMS column. Six sites have two transects.

Site management responsibility	**BMS**	**ECN**	**Totals**
Country Agencies			
English Nature	32	1 (+1)	
Countryside Council for Wales	6	1	
Scottish Natural Heritage	10		
Environment Heritage Service	1		
			52
Voluntary Conservation bodies			
Wildlife Trusts	19		
RSPB	10		
National Trust / NT Scotland	10		
Woodland Trust	2		
Independent Conservation Organisations	2		
			43
Others			
Forest Enterprise	10	1	
Local Authorities	6		
Research organisations	2	4 (+1)	
Universities and education	1	2	
Ministry of Defence		1	
Environment Agency	1		
Private	8		
			37
Total	120	10 (+2)	**130**

butterfly transects on their sites. Due to changing priorities and increasing workloads, at a few sites, particularly those where transects have been operated by Country Agency staff, volunteer transect walkers have been recruited so that the transects can continue to be monitored. Some of these volunteers have been recruited through direct contact with local Butterfly Conservation branches. At other sites no volunteers have been found and the transects have been lost from the BMS. Recruiting volunteers has not always been an ideal solution because in some cases it has not been possible to recruit a single main volunteer to take over the transect. Multiple transect recorders will inevitably mean that the data is less consistent because different people record a transect in slightly different ways.

Major biotopes represented on BMS transects
Table 4 shows the classification of BMS transects by their most predominant biotope. There are a relatively large numbers of transects on woodland and chalk grassland sites, but few farmland transects.

Table 4. The classification of BMS and ECN sites according to major biotopes (habitats). Numbers in brackets refer to transects where there is more than one transect at a site.

Major biotopes represented on BMS sites	**No. of sites**	**%**
Native woodlands	26	20
Plantation woodlands	15	9
Calcareous grassland and scrub	21 (+1)	17
Coastal dunes, cliffs, marshes etc.	22	15
Wetlands	10	8
Farmland (Arable)	7 (+3)	5
Farmland (Pasture)	7	5
Heathland	6	5
Bogs	3 (+1)	3
Upland grassland and moorland	7 (+1)	7
Various (e.g. landfill, parkland, mixed etc.)	6	5
Total:	130	

How long transects have been in the BMS and transects lost from the scheme
One of the strengths of the BMS is the increasingly long run of data that has been collected for a relatively high proportion of sites, with nearly half (46%) of the sites currently in the scheme having data covering 20 years or more of the 25 years of the scheme (Table 5).

Table 5. The length of time current sites have been in the BMS

Years	**Period of years**	**Number of sites**
1996-2000	1-5	13
1991-1995	6-10	27
1986-1990	11-15	17
1981-1985	16-20	14
1976-1980	21-25	51
1974-1975	>25	7
		130

Twenty nine transects that produced two or more years data have been lost from the BMS over the years. Of these, 24 joined the scheme between 1974 and 1980, 12 of which had produced runs of data of 10 or more years, and seven, 20 or more years. Two transects that came into the BMS after 1980, but which have now dropped out, also produced runs of data of 10 or more years.

5 ANALYSIS OF THE AMOUNT OF DATA RECEIVED

5.1 PERCENTAGE OF COUNTS COMPLETED

The overall percentage of counts completed in 2000 was 72%, the same as in 1999 (Table 6). All sites submitting at least some data have been included in the analysis. There are small changes from the percentages shown for the years 1997-99 in last year's report. This is because data from a few additional sites has been added for those years to the BMS database since last year's report was produced.

Table 6. Percentage of counts completed 1988-2000

Year	1988	98	90	91	92	93	94	95	96	97	98	99	00
% completed	73	77	78	74	77	72	70	73	71	73	67	72	72

As can be seen in Figure 4 the worst affected weeks were those in April, especially week 2 and the second week in July, week 15. A histogram for 1999 is shown for comparison (Figure 3). For details of regions see Map 1 on page 15.

Figure 3. Number of sites with completed transects in each recording week in 1999

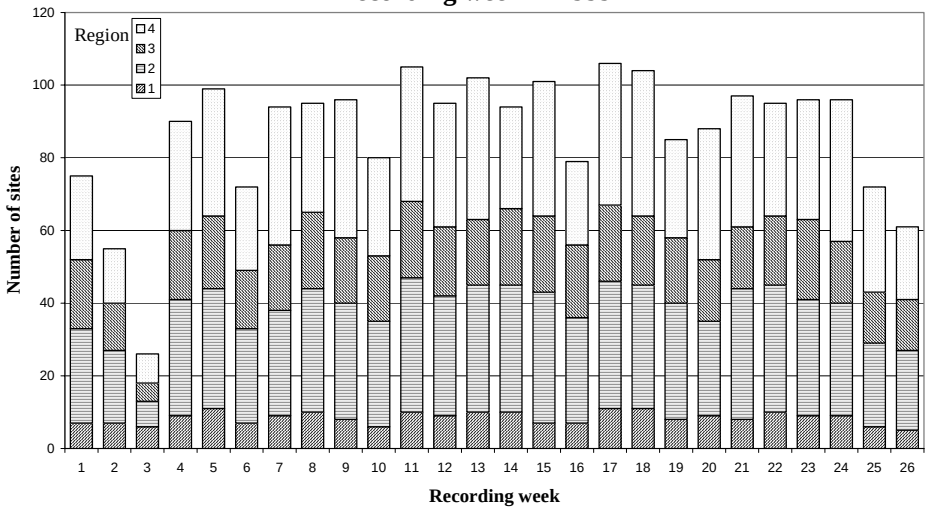
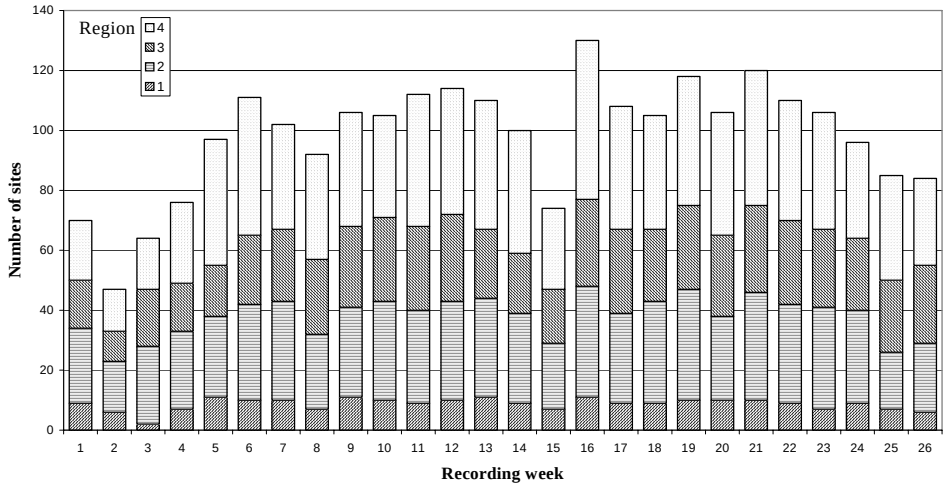


Figure 4. Number of sites with completed transects in each recording week 2000



5.2 THE NUMBER OF WEEKS RECORDED FOR EACH TRANSECT

The number of weeks recorded for each transect in 1999 and 2000 are shown in Figures 5 and 6 respectively. Note that in 1999 and 2000 all 26 weeks were recorded on five and six transects respectively. The area covered by each region is shown on Map 1 on page 15.

Figure 5. Number of weeks recorded for each transect in 1999.

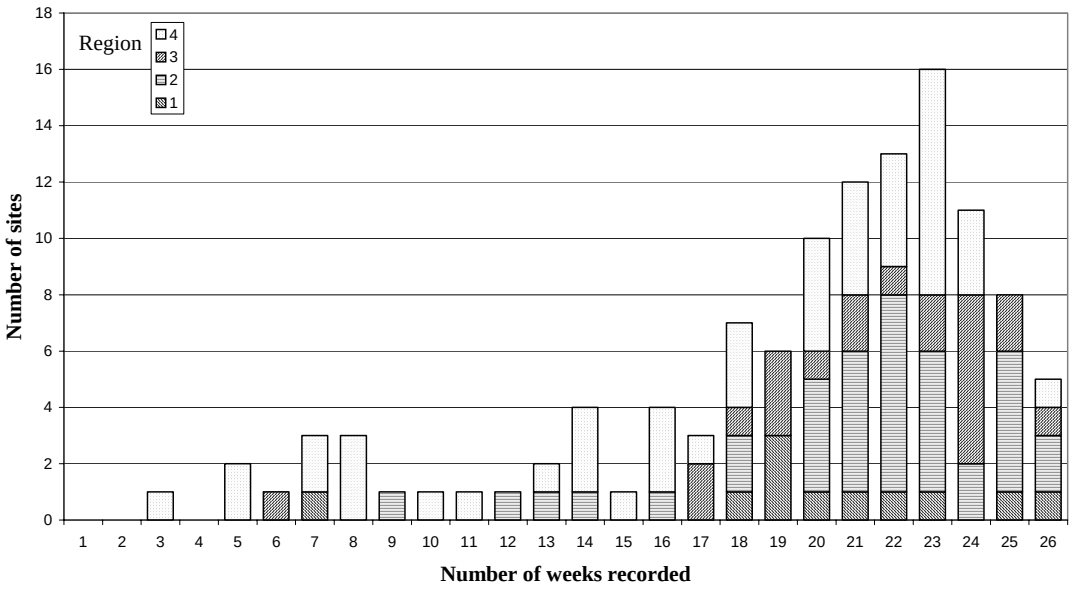
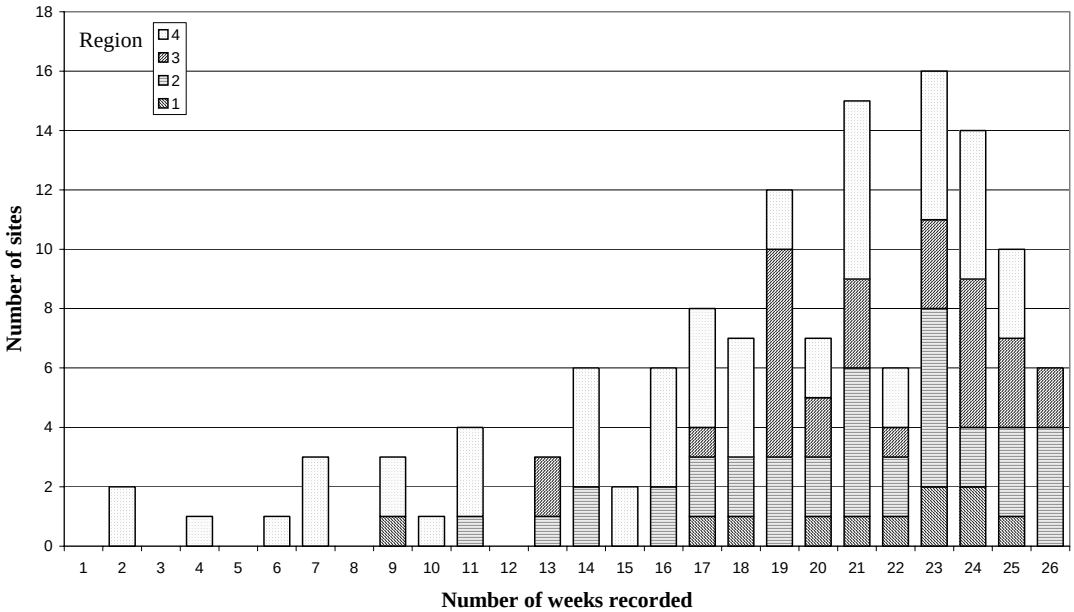


Figure 6. Number of weeks recorded for each transect in 2000.



5.3 THE PROPORTION OF ANNUAL INDICES CALCULATED

Site annual indices are calculated for each species for each transect where the species occurs and where data are sufficient.* There was an overall increase in the percentage of annual indices that could be calculated in 2000 as compared to 1999. However there were still 14 transects which provided too few data for any annual indices to be calculated (Table 7).

Table 7. The proportion of annual indices that could be calculated for 115 transects in 1997, 119 transects in 1998, 120 transects in 1999 and 130 transects in 2000.

	0%	1-20%	21-40%	41-60%	61-80%	81-99%	100%	**Total**
No. of transects in 1997	7	7	12	7	12	25	45	**115**
No. of transects in 1998	22	0	8	14	15	36	24	**119**
No. of transects in 1999	15	3	12	8	13	40	29	**120**
No. of transects in 2000	14	7	8	12	19	31	40	**130**

The process of calculating estimates is partly automated and as a general rule no estimates are calculated for a species, (and therefore no annual index), when estimates comprise 30% or more of the annual index. This has meant that in a few cases where a week has been missed at the peak of the flight period no estimate has been calculated. However in some cases, for example where numbers were very low or where the flight period pattern of increase and decrease is very smooth annual indices have been calculated where the estimates comprise more than 30% of the total.

In the past estimates were calculated by simply taking the mean of the values from the weeks on either side of the missing week(s). The semi-automated method takes three recorded values and interpolates the missing value from these. Although the two methods are slightly different the results of the two methods are similar and differences in figures obtained are likely to be insignificant.

* An annual index for a species is simply the total mean weekly count on a transect for the year including estimates. Where a species is double-brooded or, in the case of the hibernating species Peacock and Brimstone where there is a separate spring and summer flight, two separate indices are calculated. Where species produce a third brood (notably Small Copper and Wall Brown) third brood figures are combined with those of the second brood. In some cases the divisions between the broods are indistinct and a single index is given for the year. These species are: Red Admiral, Painted Lady, Small Tortoiseshell, Comma, Speckled Wood and Small Heath.

5.4 NUMBER OF ANNUAL INDICES FOR THE SCARCER SPECIES

In general, all-sites collated indices are only calculated if data from seven or more sites are available in every year since the start of the BMS in 1976, (data from sites where a zero index was produced in both of any pair of years are excluded). This limit was set based on a subjective assessment on the number of sites needed to produce a meaningful index at the start of the scheme in 1976. Usually the number of sites is much larger than this, and for the majority of species the number of sites for which data are available has increased greatly since the start of the scheme as the number of sites in the scheme has increased. However the fewer the number of sites then the less reliable are any trends in the data likely to be. The species whose collated indices need to be treated with the greatest caution are Common Blue (northern, univoltine), Chalkhill Blue, White Admiral (though the number of sites providing data for this species has increased markedly over the years), Small Pearl-bordered Fritillary and Pearl-bordered Fritillary. Consequently for these and other species represented on a relatively low number of sites, it is important to make sure that recording fully covers the flight periods so that site annual indices can be calculated which in turn will enable more reliable all-sites collated indices to be produced.

Figure 7. The number of annual indices calculated for the scarcer species compared with the number of sites where the species was actually recorded in 1999 and / or 2000.

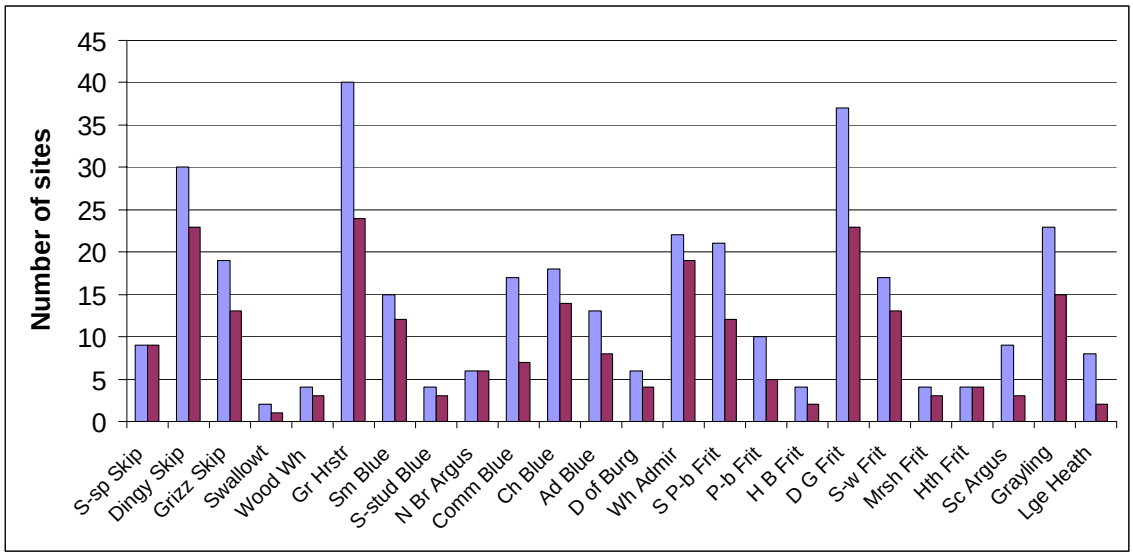


Figure 7 shows for scarcer species (includes many species too poorly represented on BMS sites to consider starting to produce an all-sites collated index), (first column) the number of transects on which the species indicated was recorded, in at least one of the last two years, 1999 and 2000 (including where an annual index could not be calculated), (second column) the number of transects for which an annual index could be calculated in both years (other than a zero in both years) and therefore the number of transects which contributed to the all-sites collated index where these were calculated.

As last year, for several species a relatively high number of sites did not produce enough data for annual indices to be produced in both years and therefore these sites could not be used in the calculation of the all-sites indices. The most extreme examples are Common Blue (northern, univoltine) (17 and 7 sites), Small Pearl-bordered Fritillary (21 and 12 sites), Dark Green Fritillary (37 and 23 sites) and Grayling (23 and 15 sites). The Scotch Argus and the Large Heath also show a big discrepancy between the number of sites on which the species were recorded and the number of sites that produced annual indices in both years.

6 ANALYSIS OF CHANGES IN BUTTERFLY NUMBERS

6.1 NUMBERS OF BUTTERFLIES RECORDED

The number of sightings of butterfly species recorded on BMS transects in 2000 are listed in Table 8. Numbers included in this analysis are only those where sufficient data were provided in either 1999 or 2000 for site annual indices to be calculated.

Table 8. Sum of site indices and order of abundance for 1999 and 2000

SPECIES	1999	2000	1999 order	2000 order
Meadow Brown	60195	50070	1	1
Gatekeeper	12898	14224	2	2
Ringlet	11540	13727	3	3
Green-veined White	9349	10803	4	4
Speckled Wood	6822	7225	5	5
Small Skipper	6633	6527	6	6
Common Blue	6618	6213	7	7
Peacock	4393	6170	11	8
Marbled White	5551	5140	10	9
Small Heath	6200	4911	8	10
Small White	3594	3869	12	11
Silver-studded Blue	106	3679	42	12
Chalk-hill Blue	6183	3468	9	13
Large White	2365	2784	14	14
Large Skipper	2508	2750	13	15
Brimstone	1840	2338	16	16
Red Admiral	1210	1997	21	17
Marsh Fritillary	167	1983	36	18
Adonis Blue	1627	1878	17	19
Small Tortoiseshell	1221	1517	20	20
Scotch Argus	1195	1419	22	21
Brown Argus	1230	1329	19	22
Orange Tip	1052	1158	25	23
Grayling	530	1063	30	24
Wall Brown	1551	1042	18	25
Common Blue (northern)	1841	970	15	26
Small Copper	981	920	26	27
Dark Green Fritillary	1068	914	23	28
Painted Lady	101	905	43	29
Comma	726	847	28	30
Clouded Yellow	17	832	51	31
Silver-spotted Skipper	1066	766	24	32
Northern Brown Argus	379	739	32	33
Heath Fritillary	641	594	29	34
Dingy Skipper	853	582	27	35
Silver-washed Fritillary	429	466	31	36
Green Hairstreak	306	280	33	38

SPECIES	1999	2000	1999 order	2000 order
Small Pearl-bordered Fritillary	91	216	45	39
Pearl-bordered Fritillary	120	189	41	40
Small Blue	182	175	34	41
Grizzled Skipper	181	134	35	42
High Brown Fritillary	133	117	39	43
Holly Blue	164	103	37	44
White Admiral	123	102	40	45
Large Heath	141	97	38	46
Purple Hairstreak	80	71	46	47
Wood White	98	69	44	48
Duke of Burgundy Fritillary	58	54	47	49
Swallowtail	44	33	48	50
Glanville Fritillary	26	30	50	51
Brown Hairstreak	16	15	52	52
White-letter Hairstreak	0	12	58	53
Lulworth Skipper	37	8	49	54
Black Hairstreak	0	4	54	55
Purple Emperor	2	3	53	56
Pale Clouded Yellow	0	1	57	57

6.2 SUMMARY OF CHANGES AT SITE LEVEL 1999/2000

Table 9 summarises the changes in the site indices for all species from 1999 to 2000 (number of sites for which site annual indices could be calculated, increases, decreases, no change). The all-sites collated indices for 1999 and 2000 are shown where these are calculated and the species names shown in bold type. Many of the rarer species do not have collated indices because they are recorded on too few BMS transects for a meaningful index to be calculated. Where collated indices have been calculated for species recorded on relatively few transects these figures should be treated with caution. These include Chalkhill Blue, Small Pearl-bordered and Pearl-bordered Fritillaries and Silver-washed Fritillary. For species with two distinct flight periods the second is used here.

Table 9. Summary of changes at site level 1999/2000

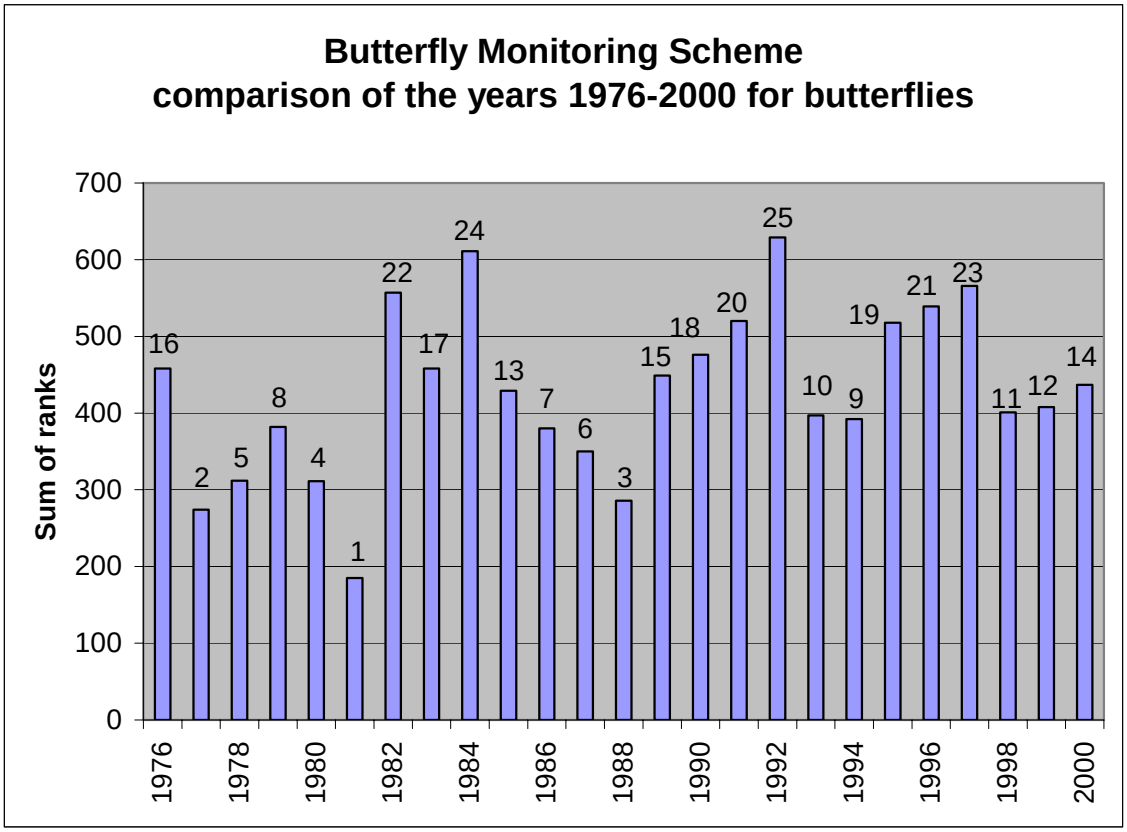
SPECIES	Brood	No. of site with index in 1999 or 2000	No. of sites with index in 1999 and 2000	Increase	Decrease	No change	Zero index in 1999 and 2000	1999 only	2000 only	National collated index 1999	National collated index 2000
Small /Essex Skipper	1	91	58	30	27	1	4	13	16	192	169
Lulworth Skipper	1	1	1	0	1	0	0	0	0		
Silver-spotted Skipper	1	10	9	3	6	0	1	0	0		
Large Skipper	1	99	61	28	33	0	4	15	19	143	151
Dingy Skipper	1	44	25	7	17	1	8	8	3	16	14
Grizzled Skipper	1	36	13	6	6	1	11	8	4	28	31
Swallowtail	1	2	1	0	1	0	0	1	0		
Wood White	1	10	3	1	2	0	4	2	1		
Pale Clouded Yellow	1	7	1	1	0	0	5	0	1		
Clouded Yellow	1	86	39	38	1	0	8	9	30		
Brimstone	1	69	40	22	15	3	3	15	11		
Brimstone	2	84	45	27	14	4	9	11	19	68	103
Large White	1	101	57	33	18	6	9	20	15		
Large White	2	107	77	33	42	2	0	8	22	91	86
Small White	2	104	64	23	39	2	1	14	25		
Small White	1	102	52	43	8	1	12	19	19	74	62
Green-veined White	2	114	74	37	37	0	3	13	24		
Green-veined White	1	103	54	40	13	1	2	27	20	377	352
Orange Tip	1	95	48	28	17	3	4	24	19	115	151
Green Hairstreak	1	50	25	12	11	2	6	8	11	174	213
Brown Hairstreak	1	9	6	4	2	0	2	1	0		
Purple Hairstreak	1	51	25	9	14	2	14	4	8		
White-letter Hairstreak	1	23	6	6	0	0	10	2	5		
Black Hairstreak	1	4	1	1	0	0	2	1	0		
Small Copper	1	99	34	18	10	6	32	15	18		
Small Copper	2	99	52	22	26	4	8	9	30	58	59
Large Copper	1	1	0	0	0	0	1	0	0		
Small Blue	1	16	9	2	7	0	5	2	0		

SPECIES	Brood	No. of site with index in 1999 or 2000	No. of sites with index in 1999 and 2000	Increase	Decrease	No change	Zero index in 1999 and 2000	1999 only	2000 only	National collated index 1999	National collated index 2000
Small Blue	2	7	3	3	0	0	2	0	2		
Silver-studded Blue	1	8	3	1	2	0	3	1	1		
Brown Argus	1	53	22	15	5	2	21	6	4		
Brown Argus	2	54	34	17	17	0	5	3	12	92	113
Northern Brown Argus	1	7	6	4	2	0	0	1	0		
Common Blue	2	91	62	23	36	3	6	6	17		
Common Blue	1	88	48	35	12	1	17	11	12	85	67
Common Blue (northern)	1	19	7	3	4	0	1	4	7	13	8
Chalkhill Blue	1	23	14	1	13	0	7	1	1	139	78
Adonis Blue	1	12	7	5	2	0	3	1	1		
Adonis Blue	2	12	8	5	3	0	2	1	1		
Holly Blue	1	68	29	2	24	3	16	10	13		
Holly Blue	2	78	24	13	9	2	34	3	17	64	113
Duke of Burgundy Fritillary	1	13	4	1	3	0	3	3	3		
White Admiral	1	31	19	10	8	1	5	6	1	21	22
Purple Emperor	1	7	2	1	1	0	3	1	1		
Red Admiral	1	98	54	40	14	0	0	18	26	90	136
Painted Lady	1	93	50	47	2	1	4	9	30	241	1957
Small Tortoiseshell	1	82	45	25	19	1	2	15	20	43	48
Camberwell Beauty	1	2	0	0	0	0	2	0	0		
Camberwell Beauty	2	2	0	0	0	0	2	0	0		
Peacock	1	80	36	24	9	3	1	21	22		
Peacock	2	105	69	38	28	3	0	10	26	187	218
Comma	1	72	36	24	8	4	0	16	20	216	327
Small Pearl-bordered Frit.	1	31	12	10	1	1	11	3	5	11	22
Pearl-bordered Fritillary	1	24	5	3	2	0	6	6	7	1	2
High Brown Fritillary	1	9	2	0	2	0	3	3	1		
Dark Green Fritillary	1	49	23	12	11	0	13	4	9	48	41
Silver-washed Fritillary	1	36	13	5	8	0	15	3	5	54	50
Marsh Fritillary	1	12	3	2	1	0	6	1	2		
Glanville Fritillary	1	1	1	1	0	0	0	0	0		
Heath Fritillary	1	4	4	2	1	1	0	0	0		
Speckled Wood	1	89	58	32	26	0	2	12	17	263	296
Wall Brown	1	87	24	11	10	3	30	14	19		
Wall Brown	2	89	42	13	26	3	23	6	18	27	20
Scotch Argus	1	7	3	1	2	0	1	0	3		
Marbled White	1	53	31	10	19	2	5	11	6	323	293
Grayling	1	33	15	6	9	0	8	2	8	78	63
Gatekeeper	1	94	68	38	30	0	2	10	14	110	128
Meadow Brown	1	116	74	40	34	0	0	17	25	161	161
Small Heath	1	97	45	13	31	1	17	19	16	26	21
Large Heath	1	7	2	2	0	0	0	3	2		
Ringlet	1	93	59	37	21	1	1	17	16	511	629

6.3 COMPARISON OF THE 25 YEARS OF THE BMS

The following method has been used to assess the overall relative abundance of butterflies in each of the 25 years of the BMS. For the 34 species for which all-sites collated indices are calculated, the years have been ranked 1 to 25 according to the collated index value for the species. The score 1 was given to the year with the lowest value, and 25 to the best year. For each year, the 34 ranks were summed, to give an overall indication of the year's quality. Figure 8 shows these sums of ranks, which theoretically could have ranged from 34 (if there had been a year in which every species was at its lowest collated index) to 850 (34 x 25). The overall ranking of years is shown above the columns in the histogram: 1981 emerges as the worst year overall, and 1992 as the best. Four of the five worst years occurred in the five years following the drought year of 1976. 2000 comes out just above average.

Figure 8. Histogram showing the sum of the ranks of each species for which a collated index is calculated for each year of the BMS.



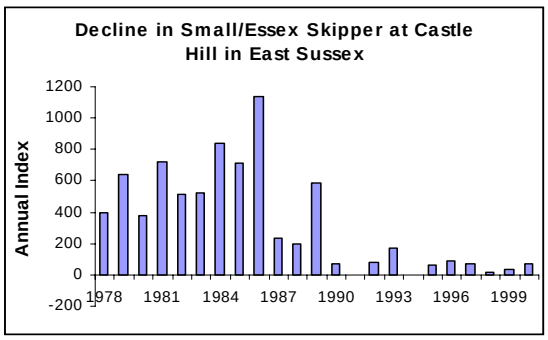
6.4 INDIVIDUAL SPECIES ACCOUNTS.

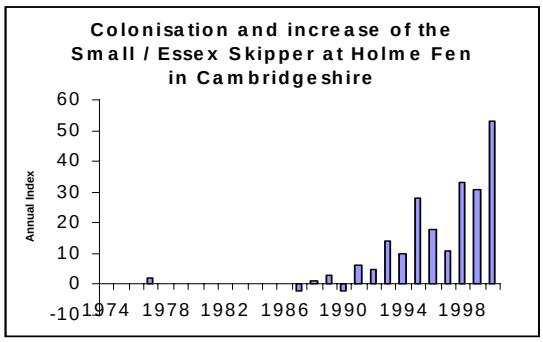
The following accounts should be looked at in conjunction with Table 2 on pages 12 & 13, Table 9 on pages 24 & 25, and Appendix I: Figures 15a-e on pages 61-66. (Compare also results in 1999 report).

Two types of index are constantly referred to in this section; the annual index for a species at a single site and the all-sites ("national") collated index. The former is referred to as "the index" and the latter always as the "collated index". A year in the text below is described as average for a species in terms of its rank order, not in terms of the mean of the collated indices. On the histograms showing site data, where the species was recorded but there were too few counts for the calculation of an index, or the species was not recorded, but there were too few counts made for a zero index to be assumed, then the histograms have a negative value (-2 or –1 respectively). In some cases, where the annual index scales are large, these negative values have been enlarged to make them visible on the histograms.

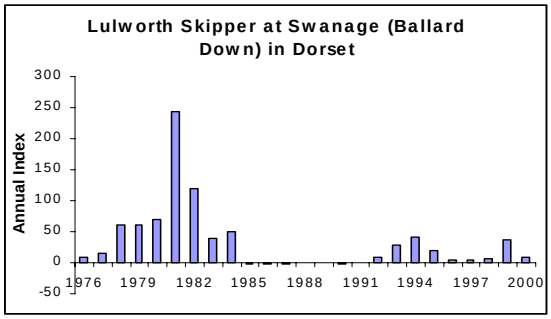
Comparisons between years for a species are made for sites where an annual index for that species could be calculated in both 1999 and 2000 (i.e. sufficient weeks recorded to cover the flight period(s) adequately) and where at least one of those indices was greater than zero.

Small/Essex Skipper: There was a small drop in the combined collated index for these two species, although there were increases at slightly more sites than there were declines. It was an average year.

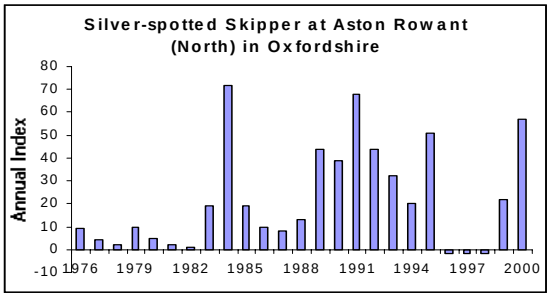


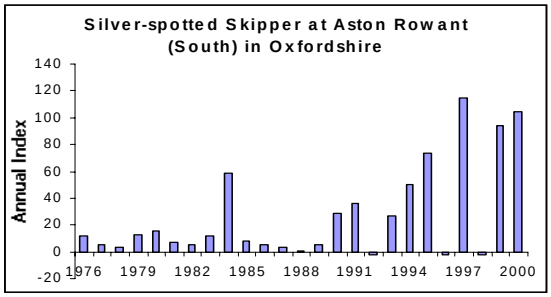


Lulworth Skipper: Numbers dropped from 1999 remaining very low on the only transect in the BMS, **Swanage** (Dorset), where this species is recorded. This butterfly requires it's foodplant, Tor Grass (*Brachypodium pinnatum*) to be growing in tall tussocks. This site is managed especially for the Adonis Blue which requires very short turf (see also section on Chalkhill Blue.

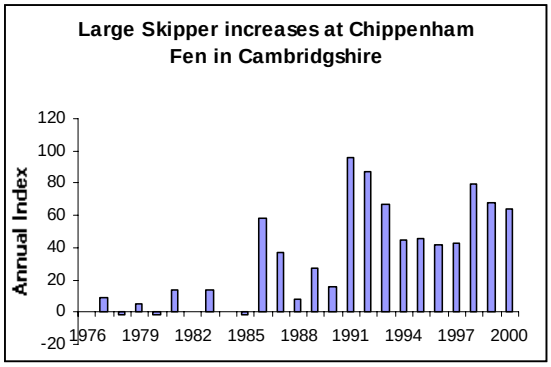


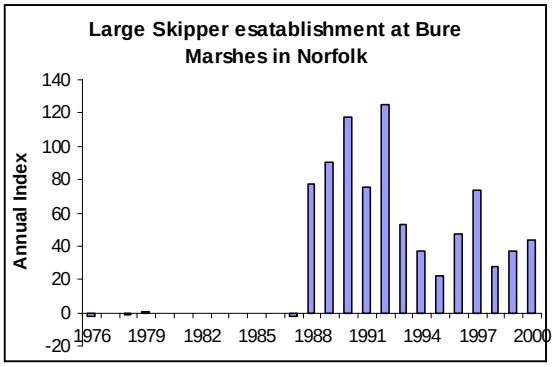
Silver-spotted Skipper: This butterfly was recorded on seven transects in 2000. Numbers dropped on most transects but increased on the two at **Aston Rowant**, where, as at the majority of BMS monitored sites, the species has been doing comparatively well in recent years.



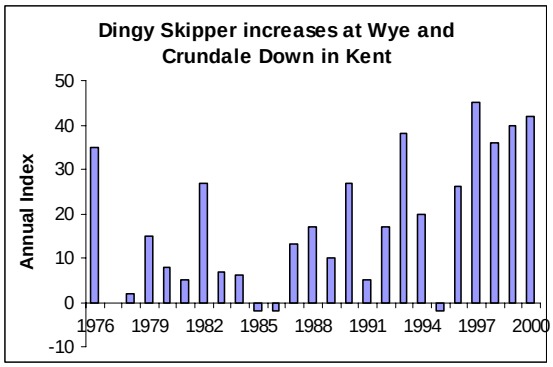


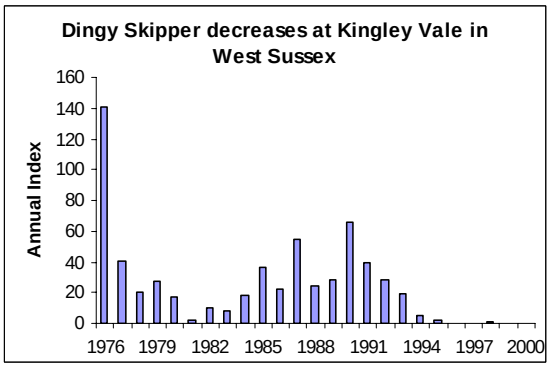
Large Skipper: A small increase in the collated index but still a below average year for this species. Apart from at **Monks Wood** (shown in last years report) numbers have increased at several other eastern England sites in recent years.



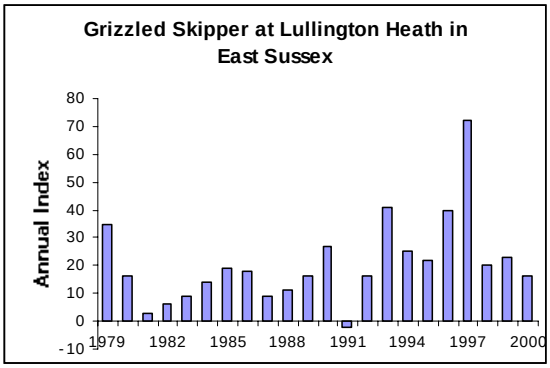


Dingy Skipper: A small drop in the collated index for this species, but one of the lowest of the series, ranking 22 out of the 25 years. This species has experienced mixed fortunes at different sites over the years, increasing at some while declining to low numbers or to extinction at others. The collated index has shown a significant decline over the monitoring period (Table 2, page 13, Appendix I: Figure 15a page 62 and Table 10, page 67)



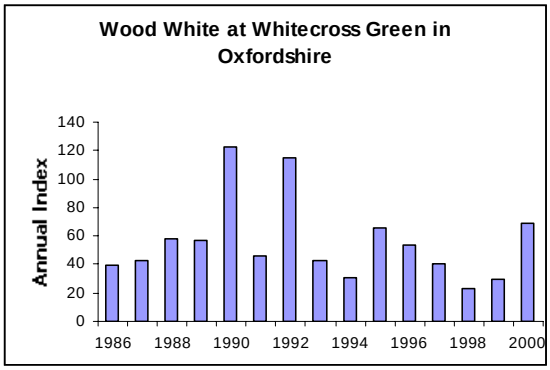


Grizzled Skipper: A small increase in the collated index but a well below average year. There was a decrease in the number of sites from which annual indices could be calculated in both 1999 and 2000 (12) compared with 1998 and 1999 (18) as crucial weeks were missed at more sites with this species in 2000. Despite the overall increase, **only Fontmell Down** (Dorset) with 29 produced an index of more than 20.



Swallowtail: A small drop in the annual index (44 to 33) at **Bure Marshes**, the only site in the BMS where this species was recorded in 2000.

Wood White: For the first time for at least seven years none were recorded on **the Shabbington Wood** or the **Oakley Wood** transects in Bernwood in Oxfordshire, however numbers increased at nearby **Whitecross Green Wood**. After a low point in the late 1980s numbers recorded on the Bernwood transects had increased substantially during the 1990s but then declined rapidly after 1997 (see Wood White section in last years (1999) report.



Clouded Yellow: See separate section on page 51

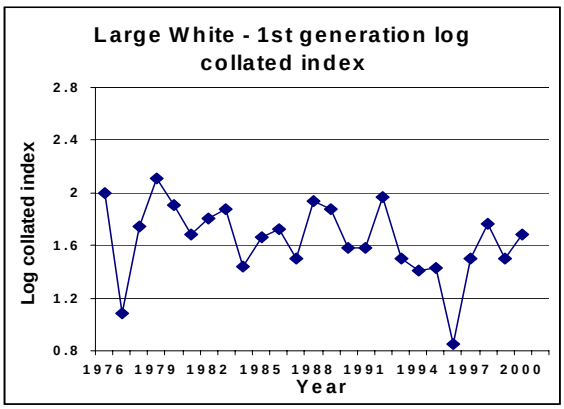
Brimstone: There was an increase in both the spring and summer collated indices. The spring collated index was above average, while the summer collated index increased by >50% from it's all-time low in 1999 to recover to about average. However this species has remained relatively stable over the monitoring period (Appendix I, Figure 15a page 62).

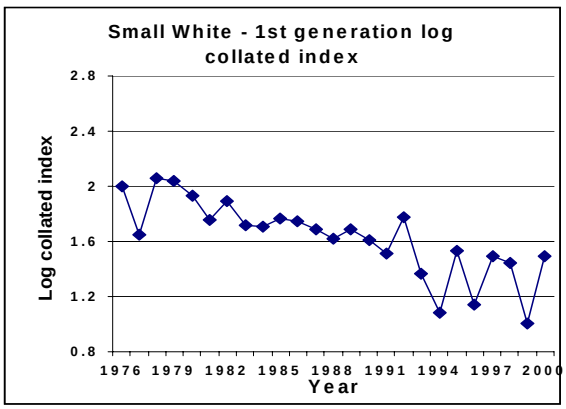
Large White: An increase in the first generation collated index giving an average collated index but a slight drop and another low collated index for the second generation.

Small White: Overall a relatively poor year for this species. There was a substantial increase in the first generation collated index from last year's all-time low, however the collated index remained relatively low compared with the rest of the series although it was the highest since 1995. The collated index for the second generation dropped slightly from 1999 and was the third lowest since the scheme began (Table 2, page 13 and Appendix I: Figure 15a page 62).

Green-veined White: A reasonable year for this species with a big (nearly doubling) increase in the first generation, remaining high in the second generation. In common with other mobile species including the Large and Small Whites, numbers of this species recorded have increased at some sites and declined at others, but it does not always respond in the same way in both generations. These changes are likely to be due to such factors as changes in habitat structure and the local availability of nectar and hostplants.

There has been a decline (see last column in Table 2, page 13) in the first generation collated index of both the **Large White** and the **Small White** (statistically significant) over the monitoring period and this can be seen at the site level on Map 2 and 3. There has not been the same overall decline in the second generation index (Appendix I: Figure 15a page 62) (no significant trend).





Maps 2-7. "Whites" on BMS transects.

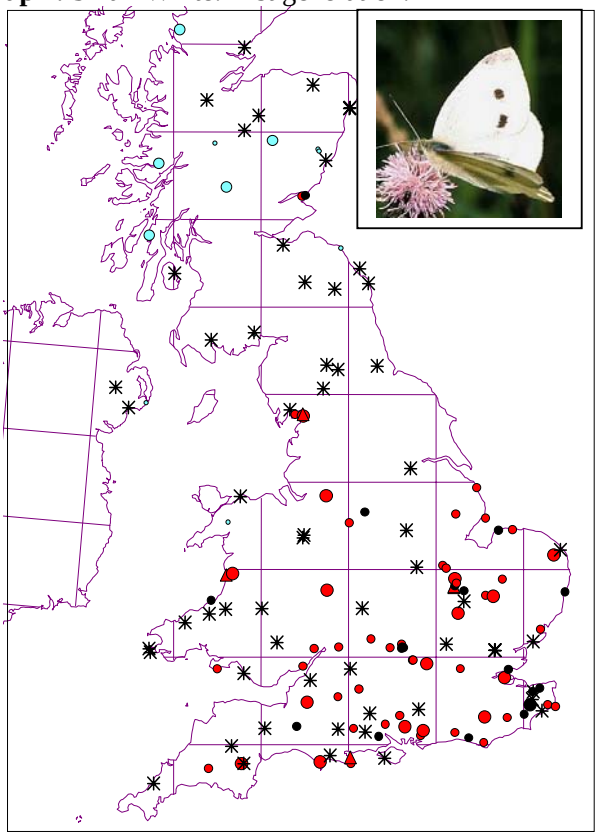
Unless otherwise indicated the following key applies to all the maps in the remainder of this report (sizes of symbols vary depending on size of map).

- ● Significant increase in the counts
- • Increase but not significant
- ● Significant decrease in the counts
- • Decrease but not significant
- ● Transects in scheme > 8 years but butterfly not recorded
- • Transects in scheme < 8 years, and recorded in the last five years, but butterfly not recorded
- ⊕ Butterfly recorded but <8 years positive values
- ♦ Transect colonised by the butterfly
- ♦ Butterfly become extinct on the transect

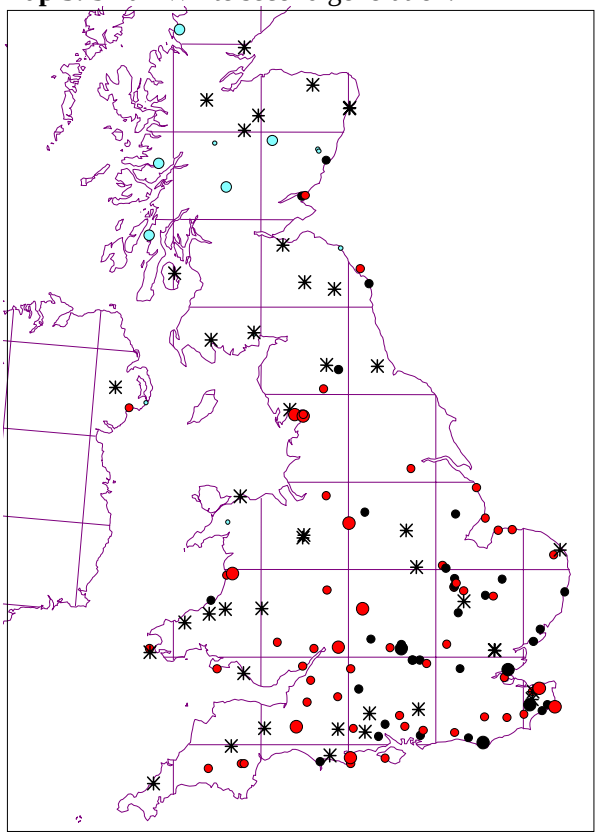
Significant trends (increase or decrease in counts over time) are identified using simple regression of $\log_{10}$ index values on years. Only data where there at least eight years of positive values have been used.

Colonisation is considered to have taken place where the butterfly was not recorded on the transect at all for at least four years (and where data were sufficient for an annual index to be calculated) followed by at least four consecutive years when the butterfly was recorded. For extinctions the opposite criteria apply.

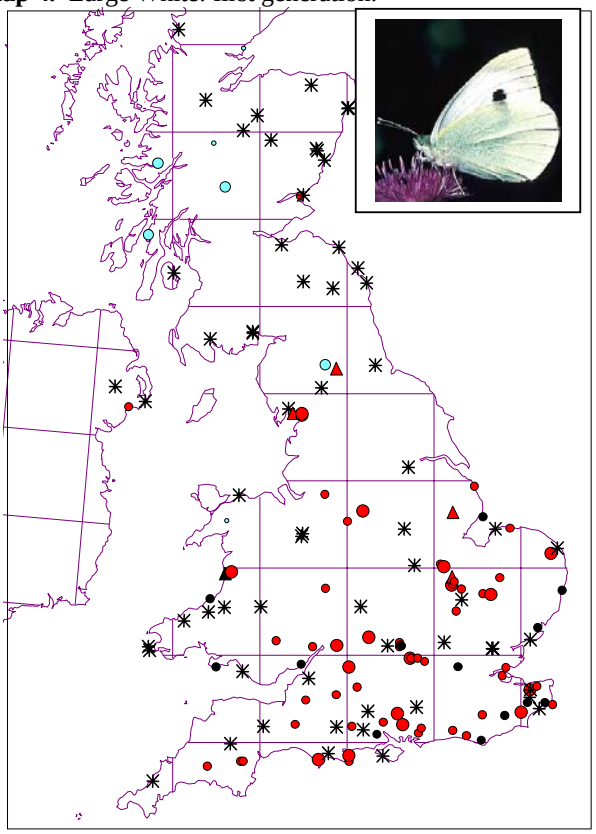
Map 2. Small White: first generation.



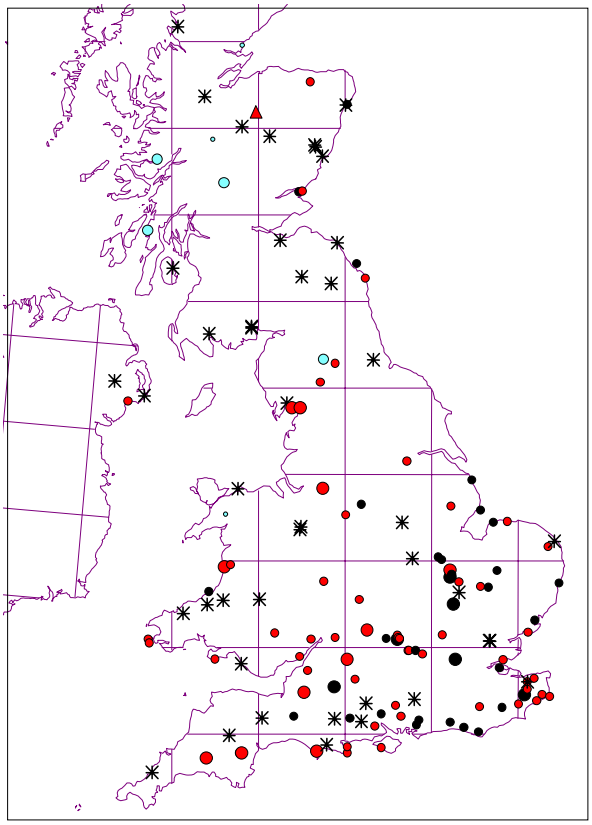
Map 3. Small White second generation.



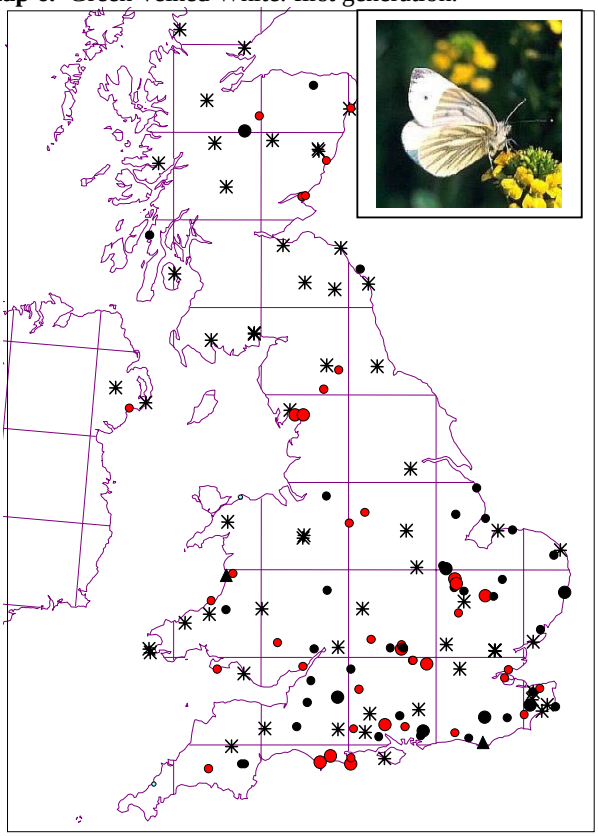
Map 4. Large White: first generation.



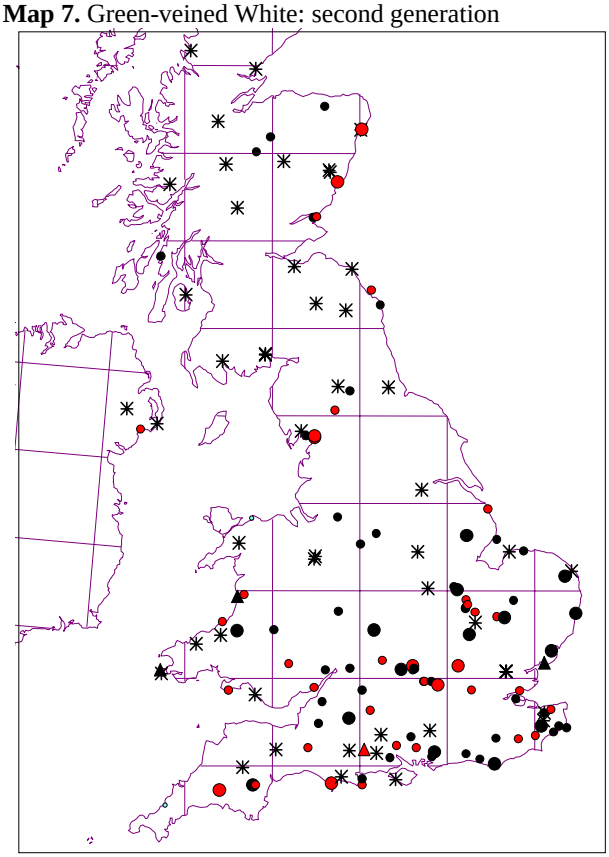
Map 5. Large White: second generation.



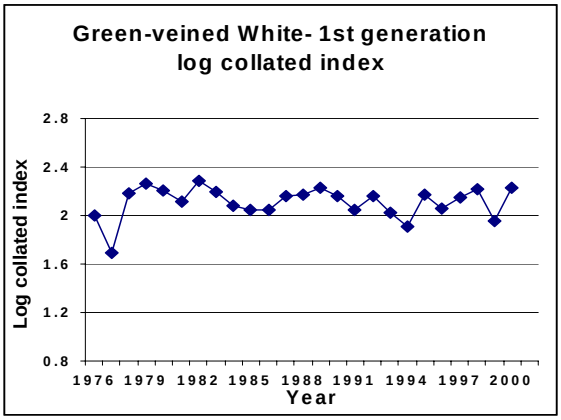
Map 6. Green-veined White: first generation.



Map 7. Green-veined White: second generation

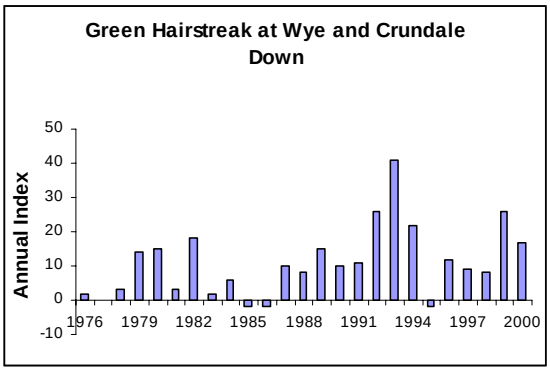


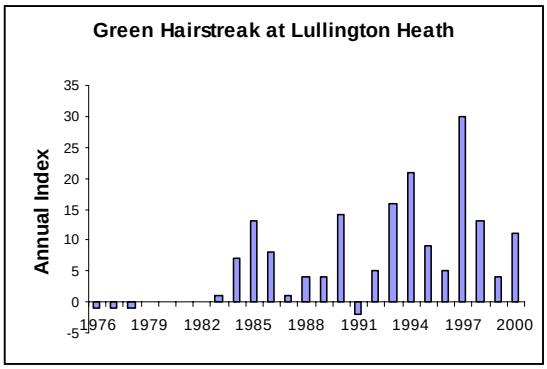
The **Green-veined White** shows no trend in the first generation but there is a significant increase in the trend in the second generation (Table 2, page 13 and Appendix I: Table 10, page 67) with significant increases in counts at many monitored sites.



Orange Tip: An increase on 1999 and a high collated index for this stable species.

Green Hairstreak: Another increase in the collated index of this species to produce the ***highest collated index of the series***.





Brown Hairstreak: This butterfly was recorded on just two of the nine transects on which it has been recorded over the past five years (the lowest number of transects since 1989). Nine were recorded at **West Dean Wood** in West Sussex and three at **Shabbington Wood** (Bernwood) in Oxfordshire.

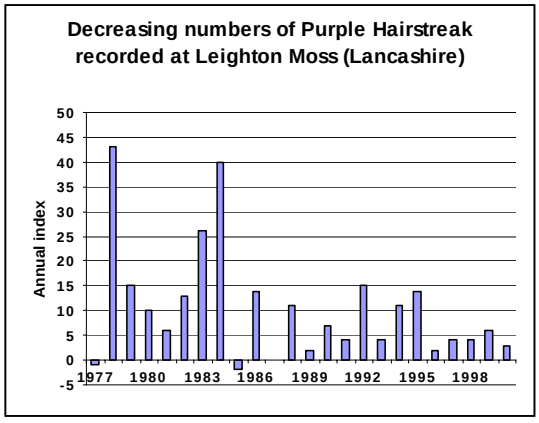
Purple Hairstreak: Below average numbers recorded on transects in 2000. Four sites produce an average of more than 10 individuals recorded per year: **Leighton Moss** (North Lancashire) (Av. 11.6), **Northward Hill** (Kent) (10.8), **Hampstead Heath** (London) (11.2) and **Alice Holt** (10.5). The only transect to record more than 10 individuals in 2000 was **Northward Hill** where 18 were recorded.

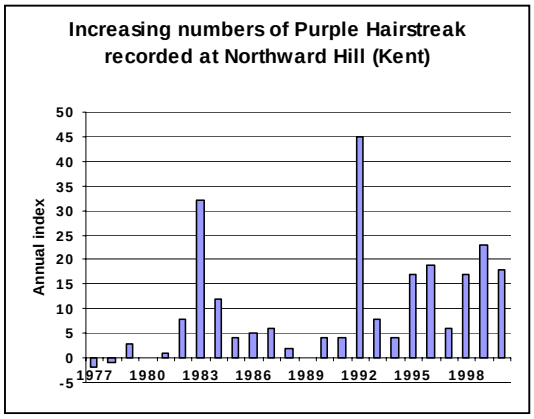
In the table below "Total transects" indicates the total number of transects on which the species had been recorded up to that date and where an annual index, including a zero, could be calculated for that year (sites where there were insufficient data to calculate an annual index are excluded from this figure). "Transects" shows the number of BMS transects that the species was recorded in that year and where an annual index could be calculated. The "Mean" is the average number of Purple Hairstreaks recorded on the "Total transects". Although, like the other hairstreaks apart from the Green Hairstreak, the Purple Hairstreak is not suited to being monitored by the transect method, these figures may give an indication of years when the species was most abundant.

Table: Purple Hairstreaks on BMS transects.

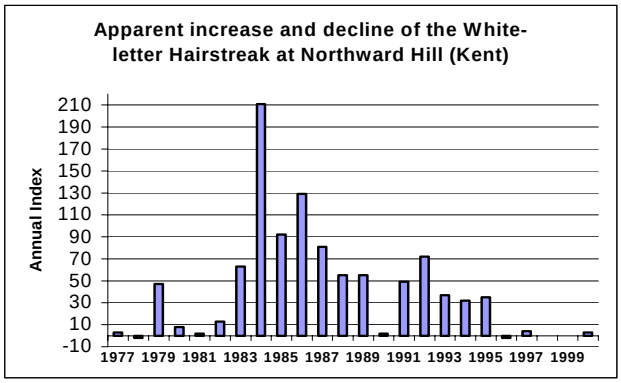
Year	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Total transects	22	23	27	33	34	35	33	38	39	39	38	38
Transects	9	6	9	8	10	14	15	24	24	15	14	10
Mean	6.0	2.0	3.7	1.4	1.3	1.9	1.8	4.1	5.4	0.9	1.7	1.1

1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
37	47	47	45	47	45	47	50	49	49	43	43	47
13	22	25	21	23	25	26	27	22	21	23	23	21
1.1	1.4	2.1	1.8	3.4	2.3	1.8	3.4	2.4	1.7	2.1	1.9	1.5





White-letter Hairstreak: After none being recorded on transects in 1999 small numbers were recorded on seven transects in 2000, the highest number of transects since the scheme began! The White-letter Hairstreak has been recorded on just 24 BMS transects since 1976, and 16 during the past 10 years. On nearly all these transects it is only recorded once every few years and even then only occasionally is more than one individual recorded in any one year. On average it has been recorded on only three transects a year.

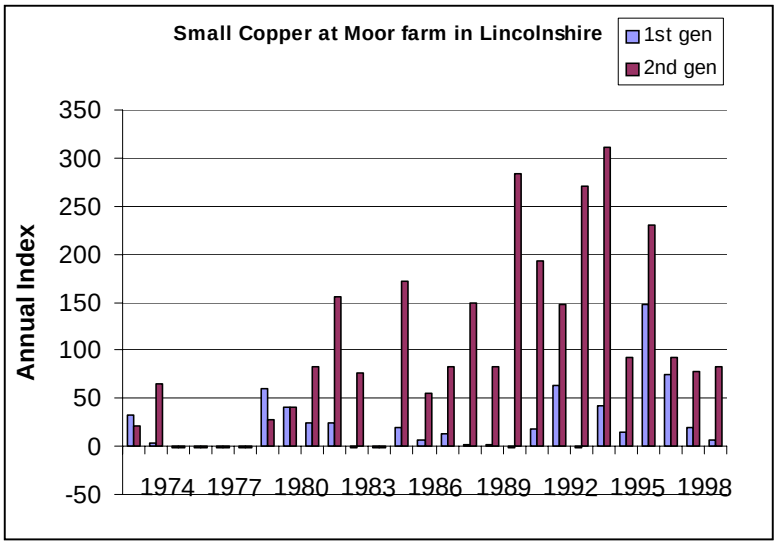


Northward Hill in Kent is a notable exception to this. Large numbers of White-letter Hairstreak were recorded regularly on the transect during much of the 1980s up to the mid 1990s (211 in 1984!). However there has been a dramatic decline in numbers recorded on the transect especially since 1995 but there has been no apparent concurrent deterioration of the butterfly's Elm habitat at the site or on the transect route. Apparently, if anything the habitat appears to have improved. The way the transect is recorded has remained consistent and there is no obvious reason for the decline in numbers recorded, though poor summer weather in the last few years may have played a part.

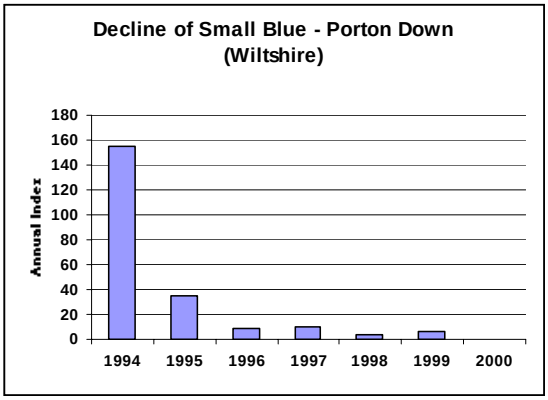
The only other transect where this butterfly is recorded regularly is **Woods Mill** in West Sussex, where it has been recorded in seven of the last nine years (highest number 13 in 1994). This site came into the BMS in 1979 but the White-letter Hairstreak was not recorded on the transect until 1992.

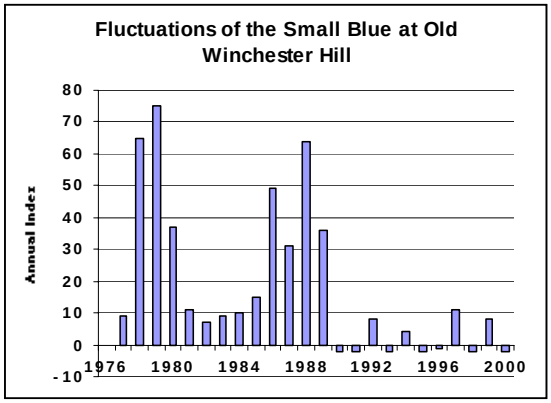
Black Hairstreak: There are only three transects currently in the BMS where this butterfly has been recorded. In 2000 it was only recorded on the **Monks Wood** transect where four were recorded on single transect count on Monday 19th June. All were at ground level. This is the highest count for **Monks Wood** since the very hot summer of 1976 when four were also recorded on a single count. The temperature at **Monks Wood** on 19th June was almost 28^0c and it had been very hot the preceding few days. It has been observed before (e.g. in **Monks Wood** in 1976) that when the weather is particularly hot this species will descend to the ground from its normal location in the scrub and tree canopy, presumably to find moisture.

Small Copper: There was a nearly 50% increase in the first generation collated index and a tiny increase in the second generation collated index to make this an average year for this species in both generations. At many sites the numbers recorded are very small, with an average per transect over the years of only 5.5 (median 1.0) in the first generation and 16.5 (median 4.9) in the second generation. Highest numbers in the second generation are recorded at **Skokholm** (Pembrokeshire), **Moor Farm** (Lincolnshire) and **Kingley Vale** (West Sussex).



Small Blue: This species was recorded on six of the 12 transects where this species has been recorded in the last 10 years with increases in the annual index only at **Oxwich** (27 to 45) and **Castle Hill** (2 to 20). However there were also good numbers recorded again at **Kenfig** (drop from 114 to 92). This butterfly appears to declining on several other transects in recent years, notably **Old Winchester Hill** (Hampshire), **Pewsey Down** (Wiltshire**), St. Margaret's Bay** (Kent) and **Porton Down** (Wiltshire). It also appears to be extinct at **Swanage** (Ballard Down) (Dorset). However numbers fluctuate considerably at some sites, e.g. **Old Winchester Hill** and **Martin Down** (Hampshire).

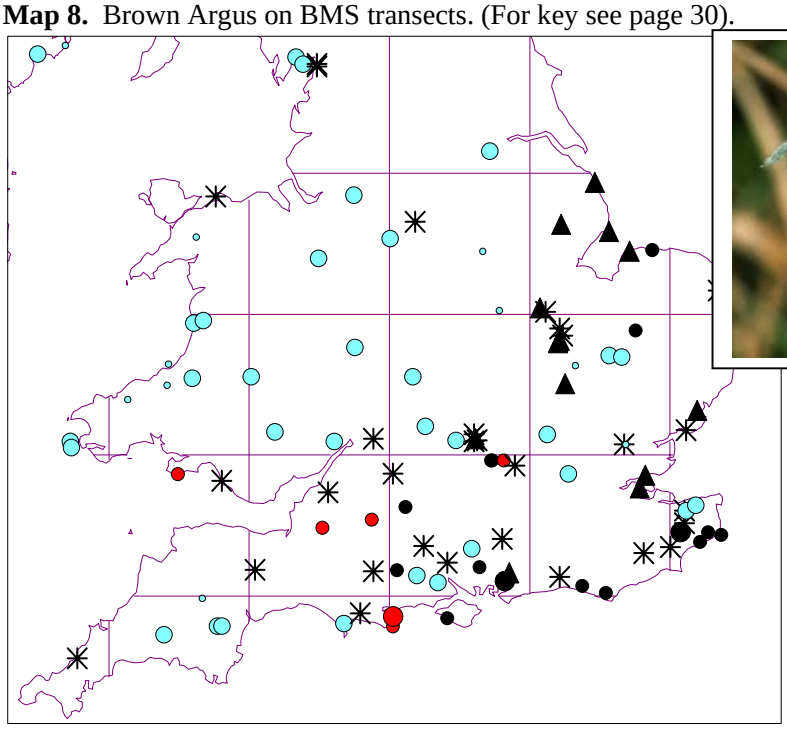


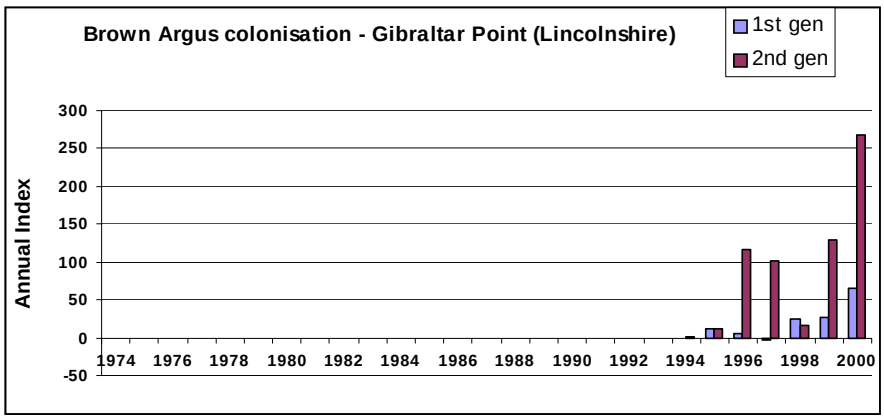


Silver-studded Blue: There are populations of this butterfly on four BMS transects. Highest numbers were recorded on the two newest transects to the scheme: **Great Orme** (Conway) produced an index of 2554 in 1999 and 3310 in 2000, and **Gere Sands** (Cornwall) produced and index of 306 in 2000. Numbers dropped at **Studland Heath** (84 to 50) and at **Tadnoll** (22 to 13), both in Dorset. Silver-studded Blue also occurs at **Walberswick** (Suffolk) but has not been recorded on the transect route since 1984.

Brown Argus: There was an increase in the collated index in both generations making this a well above average year for this species. However increases and decreases were about equal in the second generation. Despite the relatively poor summers of the last three years, this species appears to be persisting at nearly all the sites that it has recently colonised. Map 8 shows those transects that have been colonised by the Brown Argus (♦) according to the criteria we use to denote that a colonisation has taken place (i.e. at least four consecutive years when the species was not recorded at all followed by at least four consecutive years when it was recorded on the transect). There are a small number of other sites where the data do not quite meet these criteria but where the species may have colonised.

Map 8. Brown Argus on BMS transects. (For key see page 30).

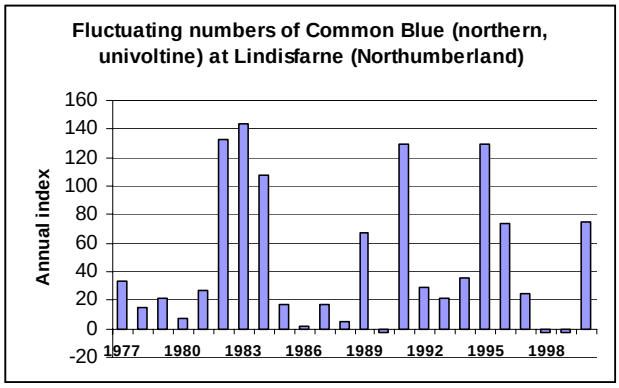




Northern Brown Argus: This species was recorded on six BMS transects in 2000. There were four increases and two decreases in the annual indices with highest numbers being recorded at **Leighton Moss** (Lancashire) (index: 155 – increase from 93 in 1999), **Smardale Gill** (Cumbria) (269 – a big increase from 88), and **Bishop Middleham Quarry** (Durham) (264 – increase from 166).

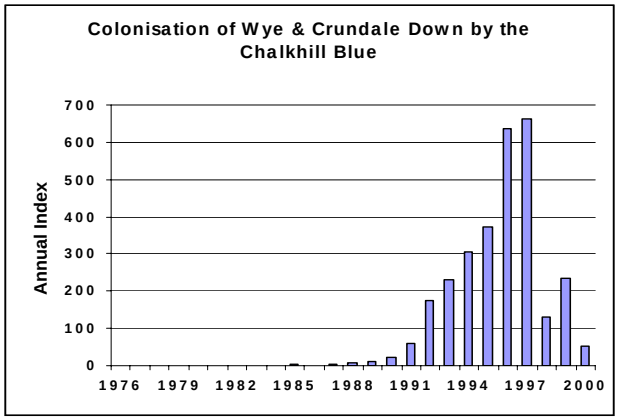
Common Blue: (bivoltine, southern)**:** It was a slightly below average year in both generations for this species. There was a big increase (>70%) in the first generation index but a decrease in the second generation index (>20%).

Common Blue: (univoltine, northern)**:** The collated index was lowest since 1986 and the second lowest in the series, however comparisons were only possible for six transects. There were three increases and three decreases.

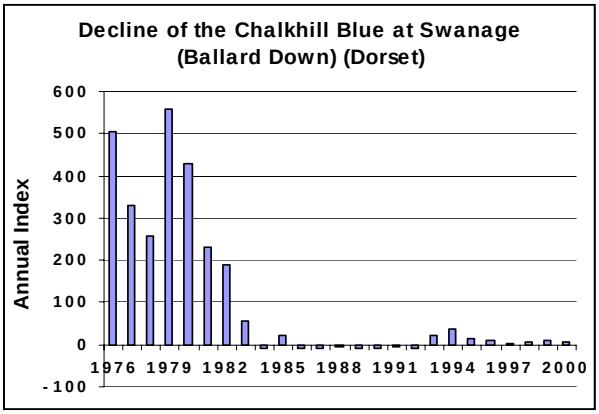


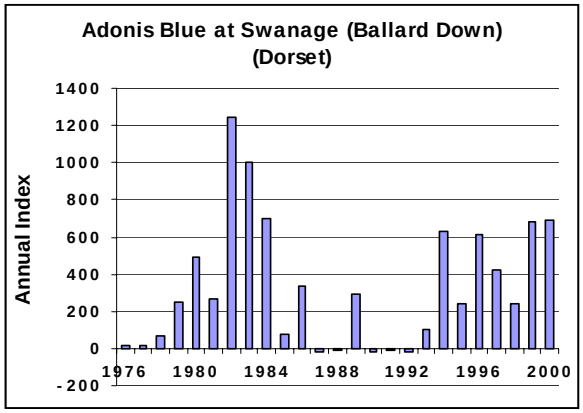
Chalkhill Blue: Comparisons were possible for 14 transects and although this was above average for the series, it was the lowest index since 1990 and the biggest drop since 1980 (see Appendix I: Figure 15b, page 63). Numbers recorded dropped on all of these transects except **Old Winchester Hill** (Hampshire), which produced the highest index of the year for this species (index: 1723 – up from 1145 in 1999). Several other transects have large populations (index >1000 in at least some years), these are **Castle Hill** (East Sussex), **Lydden** (Kent) and **Fontmell Down** (Dorset).

At **Wye and Crundale Down** (Kent) which was colonised by the Chalkhill Blue in the 1980s, numbers have declined dramatically after the high numbers of 1996 and 1997.



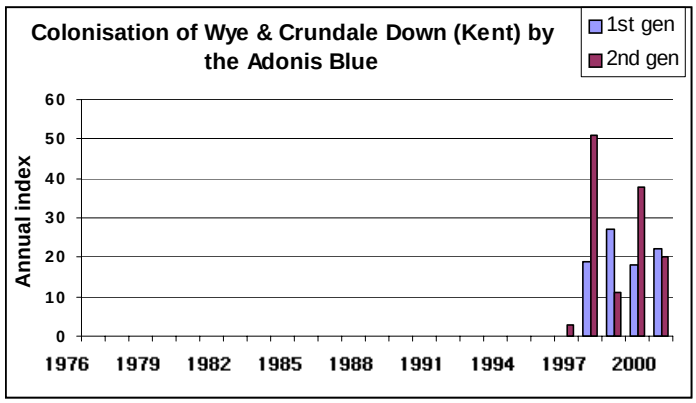
Numbers remain very low at **Swanage**, but this site is managed primarily for the Adonis Blue, which although it feeds on the same hostplant, Horseshoe Vetch (*Hippocrepis comosa*), as the Chalkhill Blue, requires its hostplant to be in very short turf, which is generally unsuitable for the Chalkhill Blue.





Adonis Blue: On the eight transects where comparisons were possible counts increased on five and dropped on three. The highest count was at **Swanage** (Ballard Down) (Dorset) (See Chalkhill section Blue above).

As with the Chalkhill Blue, the butterfly appears to have become established at **Wye and Crundale** Down (Kent), but more recently than the that species. It was recorded for the first time on the transect in 1996.



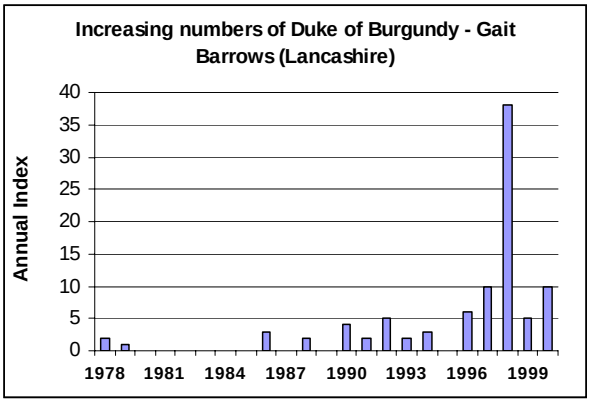
Holly Blue: A further drop in the index of this species was expected judging by the course of previous cycles in abundance. There was a big drop in the first generation index (75%), but a substantial increase in the second generation index (77%) (Table 2, page 13 and Appendix I: Figure 15e, page 66).

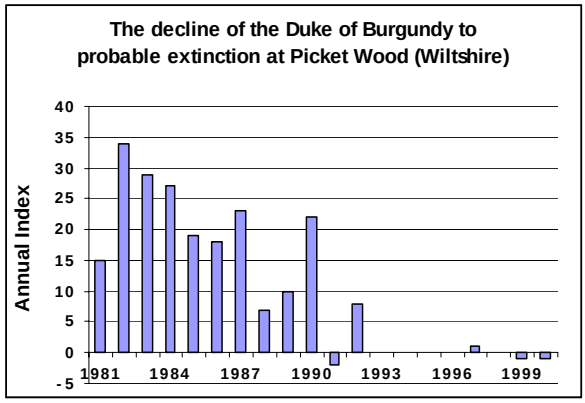
Holly Blue (northern univoltine): Very few were recorded on the six sites in the BMS where the univoltine Holly Blue is recorded. First generation annual indices were produced for only two sites and positive indices only for **Leighton Moss** (one second generation individual) and **Gait Barrows** (one first generation individual).

In recent years second generation individuals have been occurring more often at several sites. However at Hillsborough in Northern Ireland there have been no second generation individuals recorded on the transect during the seven years it has been in the BMS.

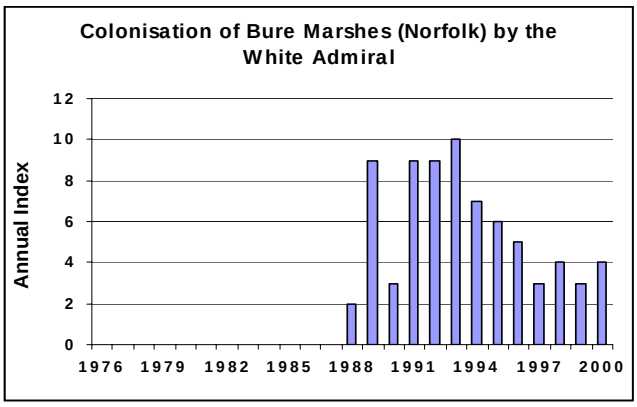
Duke of Burgundy: recorded on only four transects in 2000 (seven in 1999), but indices for three only. Numbers recorded increased at **Gait Barrows** (Lancashire) but dropped at **Denge Wood** (Kent) and **Fontmell Down** (Dorset).

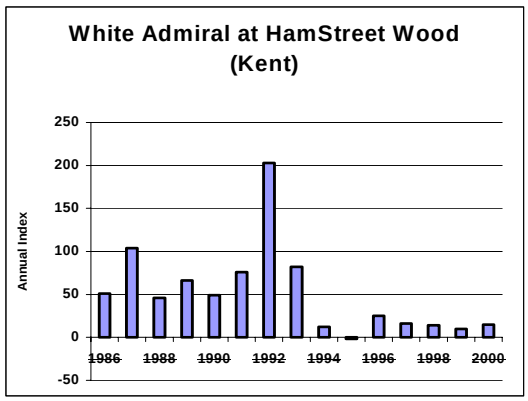
This species has been recorded on 11 BMS transects during the last 10 years, but it occurs regularly on only four of these (**Somerford Common** is the other one not mentioned above). It has almost certainly become extinct on a further five transects that are currently in the BMS.





White Admiral: Comparisons were possible for 19 transects with increases on 10 transects and decreases on eight transects. The collated index remained almost unchanged from 1999 (slight increase).





The highest site index in 2000 was for **Ham Street Wood** (Kent) where it was 15. This is also the site which has produced the highest index in any year of the scheme with 203 in 1992. Other sites that have regularly produced an index in double figures in recent years include **Picket Wood** and **Somerford Common** (both in Wiltshire), **Shabbington Wood** (Oxfordshire) **and Stour Wood** (Essex).

Purple Emperor: This butterfly was recorded on just two transects in 2000, one at Ampfield Wood (Hampshire) (first time since 1989) and two at West Dean Wood (West Sussex), the only transect where it is recorded most years. There are just four other transects in the scheme where it is occasionally recorded.

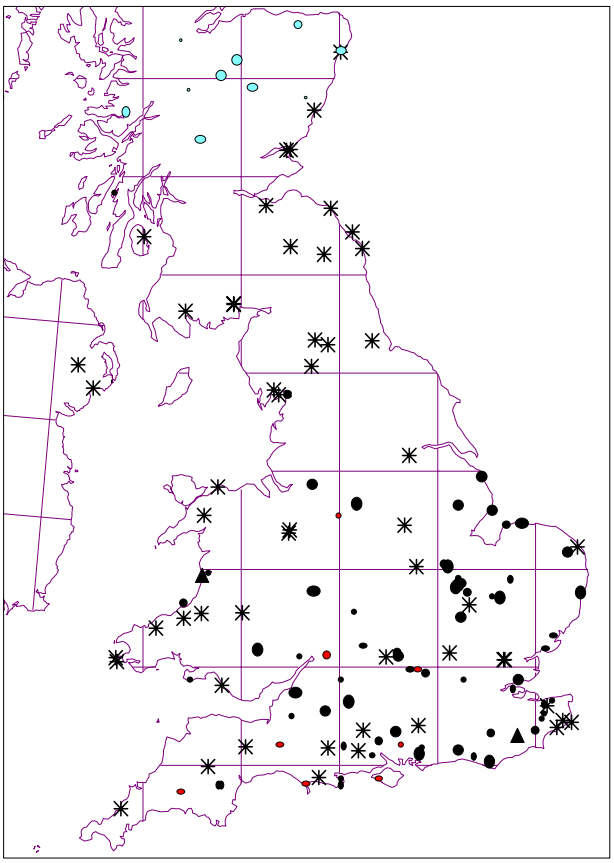
Red Admiral: See section on migrants.

Painted Lady: See section on migrants.

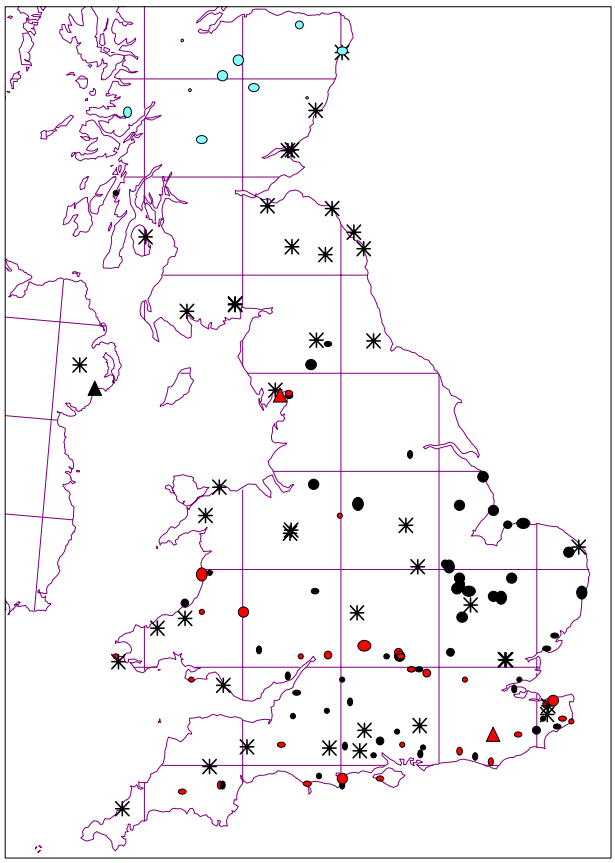
Small Tortoiseshell: There was a small increase in the collated index for this species from last years lowest index of the series.

Peacock: There was an increase in both the spring and summer indexes making these among the highest of the series (Table 2, page 13 and Appendix I: Figure 15c, page 64). There have been significant increases in the numbers recorded of the spring flight on many transects in the southern half of Britain (Map 9). There have also been significant increases at some sites in the summer flight, but interestingly these are mainly concentrated in the east of England (Map 10).

Map 9. Peacock on BMS transects – spring flight.
(For key see page 30).

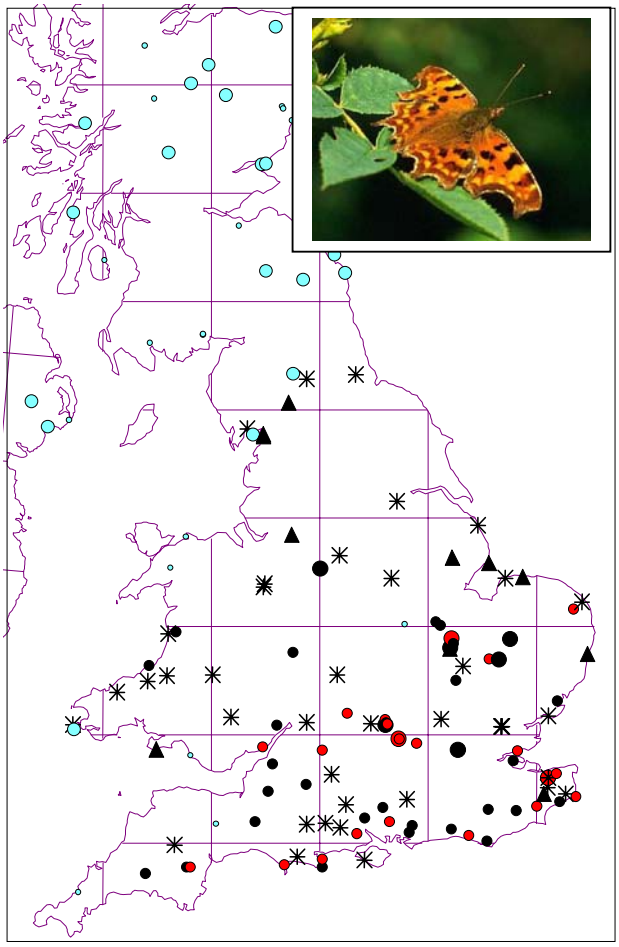


Map 10. Peacock on BMS transects – summer flight.
(For key see page 30).

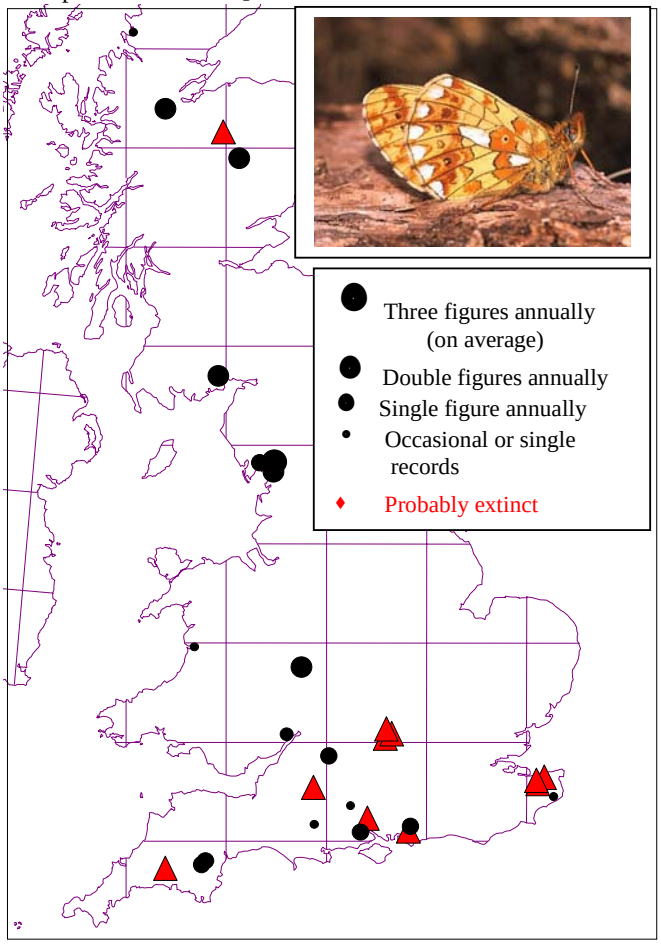


Comma: An increase of just over 50% in the collated index making this the ***highest of the series***. As the Millennium Butterfly Atlas (Asher *et al* 2001) shows this species has expanded its range in Britain by nearly 80% over the last 20 years. To a limited extent this has been mirrored by results from the BMS as several transects have been colonised within the main range of expansion shown in the atlas, although there are relatively few BMS sites in this region and even fewer with a long run of data.

Map 11. Comma on BMS transects
(For key see page 30).



Map 12. Pearl-bordered Fritillary on BMS transects.
[Note that the key and symbols are different from the other Maps in this section.]

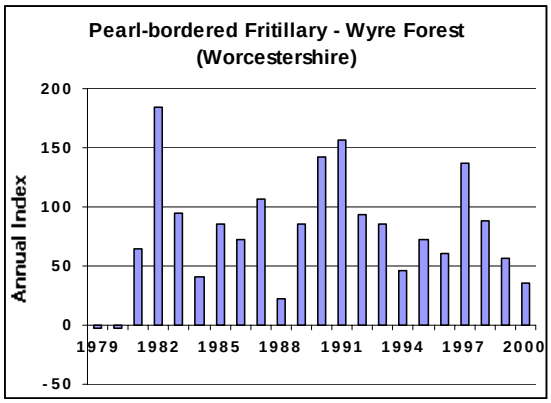


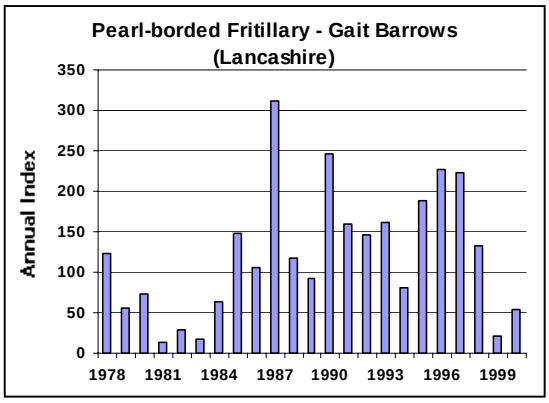
Pearl-bordered Fritillary: Only five comparisons were possible though the species was recorded on 10 transects in 2000 (eleven in 1999 and / or 2000). There were three increases and two declines. The collated index increased by nearly 70% but as in the case of the univoltine Common Blue, this result may have little meaning because of the very small number of transects contributing to the collated index.

Map 12. above shows the distribution of transects currently in the BMS where the Pearl-bordered Fritillary has been recorded. An indication of the numbers recorded annually on each transect is shown as well as transects where this butterfly has almost certainly become extinct during the monitoring period. At some sites the butterfly continues to decline, e.g. **at Somerford Common** in Wiltshire and at **West Dean Woods** in Hampshire.

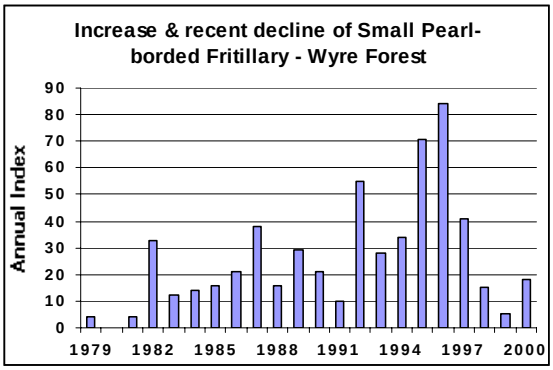
The Pearl-bordered Fritillary occurs in at least double figures at five BMS sites: **Leighton Moss** (Lancashire) **Gait Barrows** (Lancashire), **Wyre Forest** (Worcestershire), **Glen Strathfarrar** (Highland) and **Mabie Forest** (Dumfries & Galloway). The long running datasets at the first three of these sites show big fluctuations in the numbers recorded, but do not show a long–term decline in the populations at these sites.

The graphs below show that in 2000 numbers dropped at **Wyre Forest** (Worcestershire) and were the lowest since 1986, but increased at **Gait Barrows** (Lancashire).



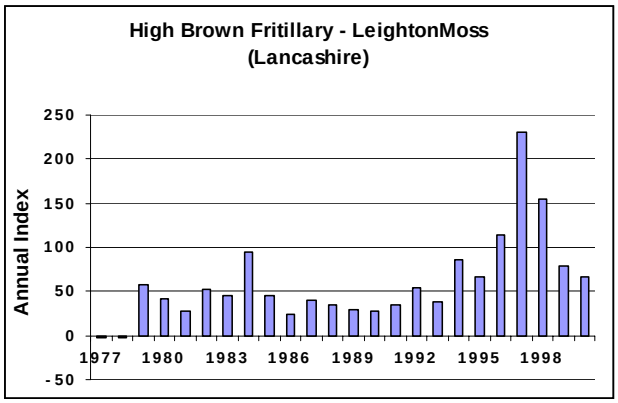


<u>Small Pearl-bordered Fritillary</u>: It was a better year on BMS transects for this species with a doubling in the collated index from its lowest collated index in the series in 1999, but still remaining low. The butterfly was recorded on 21 BMS transects in 2000 and comparisons were possible for 12 of these (an improvement on the nine in 1999). There were increases in the numbers recorded on 10 transects, and a drop on one.

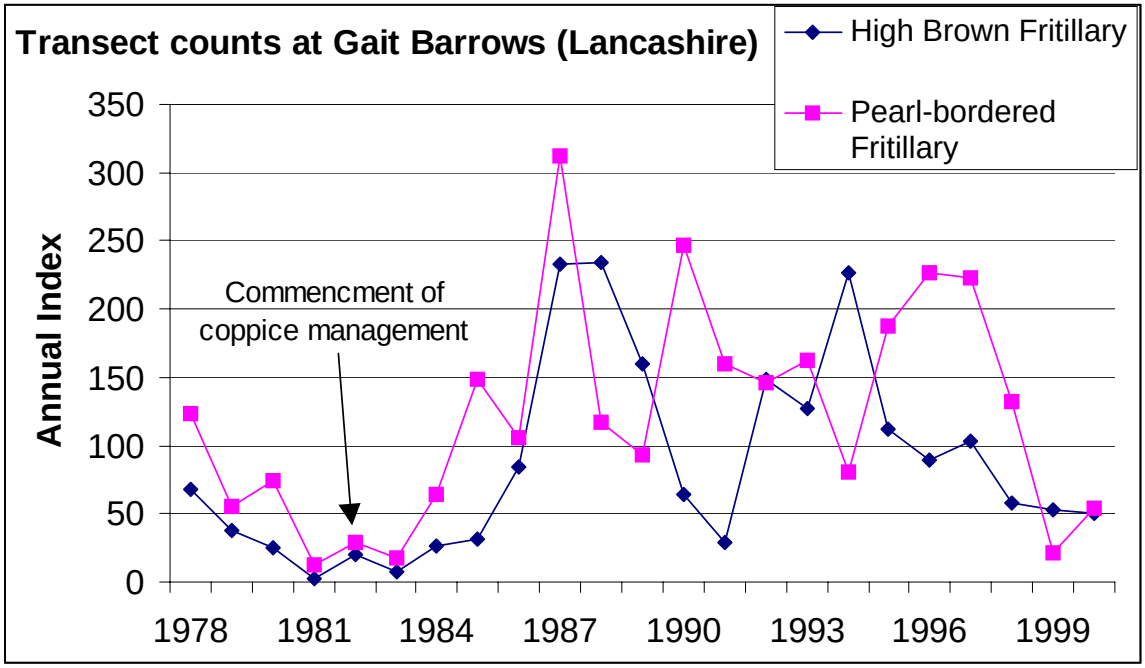


Double figures are only regularly or frequently recorded on four transects in the scheme: **Leighton Moss** (Lancashire), **Gait Barrows** (Lancashire), **Wyre Forest** (Worcestershire) and **Newborough Warren** (Anglesey). **At Wyre Forest** numbers have dropped considerably in recent years (1997-1999) but this is likely to be due to poor weather during these years, especially in June when the butterfly is on the wing. Numbers also dropped at **Leighton Moss** and **Gait Barrows** over the same period, but less so at the coastal site **Newborough Warren**.

<u>High Brown Fritillary</u>: Only recorded at **Leighton Moss** and **Gait Barrows** in Lancashire in 2000 where there was a small drop in numbers recorded on both transects. Small numbers are recorded on four other BMS transects. Of these transects it is recorded usually annually at **Bovey Valley** in Devon, but only spasmodically on the other three transects.

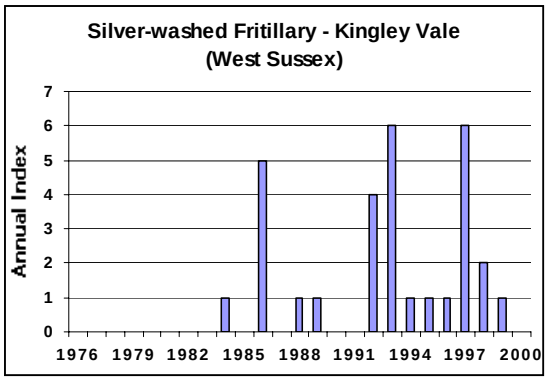


At **Gait Barrows NNR** a programme of coppice management was restarted in 1982 after years of abandonment, with some coppice being cut every year since. There was an almost immediate response in the numbers of Pearl-bordered and High Brown Fritillaries recorded on the transect. Numbers have mostly remained relatively high ever since, although numbers of both species have dropped in the last three years, probably in response to the relatively poor late spring and early summer weather of these years.

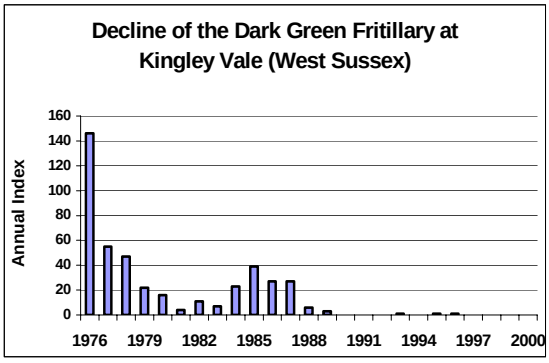


<u>Dark Green Fritillary</u>: The third successive drop in the collated index (down 15% from 1999) after the all-series high of 1997. It was the lowest collated index since 1990 and ranked 20th out of the 25 year series. This butterfly was recorded on 34 transects in 1999 and 37 transects in 2000. Comparisons were possible for 23 transects (an improvement on the 16 transects in 1999). Despite the drop in collated index there were roughly equal increases and decreases on transects.

Silver-washed Fritillary: This butterfly was recorded on 17 transects in 1999 and 16 in 2000. There was a slight fall (7%) in the collated index but it was an average year for this species. However comparisons were possible on 13 transects only (18 in 1999). There were five increases and eight decreases.

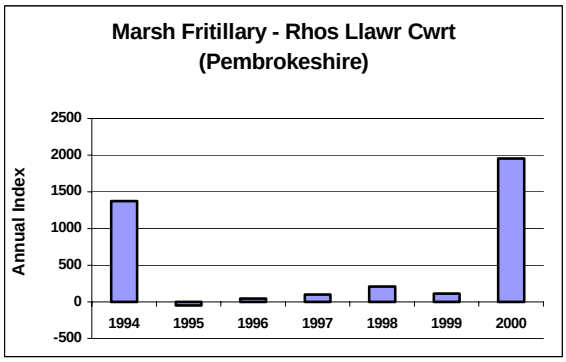


During the mid 1980s the Silver-washed Fritillary began to appear on the transect counts at **Kingley Vale** (West Sussex). Around this time the Dark Green Fritillary declined on the transect counts until none were recorded in 1990. Since then only singletons have been recorded in three years. It was last recorded in 1996. Much of the grassland is grazed very short and is unsuitable for the Dark Green Fritillary which requires its foodplants in a taller sward. Conversely woodland habitat is maturing on the site.



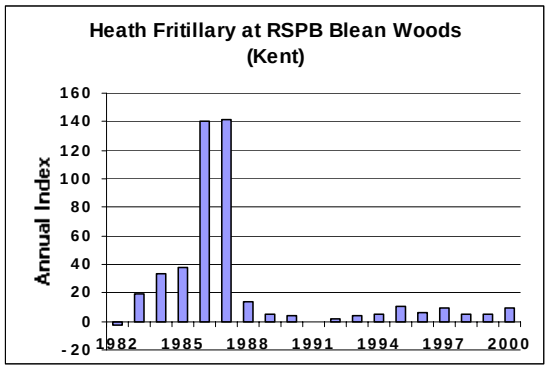
The Silver-washed Fritillary has also increased at several woodland sites where the Pearl-bordered Fritillary has probably become extinct. These sites include **Ampfield Wood** (Hampshire), **Picket Wood** (Wiltshire) and **Somerford Common** (Wiltshire) indicating the increasing shadiness of these woodland sites.

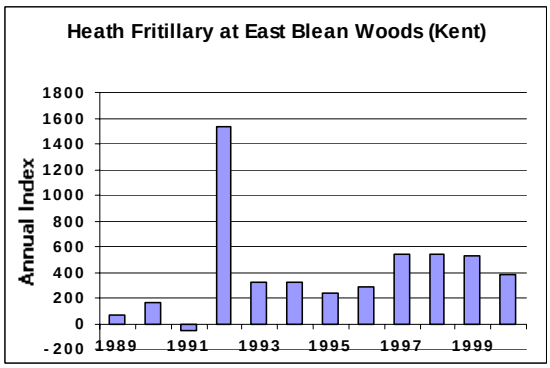
Marsh Fritillary: This butterfly occurs on six BMS transects but may be extinct on two of these (**Pewsey Down** and **Picket Wood** in Wiltshire). None were recorded on the **Taynish** (Strathclyde) transect, but some were seen off transect. Numbers fluctuate hugely in a cyclic pattern here and on other sites apparently in response to weather, food supply and the proportion of caterpillars killed by parasitic braconid wasps (*Cotesia* spp). Judging by previous cycles they should very soon reappear on transect counts at Taynish (see 1999 report).



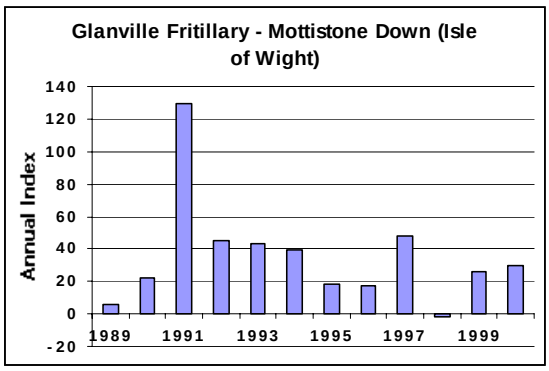
Conversely numbers were at their highest in seven years of transect counts **at Rhos Llawr Cwrt** (Pembrokeshire).

Heath Fritillary: This butterfly is recorded on four BMS transects, three in Kent and one in Cornwall. Numbers increased on all the Kent transects and remained unchanged at **Luckett Wood** (Cornwall). However numbers remain low at RSPB Blean Woods (formerly Church Wood) after relatively high numbers in the 1980s. Highest numbers are recorded on the East Blean Woods transect.





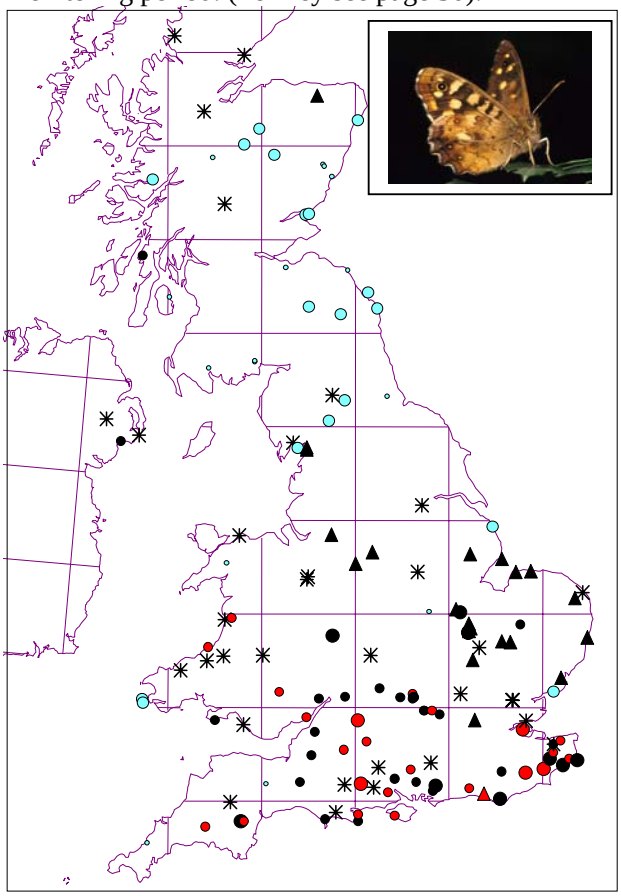
Glanville Fritillary: A slight increase in the annual index on the only transect in the scheme for this species: **Mottistone Down** (Isle of Wight).



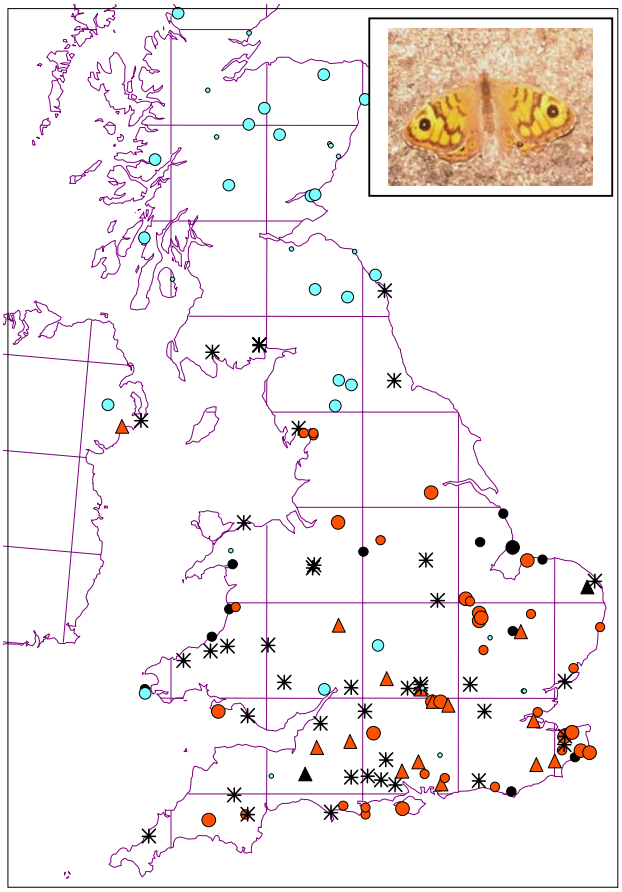
Speckled Wood: The Speckled Wood had another good year with the second highest collated index of the series (small (13%) increase from 1999). The highest was in 1992 (see Appendix I: Figure 15d, page 65). The Speckled Wood is one of 14 species detailed in the millennium butterfly atlas (Asher *et al* 2001) which are currently expanding their range in Britain. Many BMS sites have been colonised by this species during the monitoring period (Map 13) and the spread of these sites mirrors well the expansion in range shown in the atlas. There is some suggestion from the monitoring results that the species may be declining in numbers in the south of its range overall, though at some southern sites it is increasing.

The same three transects produced the highest indices for this species as in 1999. **Shabbington Wood** (Oxfordshire) produced the highest index (496), **Monks Wood** (Cambrideshire) an index of 330 and **Gait Barrows** (Lancashire) an index of 300. It now seems likely that the recent colonisations of **Gait Barrows** and **Leighton Moss** (Lancashire) by this species have resulted from unauthorised introductions.

Map 13. The Speckled Wood on BMS transects showing the many sites in the east of England that Have been colonised by this butterfly over the Monitoring period. (For key see page 30).

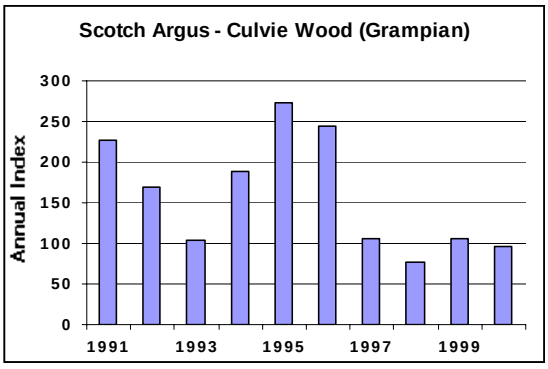


Map 14. Second generation data for the Wall Brown showing extinctions and significant declines on many BMS transects. (For key see page 30).



Wall Brown: After two years of encouraging increases that might have heralded a recovery of this species, the collated index dropped once again in the second generation (26%), despite an increase (24%) in the first generation producing the highest first generation collated index since 1993. Map 14 shows that this butterfly has become extinct on quite a few BMS transects in central and southern England. These transects occur within the area of decline indicated in the millennium butterfly atlas (Asher *et al* 2001).

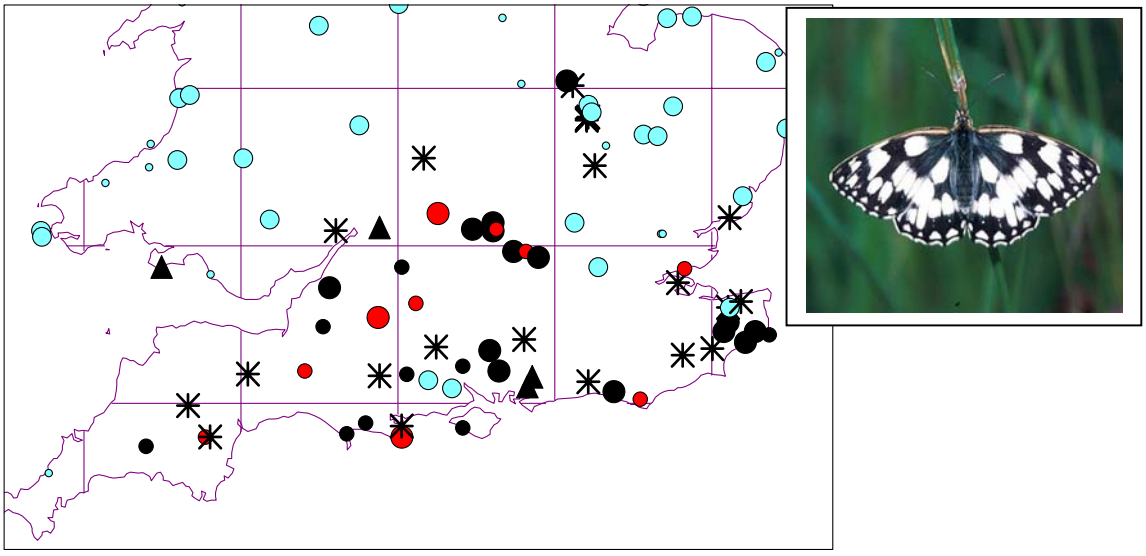
Scotch Argus: With **Creag Meagaidh** (Highland) coming into the scheme this species now occurs regularly on nine BMS transects. It was recorded on eight of these in 2000 but comparisons with 1999 data were only possible for three transects. Numbers increased substantially at **Taynish** (Strathclyde) from last years lowest count (increase from 21 to 129), but dropped at **Smardale Gill** (Cumbria) and at **Culvie Wood** (Grampian**). Smardale Gill** (one of only two sites in England where this species is known to occur) produces by far the highest indices in the scheme for this species but numbers have been declining since the highest index of 1994 (index 2005) (see figure in last years report). Until 2000 indices have always been in excess of 1000, but 894 in 2000 was the lowest index since the transect came into the BMS in 1990.



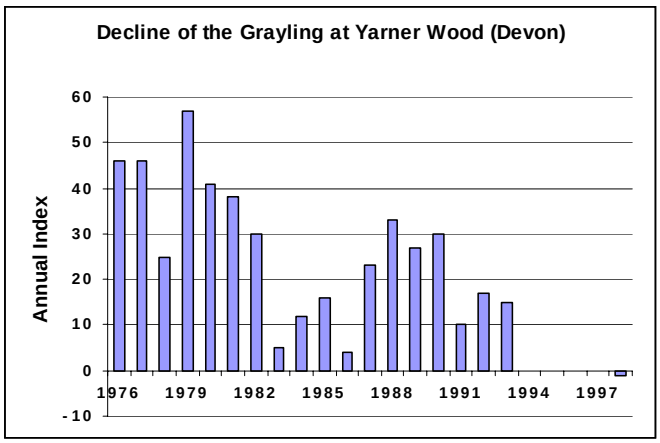
Mountain Ringlet: It was recorded on transects counts at **Ben Lawers** in 2000 but unfortunately too few weeks were covered for an index to be calculated. The butterfly also occurs at **Creag Meagaidh** where counts have been carried out for several years on a separate transect to the main one. This transect was new to the scheme in 2000 and back years data have yet to be processed.

Marbled White: There was a slight drop in the collated index but it still remains high (ranking 5th in the series). The butterfly was recorded on 46 transects in 2000 and comparisons were possible on 31 with increases on 10 and decreases on 19 (two no change) transects. It was recorded for the second year running at all three transects local to Monks Wood in Cambridgeshire: **Monks Wood**, (index 2) **Woodwalton Farm** (1), and **Bevill's Wood** (2) (see 1999 report). The collated index trend has shown a significant increase over the monitoring period (Table 2, page 13 and Appendix I: Figure 15d, page 65, and Table 10, page 67). The increasing numbers are apparent at the site level (Map 14).

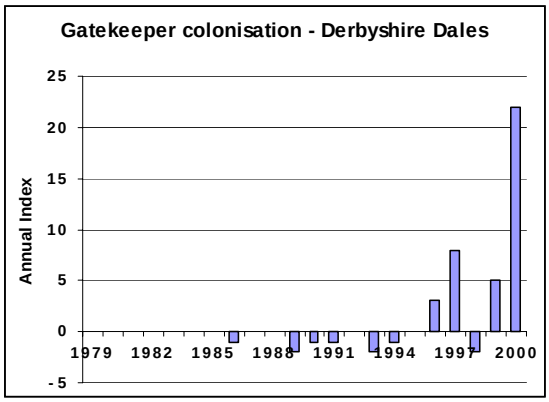
Map 14. Marbled White on BMS transects. (For key see page 30).

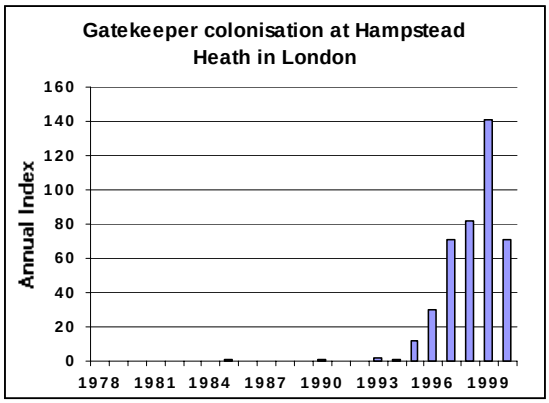


Grayling: After the big increase in the collated index in 1999 there was a 19% fall in 2000. The butterfly was recorded on 22 transects but comparisons were possible for 14 only. There were increases on five and decreases on nine transects. It was an about average year for this species, however overall this species has shown a significant downward trend over the monitoring period (Table 2, page 13, and Appendix I: Figure 15d, page 65, and Table 10, page 67), and this is reflected by the number of transects that have shown significant declines (Map 16).



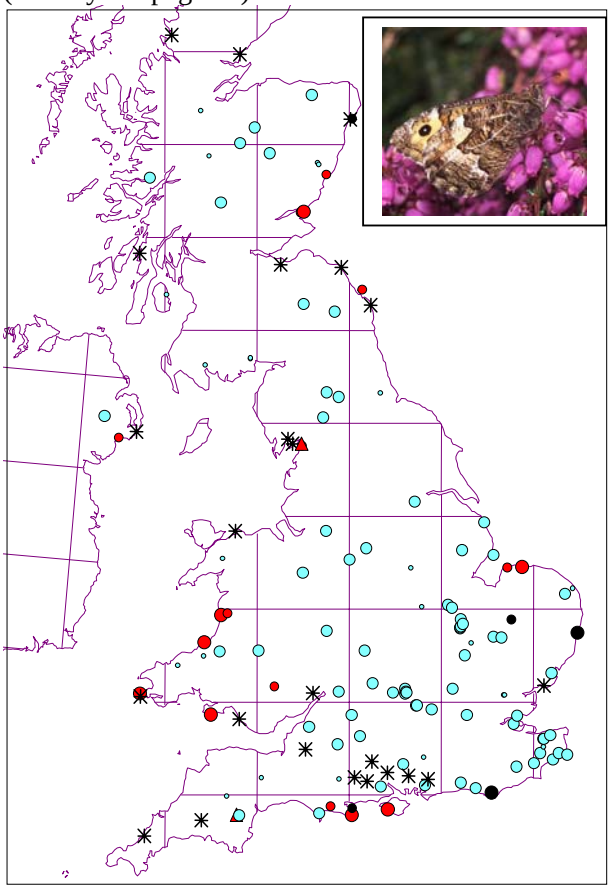
Hedge Brown: An increase in the collated index for the second year running to give another high collated index. This is another species that has been increasing its range nationally especially in the East Midlands, e.g. Leicestershire, Nottinghamshire and Derbyshire, (Asher *et al* 2001), but this is an area where there are relatively few BMS transects and so far this range expansion has been little detected by the scheme (Map 17). However there have been colonisations on two BMS transects within this range of expansion at **Rostherne Mere** (Cheshire) and the **Derbyshire Dales**. The butterfly has also been increasing in the London area and colonising new sites there (Asher *et al* 2001) including **Hampstead Heath** (London) where there is a BMS transect.



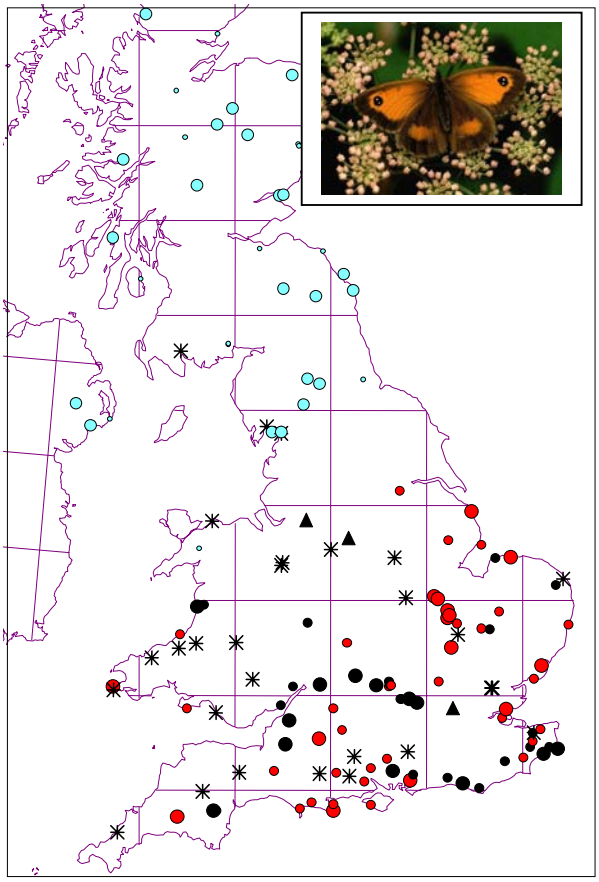


There have been significant declines at some sites, these are particularly concentrated in the east of England, but at many southern and western sites the butterfly has increased significantly on the transect counts (Map 17).

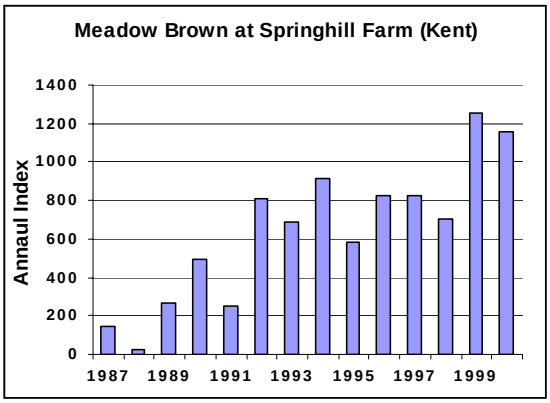
Map 16. Grayling on BMS transects.
(For key see page 30).

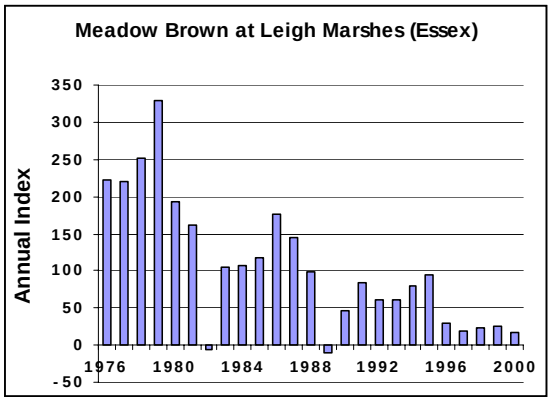


Map 17. Hedge Brown on BMS transects.
(For key see page 30).



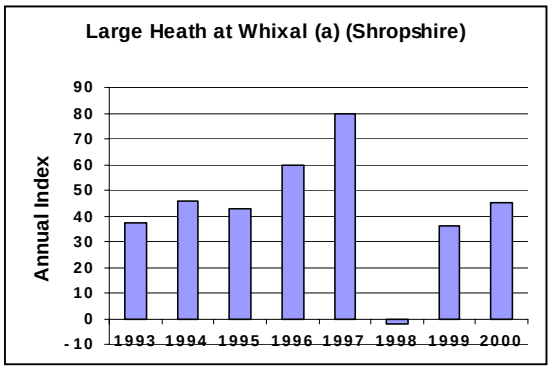
Meadow Brown: No change in the relatively high collated index. As with many species there have been major changes in the numbers recorded at some sites over the years with some sites showing a substantial increase in numbers, whereas at other sites numbers have declined dramatically. This is likely to be largely a response to changes in the habitat.





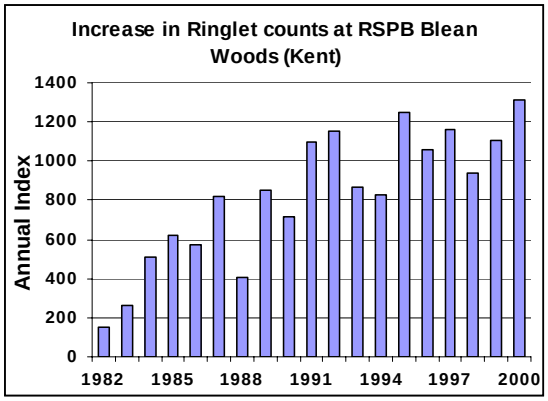
Small Heath: A nearly 20% drop in the collated index and the ***lowest of the series.*** Over the whole monitoring period there has been a highly significant decline in the collated index. There have also been significant declines in the counts at the site level on many transects in England and Wales (Map 18). indicating a widespread decline in this species. This butterfly has apparently declined in Scotland too (Pete Kinnear *pers. comm.*) though this is not evident from BMS data. This decline is in contrast to other common Satyrid butterflies except the Wall Brown, of which all but the Hedge Brown have shown significant increases (Table 2, page 13, Appendix I: Figure 15d, page 65, and Table 10, page 67). The decline of the Small Heath is of particular concern because most monitored sites where this butterfly occurs are on nature reserves and it seems likely that the butterfly will have suffered a more serious decline in the wider countryside. The causes of this decline are as yet unknown.

Large Heath: This butterfly was recorded on seven transects in 2000 but comparisons were only possible for three and of these only **Whixal** (a) recorded reasonable numbers. Here there was an increase in the count from 36 to 45. Double figures are usually recorded at four sites: **Roudsea Wood** (Cumbria), **Thorne Moors** (Lincolnshire), and on the two **Whixal** transects (Shropshire / Powys border).

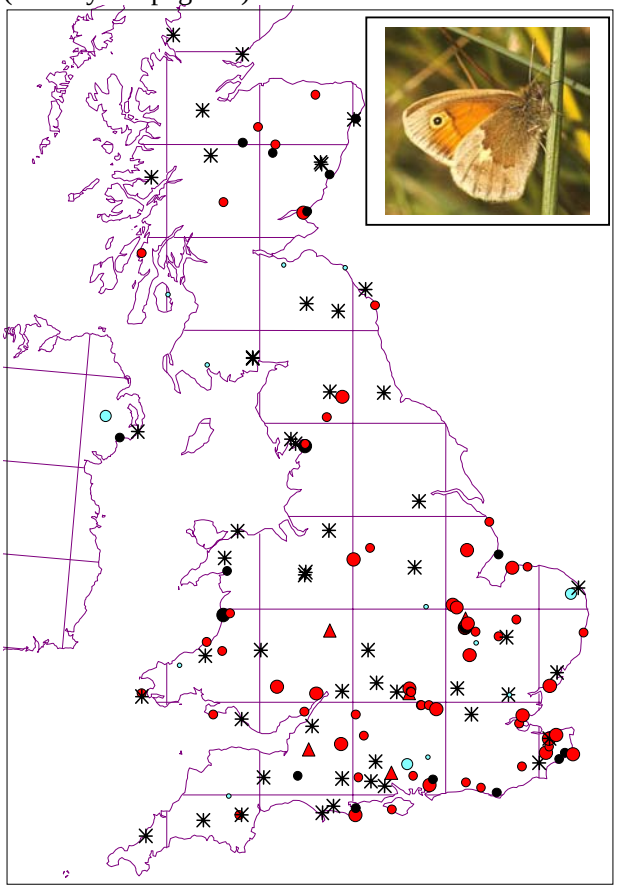


Ringlet: After last years highest collated index of the series, another increase in the collated index (>20%) taking this to the ***highest of the series***. There were increases at nearly two thirds of the 58 transects for which comparisons were possible. There have been significant increases on many transects over the monitoring period (Map 19).

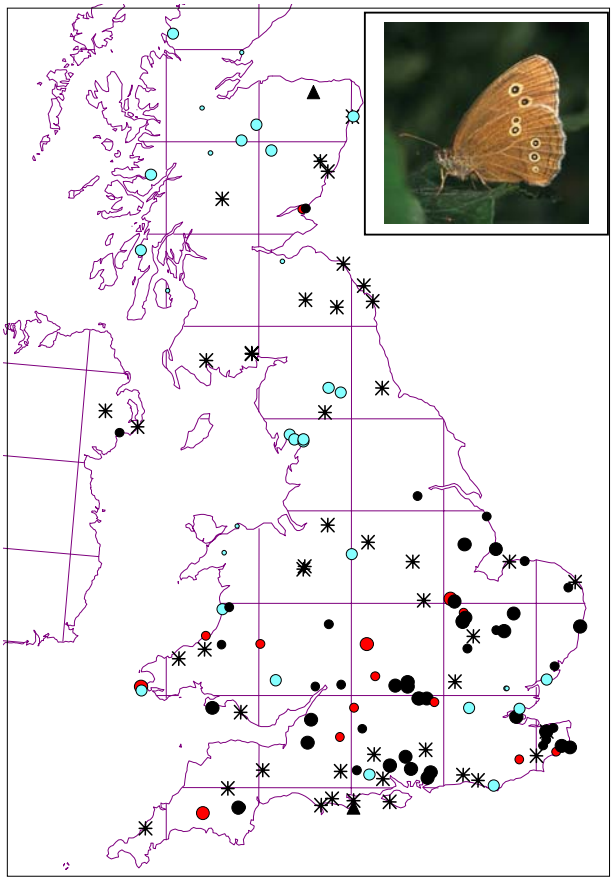
The largest count was at **RSPB Blean Woods** (formerly Church Wood) in Kent where numbers have been steadily increasing over the years.



Map 18. Small Heath on BMS transects.
(For key see page 30).



Map 19. Ringlet on BMS transects.
(For key see page 30).



7 MIGRANT BUTTERFLIES IN 2000

7.1 BUMPER CLOUDED YELLOW YEAR

Judging by the BMS transect counts, the year 2000 saw the biggest migration of the Clouded Yellow to the UK since 1983, which itself probably had the highest numbers seen in the UK since 1947 (see 1983 BMS Report to Recorders and Pollard and Yates, 1983). This butterfly is normally unable to survive the British winter in any of its life stages and its presence here depends on immigration from southern Europe or Africa each spring. However, there is at least one recent instance where this species has been recorded overwintering as larvae in Britain and subsequently appearing as adults in the spring (Skelton 1999).

The first Clouded Yellows recorded on transects were seen in week 11 (10th-16th June) of the BMS recording season. Singletons were recorded at Swanage (Ballard Down) (Dorset) and Alresford Farm (Hampshire) on 10th, Springhill Farm (Kent) on 11th, Lydden (Kent) on 13th and Castle Hill (East Sussex) on 16th June. The butterfly was then recorded weekly on transects through to the end of the recording season (Figure 10). However there continued to be reports of Clouded Yellows seen in suitable weather until the first week in November (http://groups.yahoo.com/group/uk-leps/). In 1983 the butterfly was first recorded on transects on 8th June, week 10 (Figure 9), at Swanage and Radipole Lake (Dorset) and in the Derbyshire Dales.

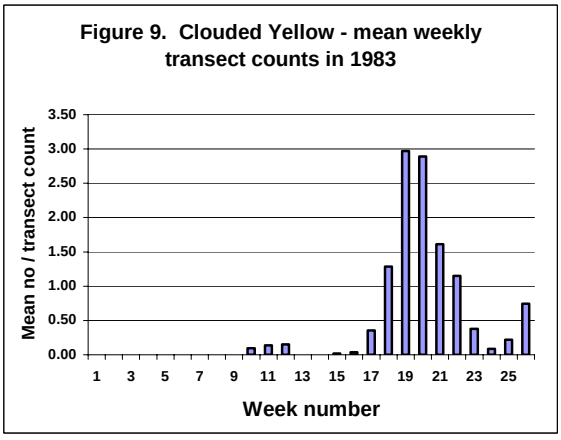


Figure 9. Clouded Yellow - mean weekly transect counts in 1983

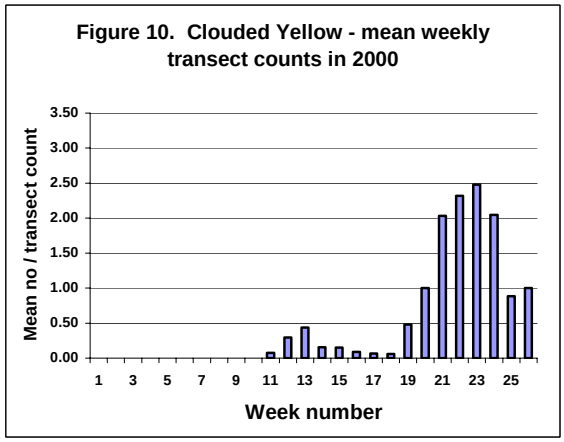


Figure 10. Clouded Yellow - mean weekly transect counts in 2000

Forty three of 61 transects that were walked in both 1983 and 2000 produced sufficient data for an annual index for the Clouded Yellow to be calculated in both years, though for three sites the index was zero in both years. For the remaining 18 transects there were too many gaps in the data for indices to be produced. Clouded Yellows were recorded on the remaining 40 transects in at least one of the two years, and 31 of these transects in both years (Figure 11).

The average number of Clouded Yellows recorded on the 40 transects was very similar for the two years, being slightly higher in 2000 (12.5) than in 1983 (11.5). One can conclude from this that numbers present in the UK in both years were very alike and if anything 2000 was a slightly better year.

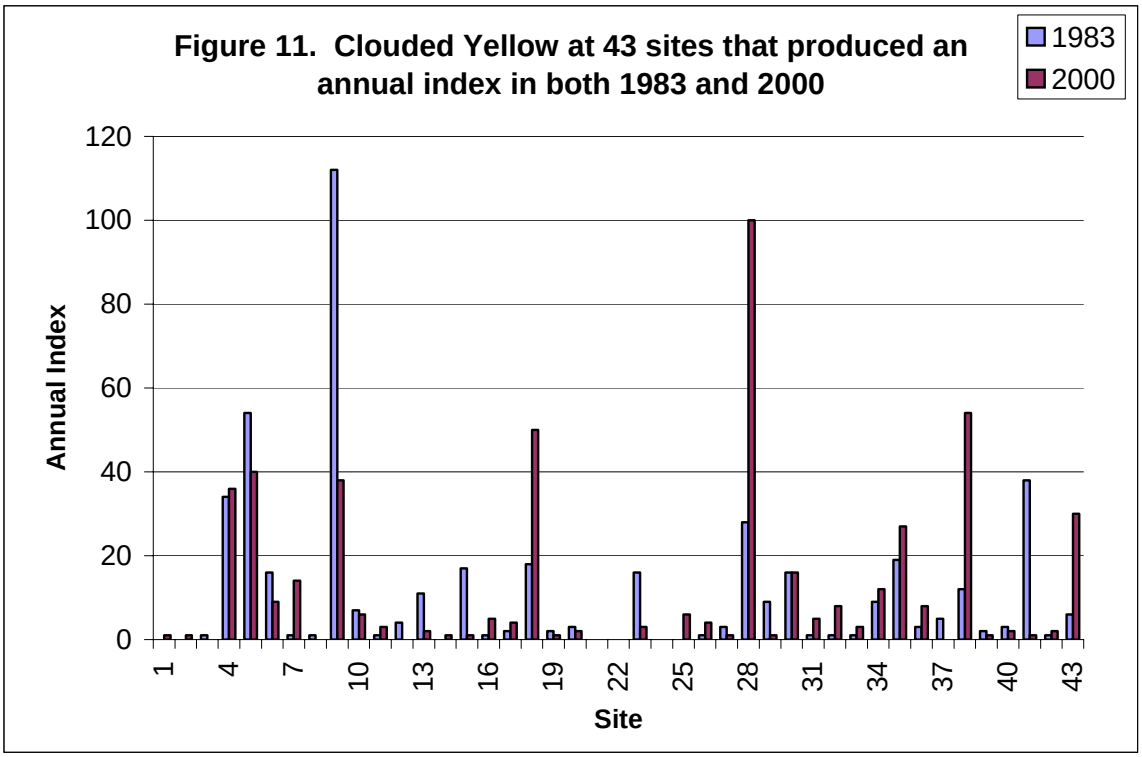


Figure 11. Clouded Yellow at 43 sites that produced an annual index in both 1983 and 2000
1983
2000
Annual Index
120
100
80
60
40
20
0
1
4
7
10
13
16
19
22
25
28
31
34
37
40
43
Site

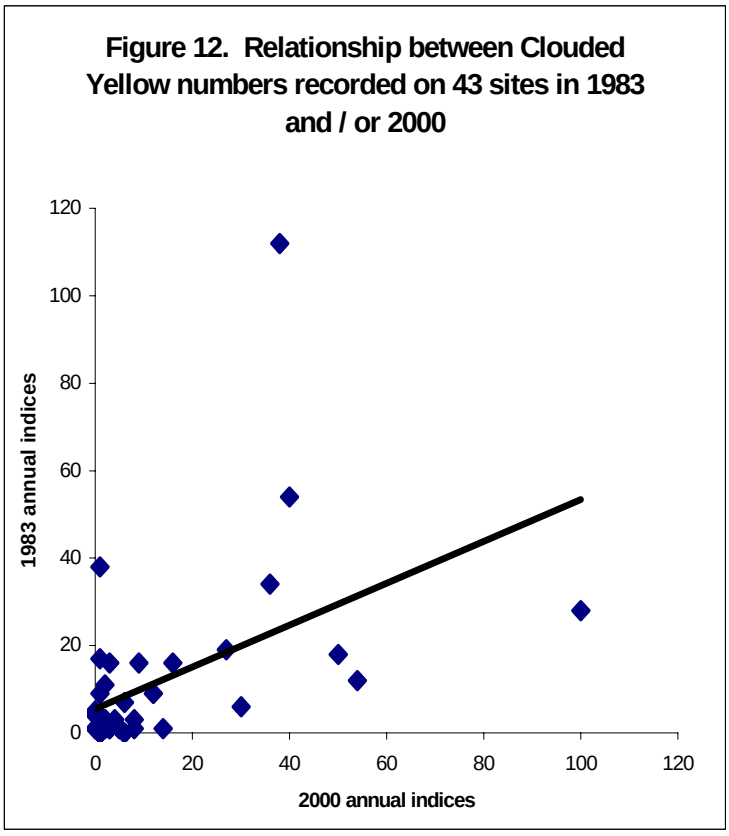
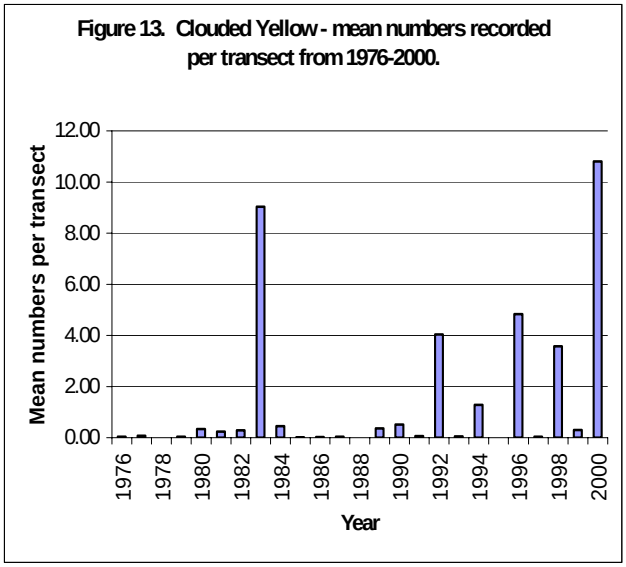


Figure 12. Relationship between Clouded Yellow numbers recorded on 43 sites in 1983 and / or 2000
1983 annual indices
120
100
80
60
40
20
0
0
20
40
60
80
100
120
2000 annual indices



BMS data also indicates that there has been a general increase in numbers of Clouded Yellows reaching and breeding in the UK over the last decade with higher numbers being recorded every other year for five of the last 10 years (Figure 13).

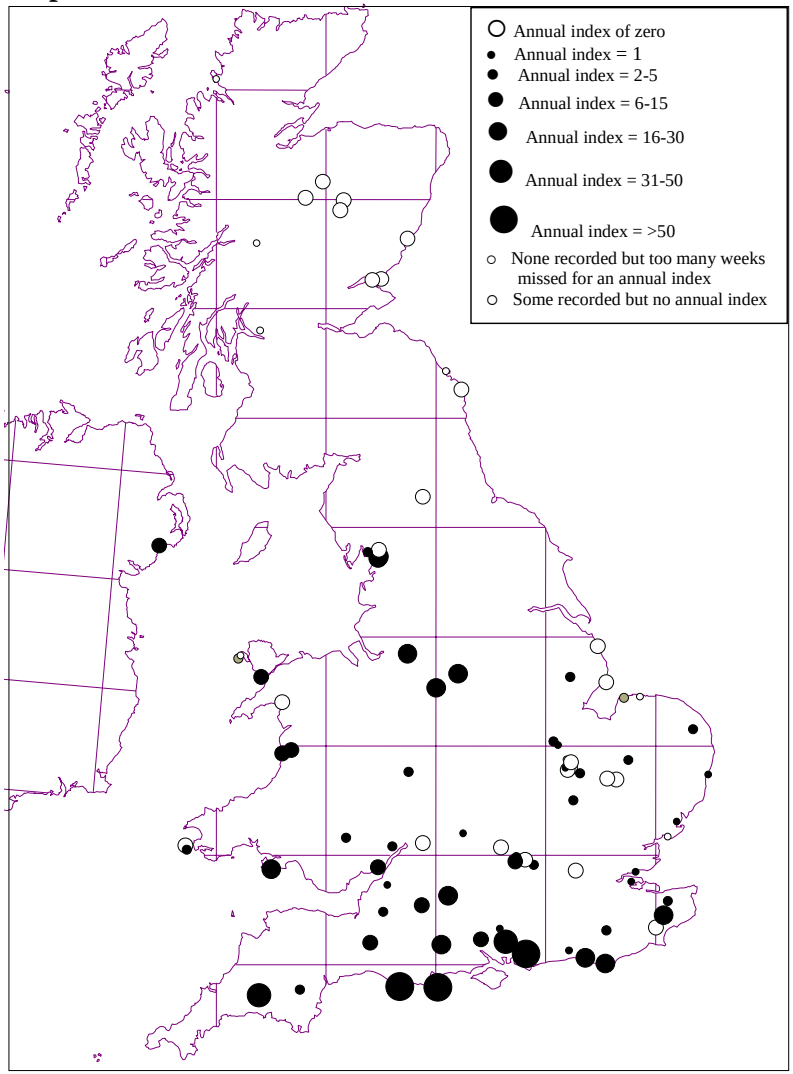
As in 1983, and as to be expected, most of the biggest counts were in the south of England, especially towards the south coast, though in both years there were some larger counts in the midlands and in Wales (Maps 20 & 21). In 2000 the butterfly was recorded farther north than in 1983 and was recorded on transects in southern Scotland and at Taynish on the west coast and Northumberland in the east, however there were fewer sites in this region in 1983.

There are just three BMS transects in Northern Ireland and although it was recorded on two of these, there was sufficient data for an annual index at only one site (Murlough) where 12 were recorded. However there were many Clouded Yellows seen throughout Northern Ireland with up to 60 being seen at any one location on any one day (Ian Rippey *pers. comm.*). 1992 was also a relatively good year for Clouded Yellows in the UK (Figure 13), but judging by reports was better in Northern Ireland than in the rest of the UK and may have been better there than 2000 (Ian Rippey *pers. comm.*).

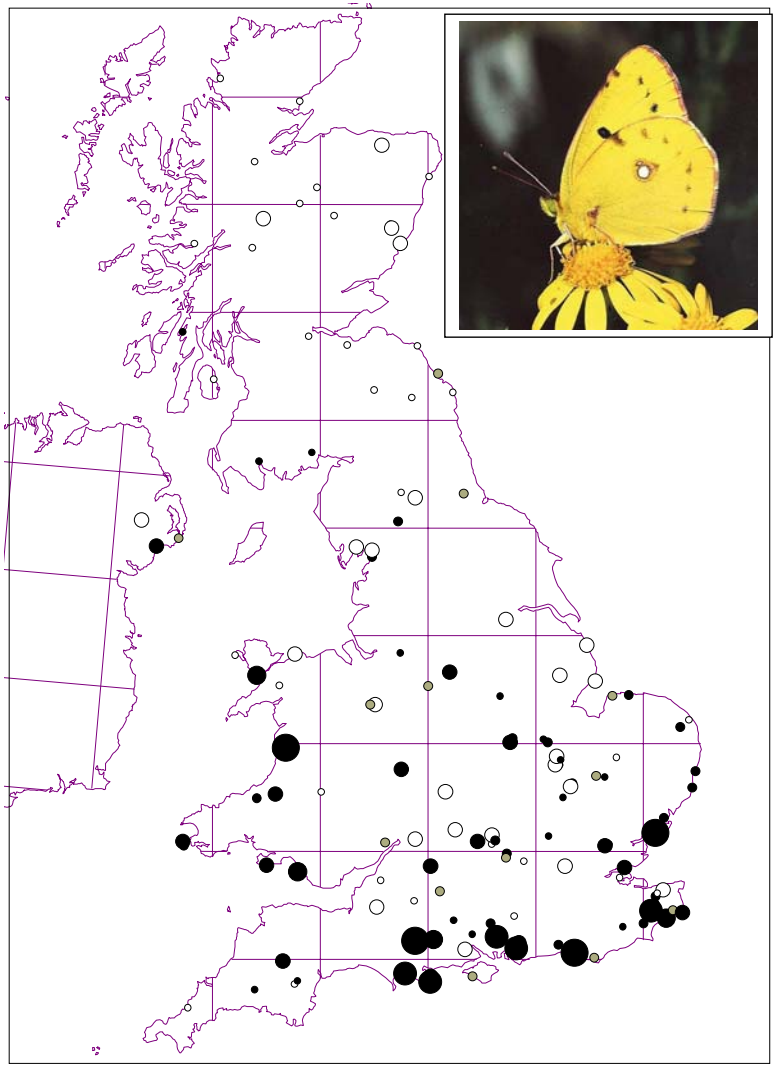
In 1983 data from the BMS suggested that the geographical spread of the initial immigrants largely determined the distribution of the second generation, i.e. there was no further spread northwards by the second generation butterflies (Pollard *et al* 1984)(Maps 20 & 22). This was probably also the case in 2000, however Clouded Yellows were recorded on transects further north in 2000, with immigrants being recorded as far north as Lindisfarne on the Northumberland coast (Map 23). There are relatively few sites north of this and numbers of immigrants reaching this far north were probably small. A single second generation Clouded Yellow was recorded a little further north at Taynish on the west coast of Scotland (Map 21).

Apart from on transects, immigrant and second generation Clouded Yellows were recorded further north in 2000. There were several June and September records north of Oban in the west of Scotland as far north as Skye (June 19th) and on the east side at Loch Fleet (27th Jun and 15th July) on the north side of the Moray Firth, though none were recorded on the transect there. There were also several records for June and September further south in the Moray firth area (David Barbour *pers. comm.*). The very small numbers present compared with further south in England probably explains why none were picked up on the more northern transects.

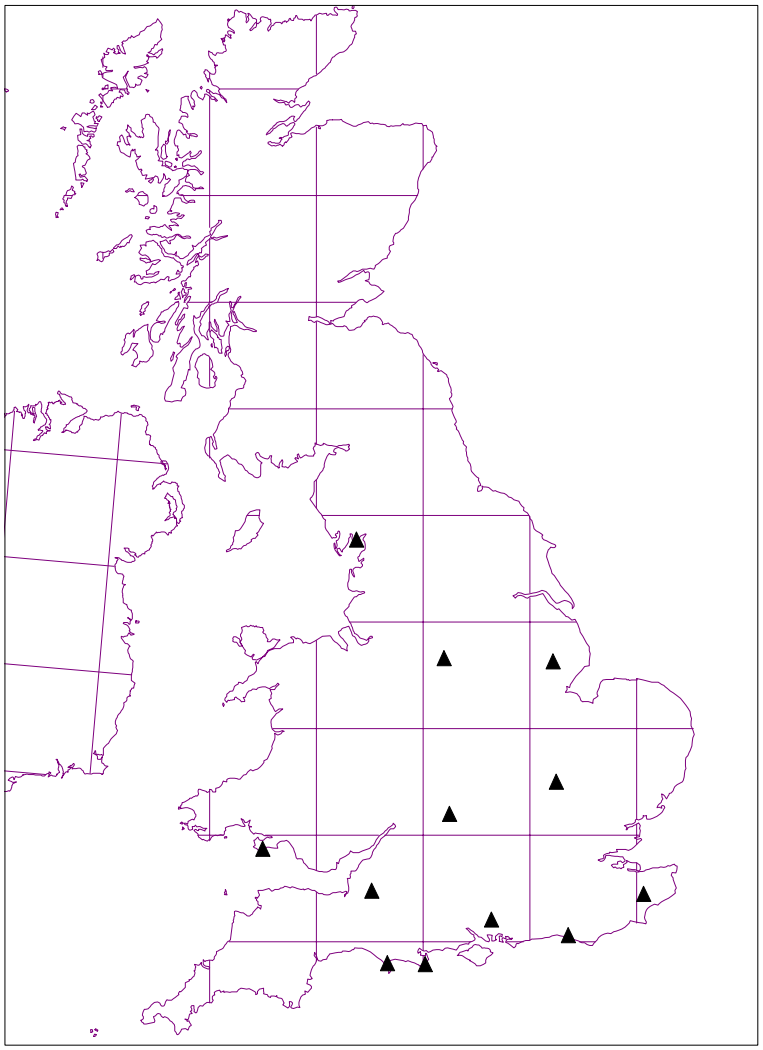
Map 20. Clouded Yellow on BMS transects in 1983



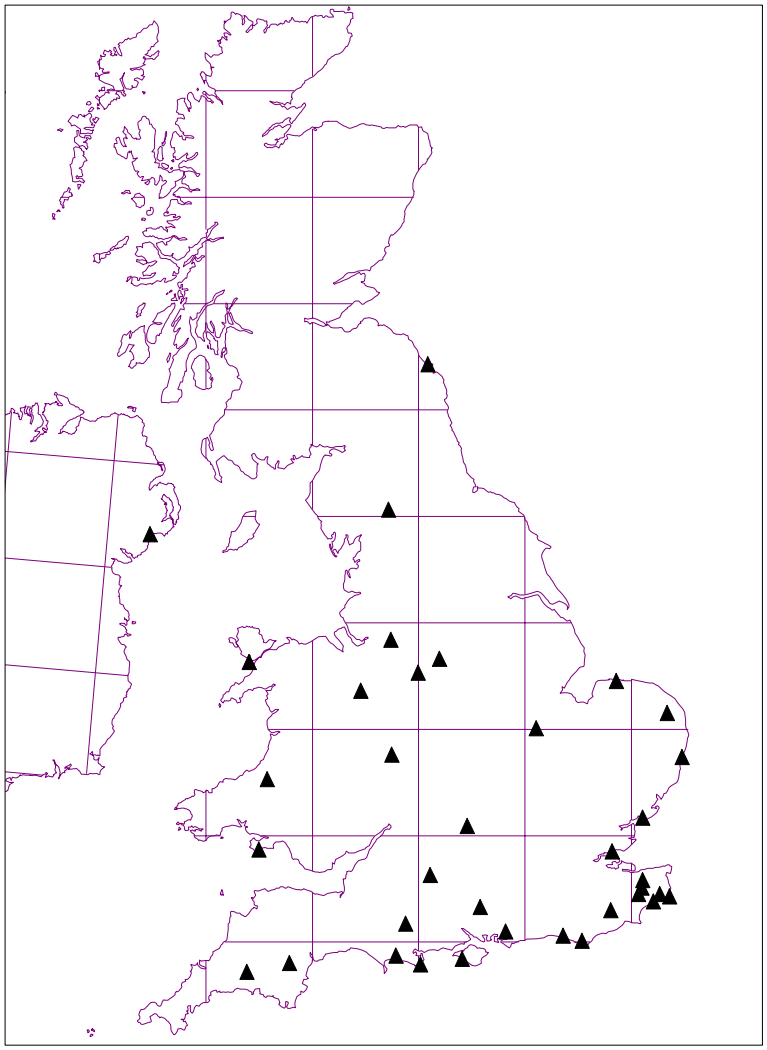
Map 21. Clouded Yellow on BMS transects in 2000



Map 22. Transects where Clouded Yellows were recorded during the initial immigration period in June 1983.



Map 23. Transects where Clouded Yellows were recorded during the initial immigration period in June 2000.

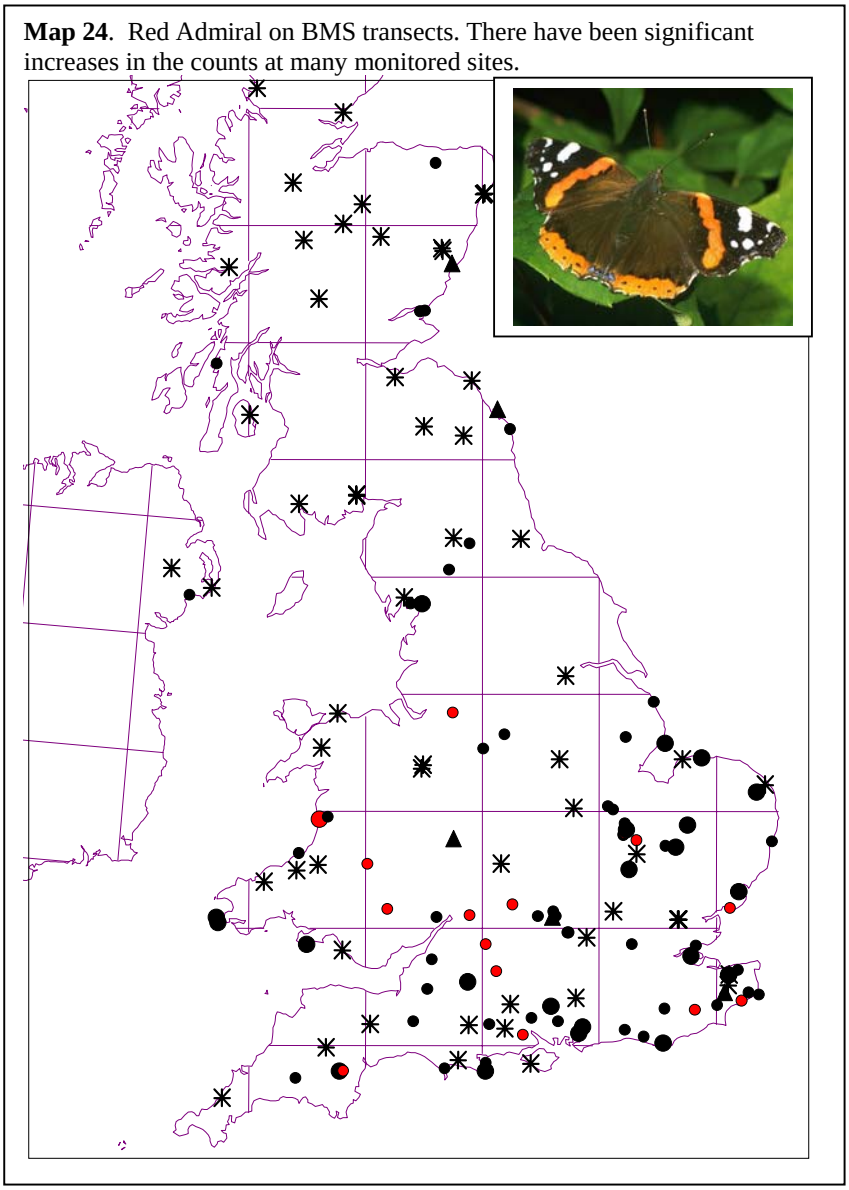


7.2 GOOD YEAR FOR THE RED ADMIRAL

The collated index for the Red Admiral increased by just over 50% making this the fifth highest collated index of the series. The collated index trend has shown a significant increase over the monitoring period (Appendix I: Figure 15c, page 64 and Table 10, page 67) and there have been significant increases in the counts on many transects (Map 24).

Pollard & Greatorex-Davies (1998) examined the BMS data from 1976-1996 for this species for evidence for one or more of three possible causes for this increase in Britain: 1). Greater breeding success; 2). Improved overwintering success; 3). Increased immigration. The following conclusions from the data were made. Trends during most of the season were similar to those of immigrant or overwintered individuals in the spring and so the evidence does not support greater breeding success in Britain. Abundance in the spring was not correlated with abundance the previous autumn, when trend was taken into account, and so it seemed unlikely that overwintering in Britain was important. Thus the increase in abundance was probably due to increased immigration.

Map 24. Red Admiral on BMS transects. There have been significant increases in the counts at many monitored sites.

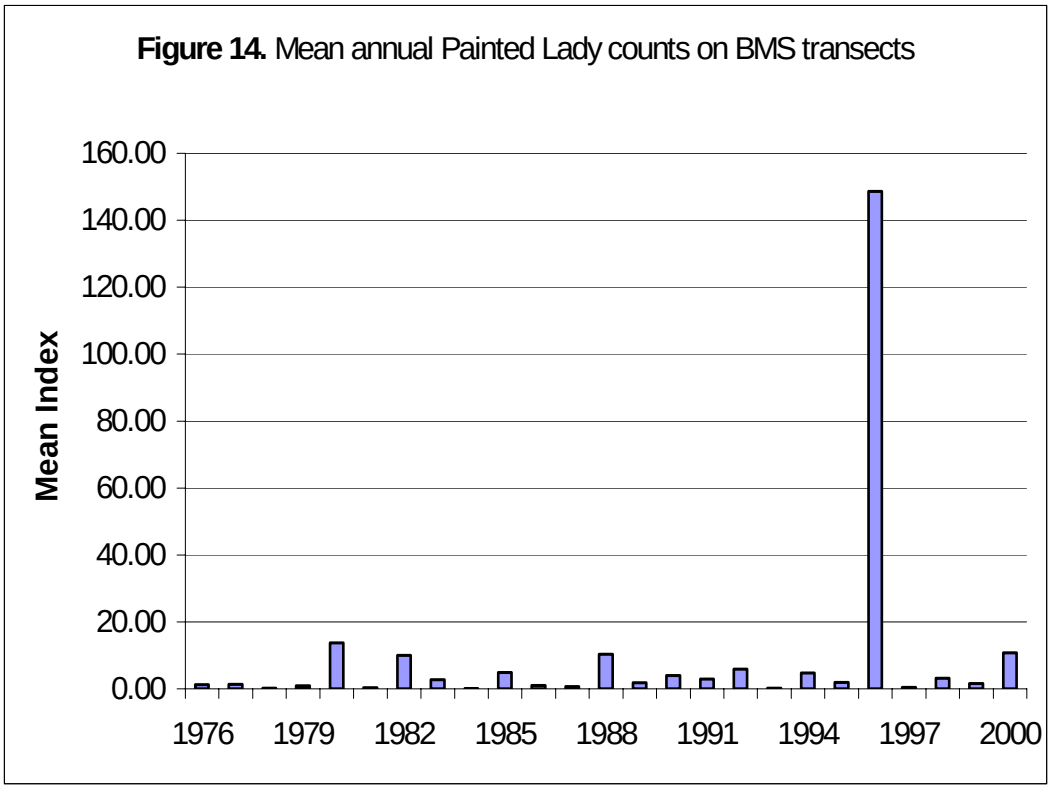


7.3 SECOND BEST YEAR FOR THE PAINTED LADY.

The butterfly produced its second highest index of the series (Appendix I: Figure 15e page 79), but numbers were still small compared with the exceptional year of 1996 when more than ten times as many butterflies were recorded per transect (Figure 14).

It will be noted from Figure 14 that the mean numbers of butterflies recorded on transects in 1980 was higher than in 2000 but that the collated index is higher for 2000 (Appendix I: Figure 15e, page 79). But this is probably because the mean figures shown in the histogram are not from all the same sites each year. Some of those sites monitored in 1980 are no longer in the BMS and many new sites have joined the scheme since then. In addition not all sites have sufficient data for an annual index in every year. Like is not being compared with like. The chaining method that is used to calculate the collated index gives a more accurate comparison of the years because it is looking at the ratio of change between sites producing indices in both of any pair of years. However we have included the histogram because it gives a good visual impression of just how abundant the Painted Lady was in 2000 compared with other years and what an extraordinary year it was for this species.

Figure 14. Mean annual Painted Lady counts on BMS transects



8 PUBLICATIONS USING BMS DATA

8.1 PUBLICATIONS IN 2000/2001

Asher, J., Warren, M. Fox, R., Harding, P., Jeffcoate, G. & Jeffcoate, S. (2001*). The Millennium Atlas of Butterflies in Great Britain and Ireland.* Oxford University Press.

Cowley, M.J.R., Thomas, C.D., Roy, D.B., Bulman, C.R., Wilson, R.J., León-Cortés, J.L., Gutiérrez, D., Quinn, R.M., Moss, D., & Gaston, K.J. (2001) Density-distribution relationships in British butterflies. I. The effect of mobility and spatial scale. *Journal of Animal Ecology*, **70,** 410-425.

Fox, R., Warren, M.S., Harding, P.T., McLean, I.F.G., Asher, J., & Roy, D. (2001). *The State of Britain's Butterflies*. Butterfly Conservation, CEH and JNCC, Wareham.

Roy, D.B., Rothery, P., Moss, D., Pollard, E., & Thomas, J.A. (2001) Butterfly numbers and weather: predicting historical trends in abundance and the future effects of climate change. *Journal of Animal Ecology*, **70**, 201-217.

Sparks, T.H., Roy, D.B., & Mason, C.F. (2000) Phenology in Essex: lessons from the past and examples of recent trends. *Essex Naturalist*, **17,** 31-37.

8.2 PUBLICATIONS DUE IN 2001/2002

Rothery, P. & Roy, D.B. (in press) Application of generalized additive models to butterfly transect count data. *Journal of Applied Statistics*.

Shreeve, T., Dennis, R.L.H., Roy, D.B., & Moss, D. (in press) An ecological classification of British butterflies: ecological attributes and biotope occupancy. *Journal of Insect Conservation.*

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Menzel, A. & Fabian, P. (1999) Growing season extended in Europe. *Nature*, **397,** 659.

Moss, D. & Pollard, E. (1993). Calculation of collated indices of abundance of butterflies, based on monitored sites. *Ecological Entomology*, **18, 77-83.**

Pollard, E. (1979). A national scheme for monitoring the abundance of butterflies. *Proceedings & Transactions of the British Entomological & Natural History Society. **12,** 77-90*

Pollard, E. (1991). Changes in the flight period for the Hedge Brown butterfly *Pyronia tithonus* during range expansion. *Journal of Animal Ecology* **60,** 737-748.

Pollard, E.P. & Greatorex-Davies, J.N. (1997). Flight periods of the Small Heath butterfly, *Coenonympha pamphilus* (Linnaeus) (Lepidoptera: Nymphlidae, Satyrinae) on chalk downs and in woodland in southern England. *Entomologist's Gazette*. **48,** 3-7.

Pollard, E.P. & Greatorex-Davies, J.N. (1998). Increased abundance of the Red Admiral *Vanessa atalanta* in Britain: the roles of immigration, overwintering and brteeding within the country. *Ecology Letters*. **1,** 77-81.

Pollard, E.P., Greatorex-Davies, J.N. & Thomas, J.A. (1997). Drought reduces breeding dsuccess of the butterfly *Aglais urticae*. *Ecological Entomology*. **22,** 315-318.

Pollard, E.P., Hall, M.L. & Bibby, T.J. (1984). The Clouded Yellow migration of 1983. *Entomologist's Gazette*. **35,** 227-231.

Pollard, E.P. & Yates, T.J. (1993) *Monitoring butterflies for ecology and conservation; The British Butterfly Monitoring Scheme*. Chapman & Hall, London.. 274 pp.

Roy, D.B. & Sparks, T.H. (2000) Phenology of British butterflies and climate change. *Global Change Biology*, **6,** 407-416.

Shreeve, T.G. (1989). The extended flight period of *Maniola jurtina* (Lepidoptera, Satyridae) on chalk downland: seasonal changes in the adult phenotype and evidence for a population of mixed origins. *Entomologist* **108,** 202-215.

Skelton, M. J. (1999). Successful overwintering by Clouded Yellow *Colias croceus* (Geoff.) in southern England. *Atropos,* **8,** 3-6.

Sparks, T. & Crick, H. (1999) The times they are a-changing? *Bird Conservation International*, **9,** 1-7.

10 ACKNOWLEDGEMENTS

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We particularly wish to express our gratitude to all the recorders and site managers who make the BMS possible through their enthusiasm and commitment to recording their transects as part of the scheme. We would especially like to thank Val Burton for all her willing hard work during the autumn months processing the incoming data and inputting it onto computer. We would also like to thank Tim Sparks and Peter Rothery for their statistical help and advice. The map showing the distribution of monitored sites was constructed using Alan Morton's DMAP programme. We thank Ernie Pollard for his continued help and advice at various times throughout the year, and Butterfly Conservation for providing multiple copies of Transect Walker for use by BMS recorders. Butterfly photographs are by Nick Greatorex-Davies except the Peacock (page 39), Large and Small Whites (pages 30 and 31) and Clouded Yellow (page 50). These photographs were taken by Eddie John and are used by permission. Finally we would like to thank Carl Thompson and his team at the Joint Reprographic Services Unit at the Natural Environment Research Council's headquarters in Swindon for producing this report for us again this year.

APPENDIX I

COLLATED INDICES GRAPHS FOR 34 SPECIES, 1976-2000

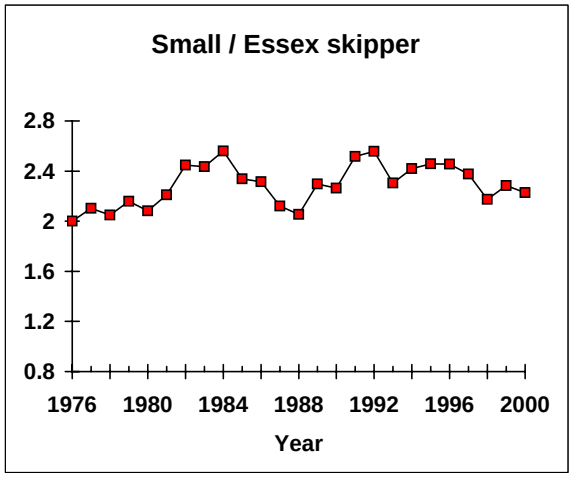
Figures 15a-e. The graphs on the following pages show fluctuations in the national collated (all sites) index values for all species for which this figure is calculated. These collated indices are derived from the site annual indices (see footnote on page 20) using the method of Moss and Pollard (1993). For species for which two separate indices are produced, the second is shown here.

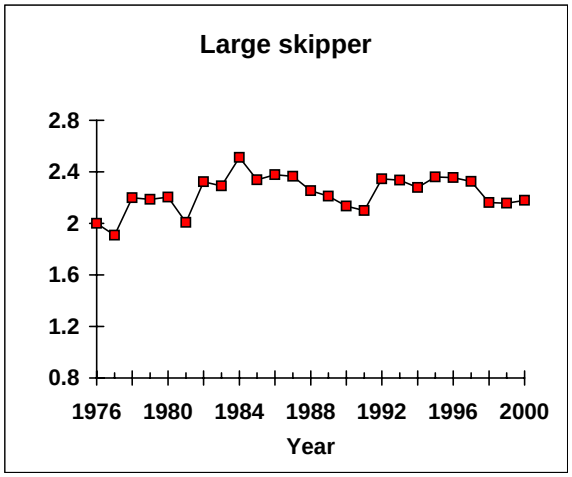
Graphs should be interpreted with caution for species which produce, or have produced, collated indices from relatively few sites, notably, Common Blue (northern, univoltine), Chalkhill Blue, White Admiral, Small Pearl-bordered Fritillary, Pearl-bordered Fritillary and Silver-washed Fritillary. The Brown Argus is now recorded on many transects and despite possible identification problems (especially confusion with brown Common Blue females), we consider that the collated index for this species has become increasingly reliable in recent years. All figures are of logged values and the same scale so that visual comparisons can be made.

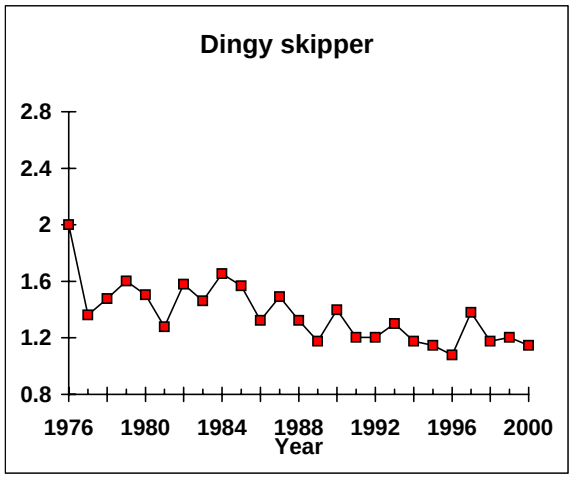
In the cases of the Holly Blue and the Painted Lady, the fluctuations in the "all sites" indices are somewhat greater than for other species. These are shown together on a separate figure (15e on page 75) so that they can be drawn at the same scale as the rest.

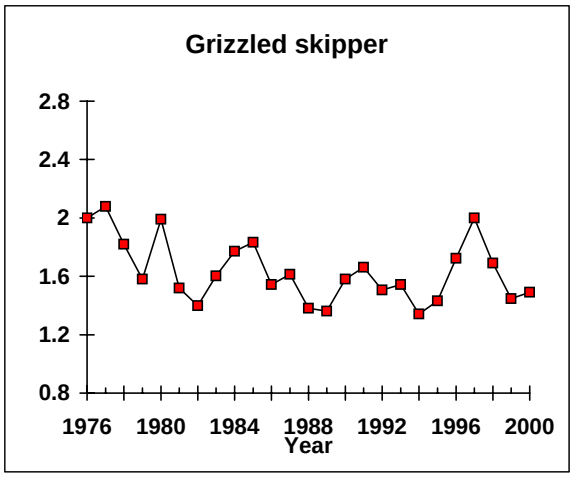
Please note that these figures are for information only and should not be quoted or used in any way without prior permission from CEH.

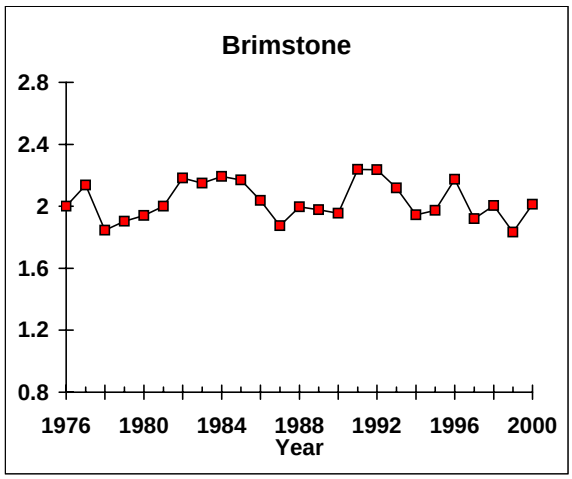
Figure 15a. Log collated indices 1976-2000

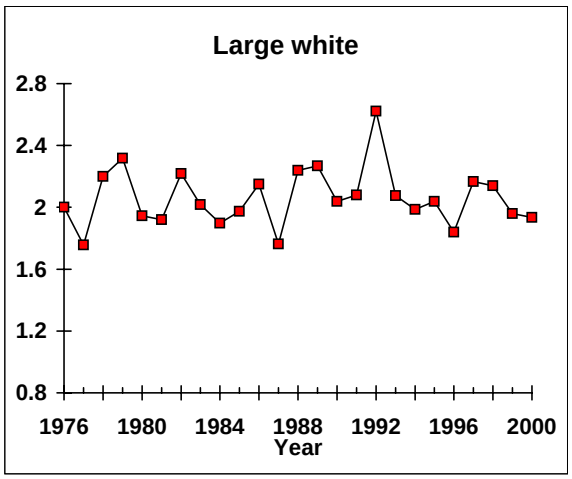


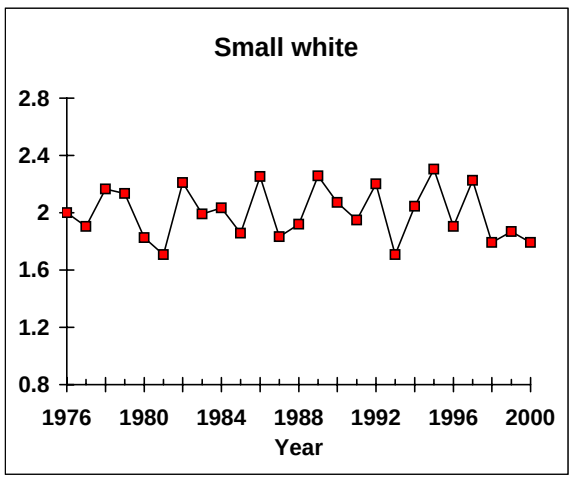












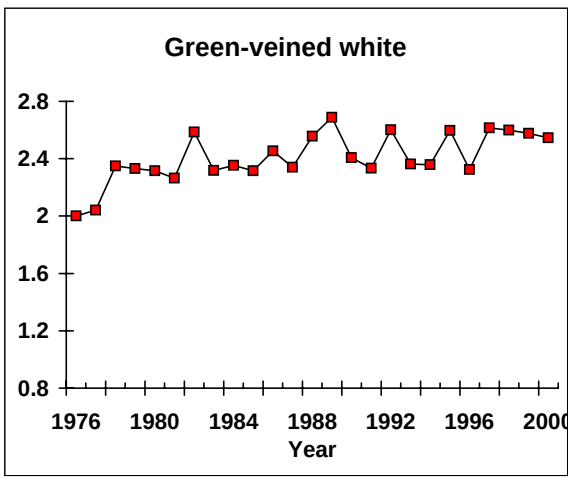
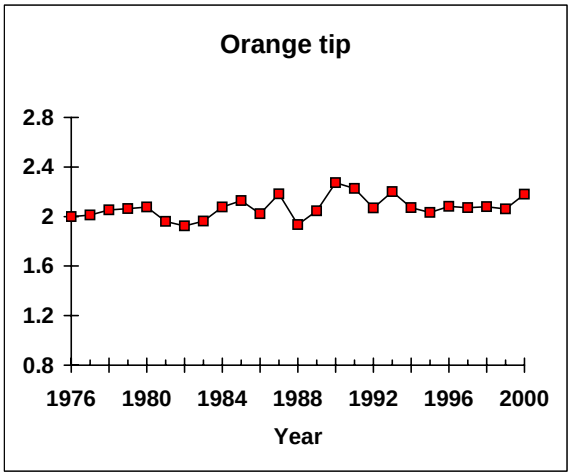
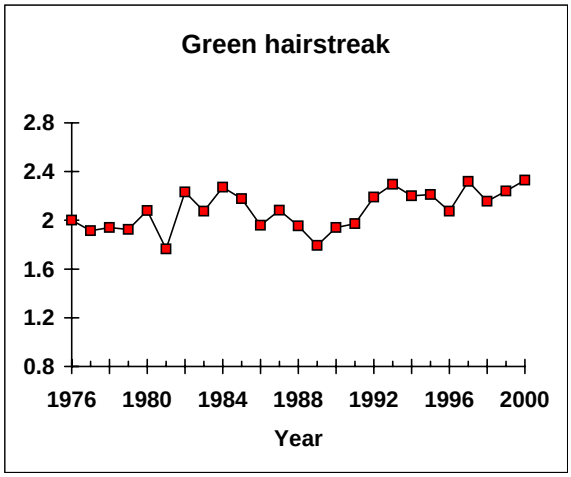
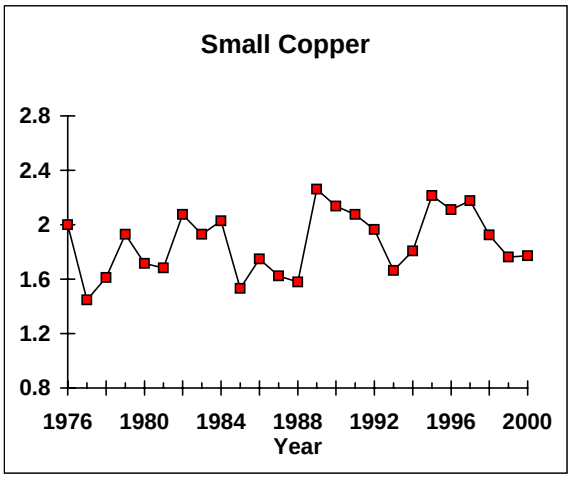
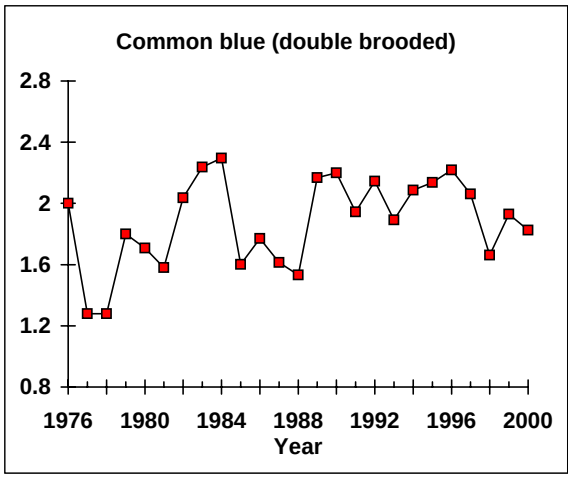


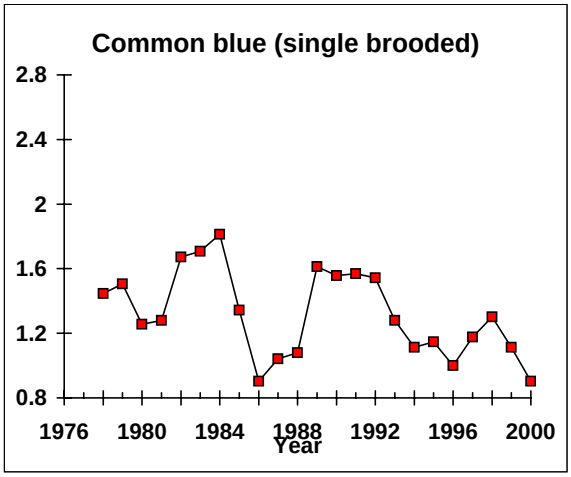
Figure 15b. Log collated indices 1976-2000

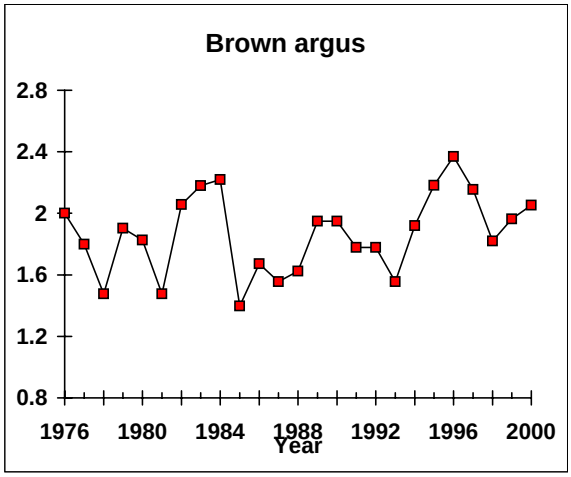


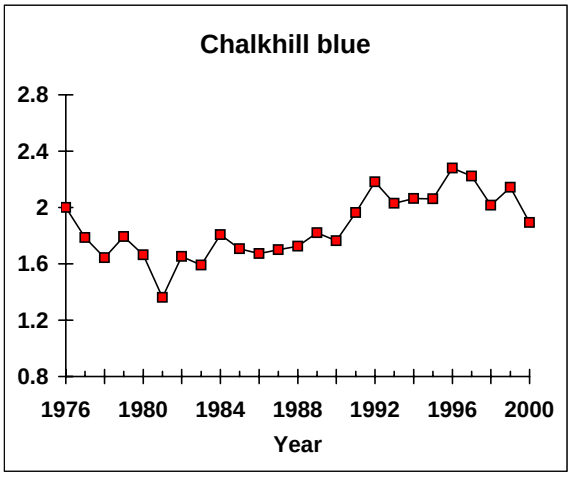












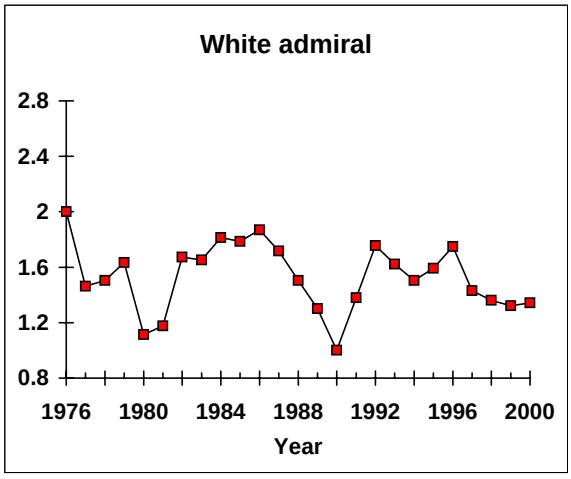
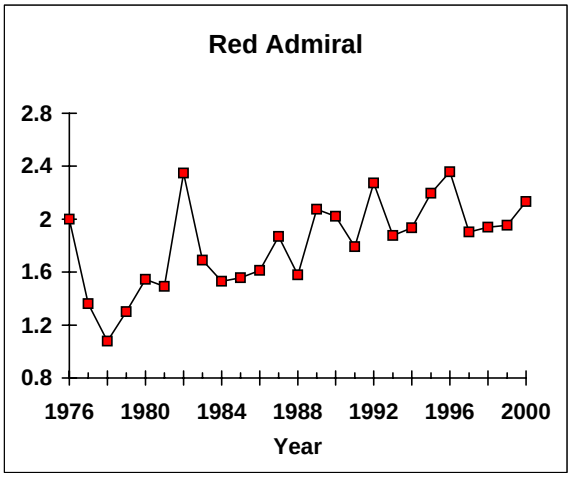
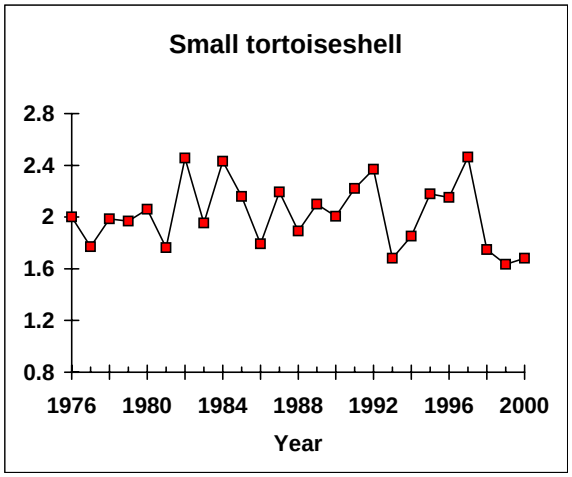
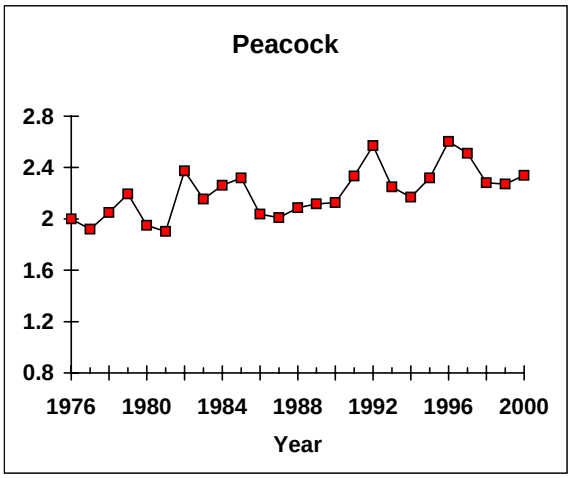
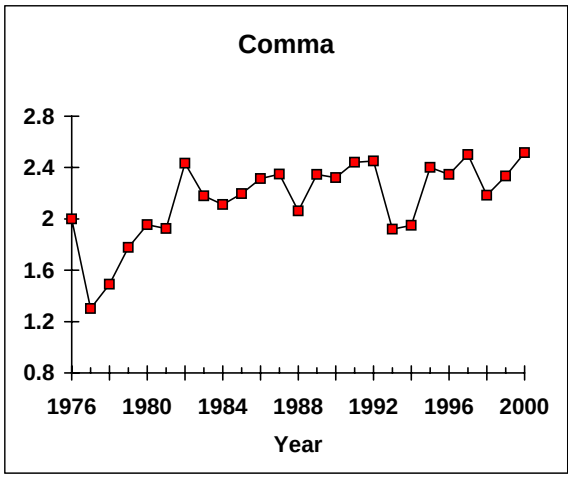


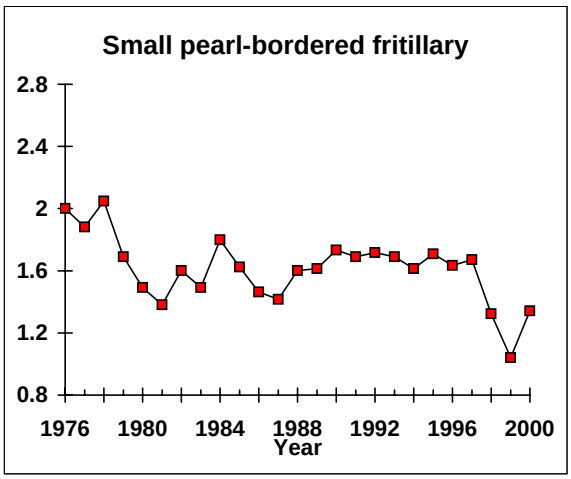
Figure 15c. Log collated indices 1976-2000

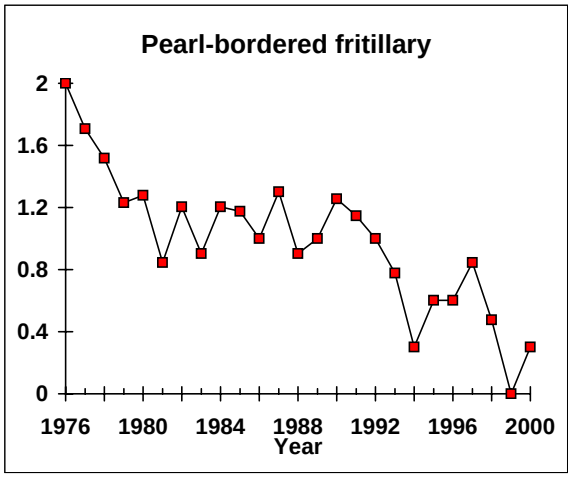


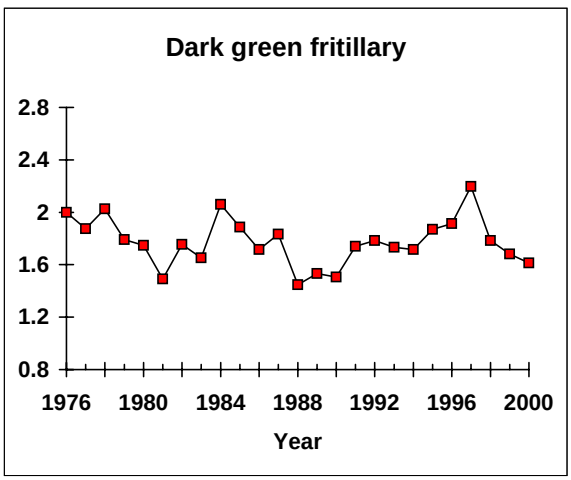












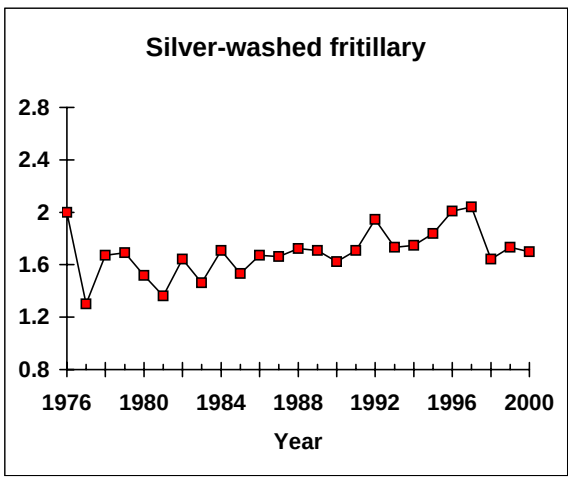
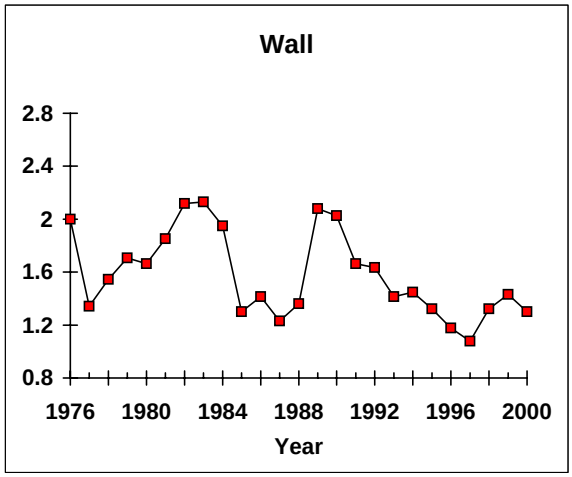
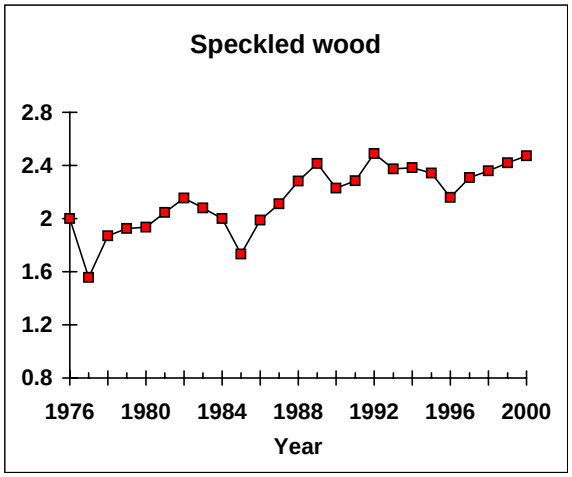
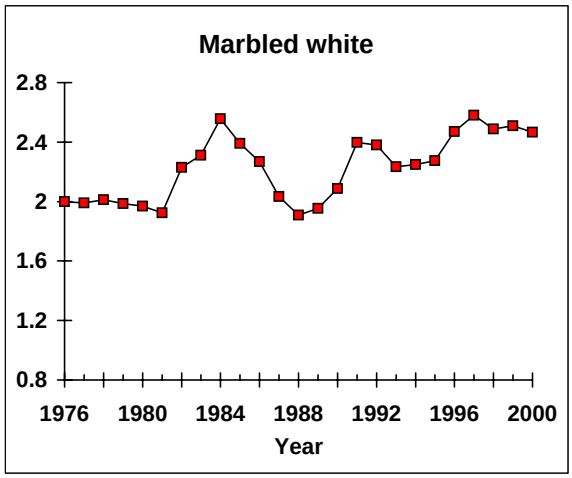
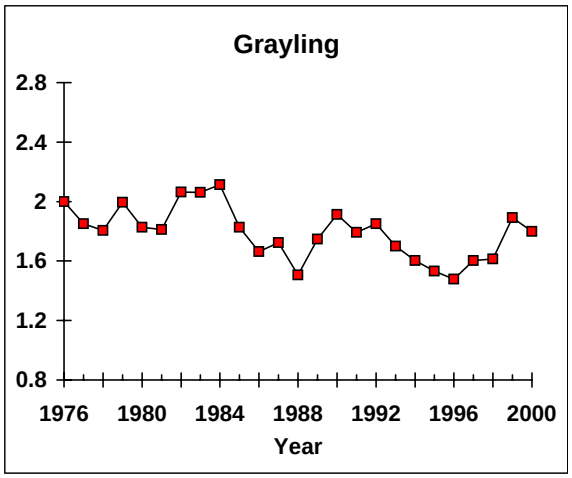


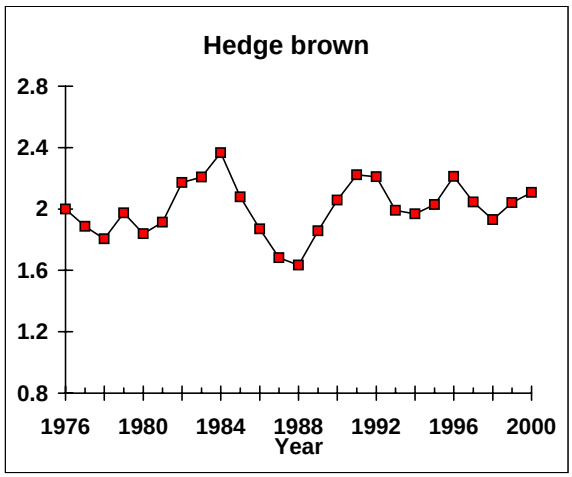
Figure 15d. Log collated indices 1976-2000

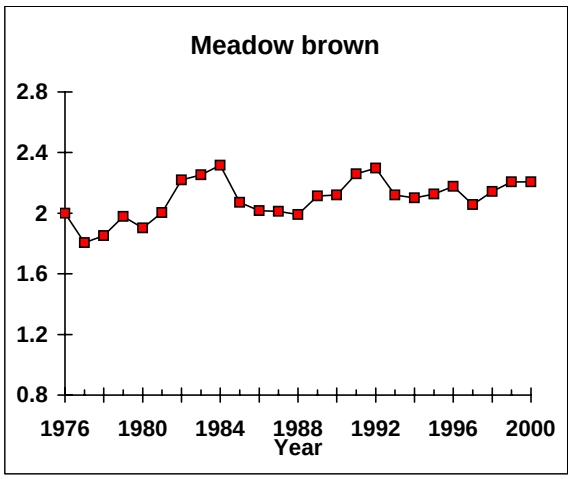


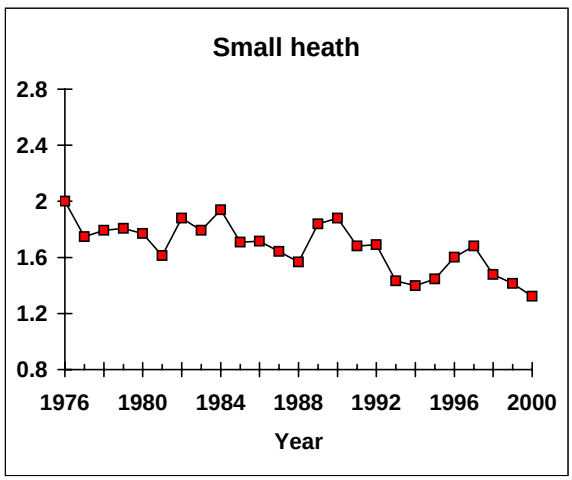












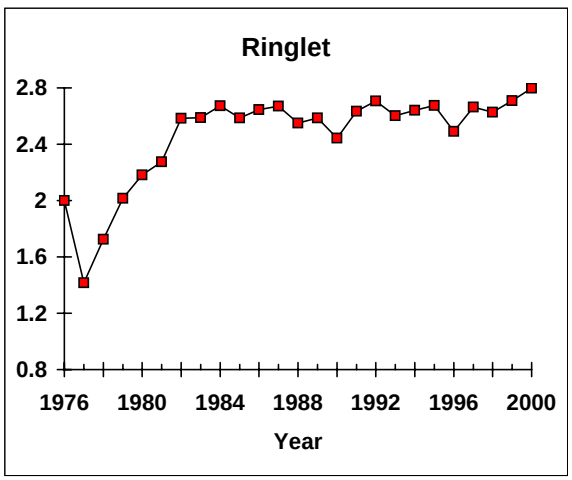
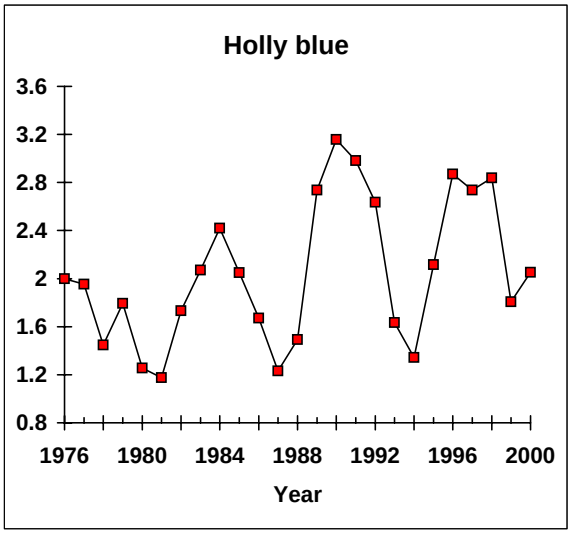
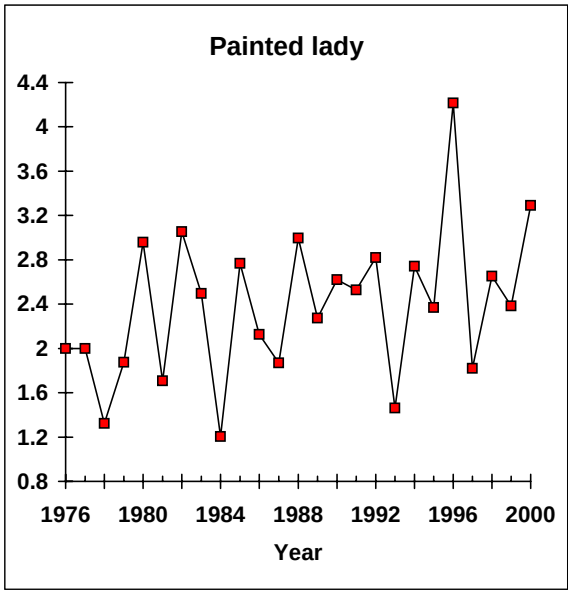


Figure 15e. Log collated indices 1976-2000





APPENDIX II

PHENOLOGY OF BRITISH BUTTERFLIES AND CLIMATE CHANGE

Summary of the paper: **Roy, D.B. & Sparks, T.H.** (2000) Phenology of British butterflies and climate change. *Global Change Biology*, **6,** 407-416.

Introduction

With increasing evidence for human-induced global climate change, phenology [1] has taken on greater importance as an indicator of species' response to the changing environment. In order to predict future responses of species to a changed climate, we first need to discover how species have responded to climate in the past. Several recent studies, covering a diverse range of taxonomic groups and biological event, have demonstrated strong relationships between phenological events and climate. For example, analyses of long-term datasets have shown earlier nesting and arrival from migration for birds, an extended growing season of plants across Europe and advanced flowering of plants. Yet, although invertebrates make up over 50% of the world's terrestrial biodiversity, datasets on their phenology are limited.

The Butterfly Monitoring Scheme data is perhaps the most reliable long time-series of change in population change available for any taxon of terrestrial invertebrate and have been frequently used to address important research questions. In addition, butterflies are excellent organisms for studying the effects of environmental change. As warmth-loving animals their activity is closely controlled by weather and many species are constrained by climate and reach their northern range limit in Britain. They are also fecund [2], have high dispersal ability and an annual or more frequent life cycle, so changes in abundance and distribution (as shown by the recent Butterflies for the New Millennium Atlas (Asher *et al* 2001)) can be detected over a relatively short time-scale. Butterflies are also an ideal group for phenological recording, as they are conspicuous and have a high public profile. Indeed, butterflies are a key group within a new National Phenological Recording Network (http://www.phenology.org.uk).

We have used the wealth of data on the flight-periods of butterflies in the BMS to examine the effects of climate on phenology. We have analysed 35 out of the total of 51 species covered by the scheme for the years 1976 to 1998. Species present in less than 20 years or with a mean of less than five sites recorded per year were excluded. Data for each species have been summarized for each year to provide simple parameters to describe flight-period characteristics. The following measures have been derived across all sites: mean first appearance date, mean peak appearance date and mean length of flight period. For individual species, the number of flight periods ranged from 115 for **Adonis Blue** to over 1700 for **Meadow Brown**. For these phenological measures, we have examined both the trend over time and the relationship with variation in climate.

Results

Between 1976 and 1998 central England spring temperature increased by approximately 1.5ºC and summer temperature by approximately 1ºC (Figure 1), even though 1976 was the warmest summer. Table 1 summarises trends in mean first appearance date, peak flight date and length of flight period over the same time period. The first appearance of most species (26 species) is

[1] Phenology: study of the timing of recurring natural phenomena – in this section butterfly flight periods.
[2] Fecund: producing, or having the potential to produce a large number of offspring.

earlier in recent years. This relationship is significant for 13 species, most notably **Orange Tip**, **Red Admiral** and **Comma** (Figure 2) where appearance has advanced by 17.5, 36.3 and 30 days respectively over the period 1976 to 1998. Mean peak appearance is also earlier in recent years for most species (27 species), but the relationship is significant for only three species, e.g**. Green Hairstreak** (10.8 days earlier, Figure 3). Twelve species have a significant relationship with mean flight period length over time, e.g. **Large Skipper** (10.1 days longer, Figure 4). With the exception of grayling, this relationship is for a longer flight period in later years. The most marked increase in duration of flight period over the period 1976 to 1998 are for **Red Admiral** (39.8 days), **Green-veined White** (23.5 days), **Adonis Blue** (30.6 days) and **Comma** (30.1 days).

For almost all species, we found a highly significant relationship with weather of both first appearance date and peak flight date. For almost all species temperature had a negative effect; warmer weather tended to produce earlier first and peak appearance. The most striking result is that many species showed earlier first and peak appearance with warm spring temperature (e.g. **Orange Tip**, Figure 5a), or with summer temperature (e.g. **Meadow Brown**, Figure 5b). Table 2 gives the predicted change in appearance dates per 1°C change in temperature; most models suggest that such a rise in temperature could advance both mean first and peak appearance by 2-10 days.

Figure 1. Time trends in spring and summer Central England Temperature (CET), 1976-1998. Open circles are spring temperatures (mean February-April CET) and solid circles are summer temperatures (mean May-July CET).

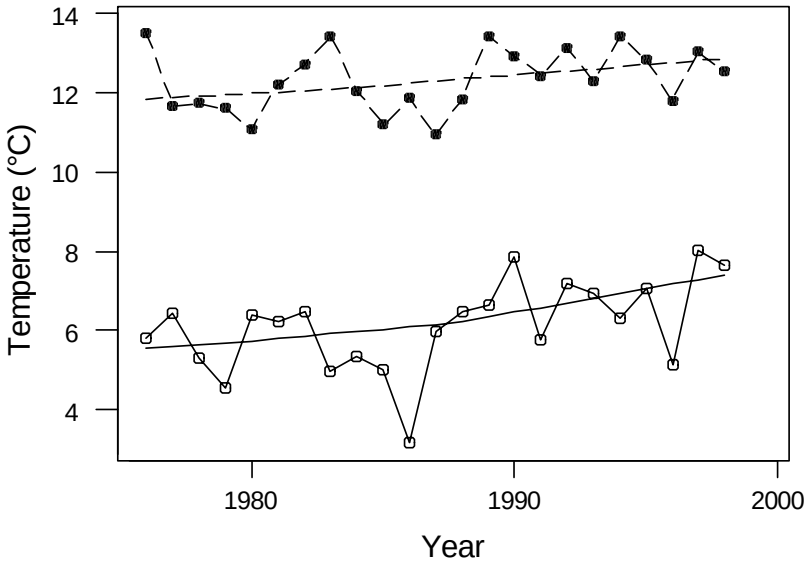


Table 1. Trends over time (1976-1998) for mean first appearance, peak flight date and length of flight period. Arrows indicate direction and significance of change over time, i.e. down arrow for mean first appearance date indicates earlier appearance over time. Change per decade are given as number of days. Significance levels of trend (↓ not significant, ↓↓ 5% level, ↓↓↓ 1%, ↓↓↓↓ 0.1%).

		Mean first appearance date		Mean peak appearance date		Mean length of flight period	
			Change 10 yr		Change 10 yr		Change 10 yr
a) species with one flight period each year							
Thymelicus sylvestris (Poda.)	Small Skipper	↓	-1.4	↓	-1.6	↓	-0.9
Ochlodes venata (Br. & Grey)	Large Skipper	↓	-3.7	↓	-2.3	↑↑↑	4.4
Erynnis tages (L.)	Dingy Skipper	↓↓	-5.1	↓	-3.4	↑↑	4.3
Pyrgus malvae (L.)	Grizzled Skipper	↓↓↓	-6.0	↓	-4.4	↑	3.4
Anthocharis cardamines (L.)	Orange Tip	↓↓↓↓	-7.6	↓↓↓	-7.0	↑	1.2
Callophrys rubi (L.)	Green Hairstreak	↓↓	-4.3	↓↓	-4.7	↓	-0.2
Quercusia quercus (L.)	Purple Hairstreak	↓	-1.7	↓	-3.8	↓	-0.4
Lysandra coridon (Poda)	Chalkhill Blue	-	0.0	↓	-0.3	↑	0.0
Limenitis camilla (L.)	White Admiral	↓	-3.1	↓	-2.5	↑	0.4
Clossiana selene (D. & S.)	Small Pearl-bordered Fritillary	↓	-1.8	↓	-0.5	↑	1.6
Clossiana euphrosyne (L.)	Pearl-bordered Fritillary	↓↓↓	-6.7	↓	-4.7	↑	1.8
Argynnis aglaja (L.)	Dark Green Fritillary	-	0.0	↓	-0.5	↓	-1.8
Argynnis paphia (L.)	Silver-washed Fritillary	↓	-4.4	↓	-2.3	↑↑	3.5
Melanargia galathea (L.)	Marbled White	↓↓	-4.6	↓	-3.2	↑	1.7
Hipparchia semele (L.)	Grayling	↓	0.4	↓	-2.7	↓↓↓	-4.6
Pyronia tithonus (L.)	Hedge Brown (Gatekeeper)	↓	-1.6	↓	-2.0	↓	-1.1
Maniola jurtina (L.)	Meadow Brown	↓	-2.0	↓	-0.8	↑	2.1
Aphantopus hyperantus (L.)	Ringlet	↓↓	-4.6	↓	-3.2	↑↑↑	4.6
b) species with two flight periods, but only one generation							
Gonepteryx rhamni (L.)	Brimstone	↓↓	-5.3	↓	-2.6	↑↑	5.7
Inachis io (L.)	Peacock	↓↓↓	-12.8	↓↓	-8.1	↑↑	10.4
c) species with two or more flight periods representing different generations							
Pieris brassicae (L.)	Large White	↑	3.7	↑	5.2	↓	-1.9
Pieris napi (L.)	Green-veined White	↓↓↓	-6.6	↑	0.6	↑↑↑↑	10.2
Pieris rapae (L.)	Small White	↑	3.6	↑	5.6	↓	-2.1
Lycaena phlaeas (L.)	Small Copper	↑	0.1	↑	0.3	↑	1.1
Aricia agestis (D. & S.)	Brown Argus	↑	2.2	↑	0.9	↓	-2.4
Polyommatus icarus (Rott.)	Common Blue	↑	0.2	↑	1.3	↑	0.1
Lysandra bellargus (Rott.)	Adonis Blue	↓↓	-11.2	↓	-5.0	↑↑	13.3
Celastrina argiolus (L.)	Holly Blue	↓	-2.9	↓	-4.1	↑	3.6
Vanessa atalanta (L.)	Red Admiral	↓↓↓↓	-15.8	↓	-1.6	↑↑↑	17.3
Cynthia cardui (L.)	Painted Lady	↓	-8.3	↓	-2.3	↑	9.8
Aglais urticae (L.)	Small Tortoiseshell	↓	-2.5	↓	-0.7	↑	1.8
Polygonia c-album (L.)	Comma	↓↓↓	-13.2	↓	-1.2	↑↑↑	13.1
Pararge aegeria (L.)	Speckled Wood	↓	-5.2	↑	5.2	↑↑↑	8.9
Lasiommata megera (L.)	Wall Brown	↑	2.9	↓	-3.4	↓	-6.1
Coenonympha pamphilus (L.)	Small Heath	↓	-1.0	↑	1.6	↑	1.2

Figure 2. Time trends for first appearance date of **Comma**. Week 1 is the first week in April.

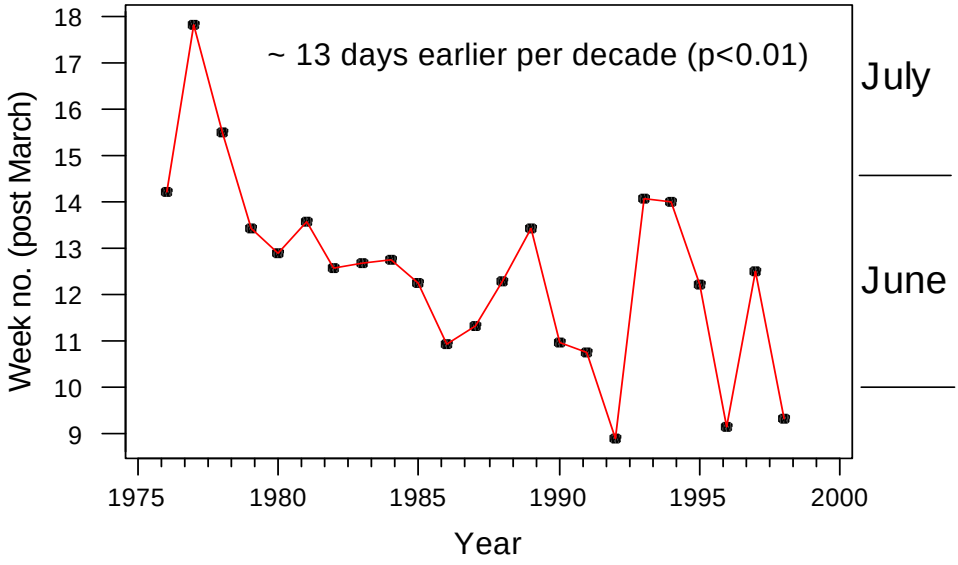


Figure 3. Time trends for peak appearance date of **Green Hairstreak**. Week 1 is the first week in April.

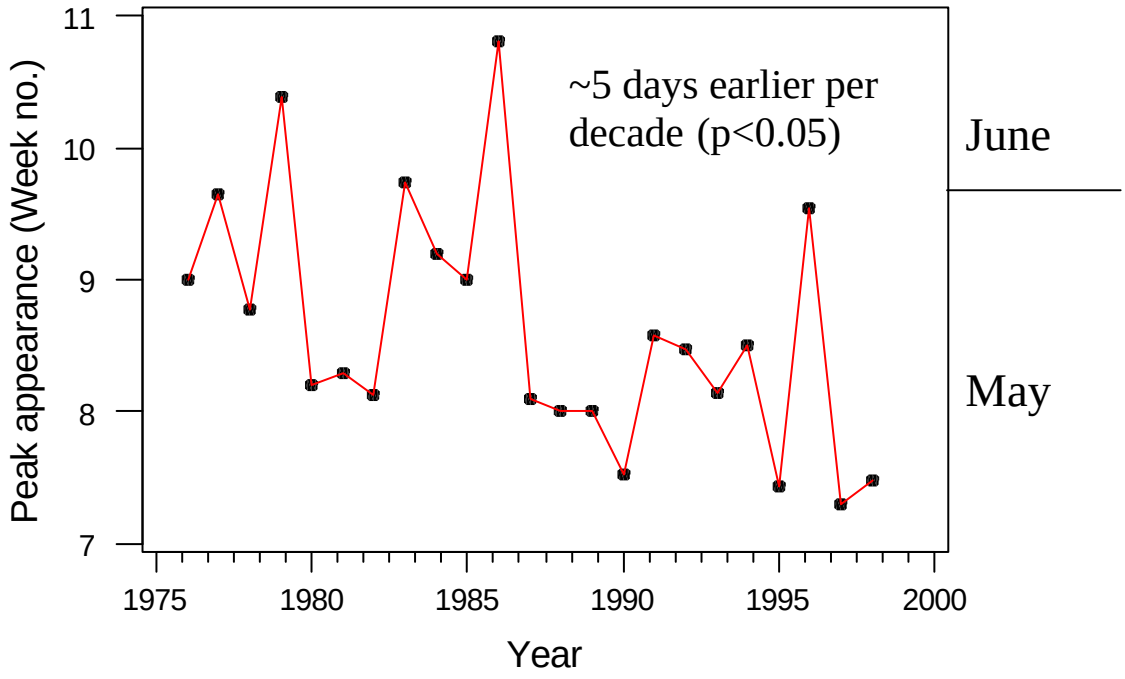


Figure 4. Time trends for length of flight period of **Large Skipper.**

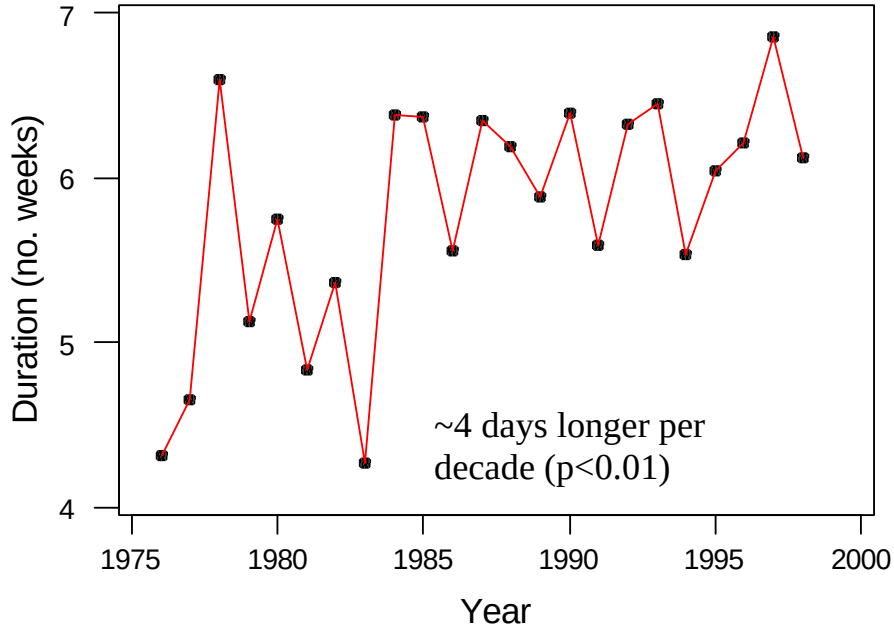
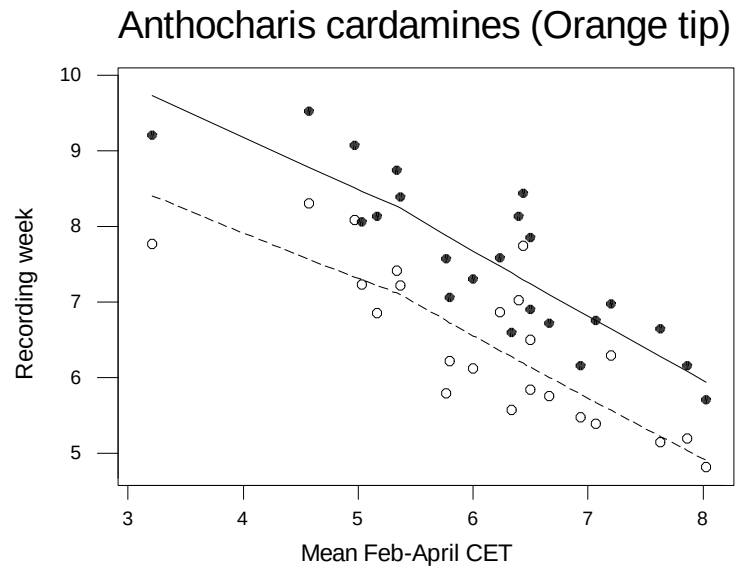


Figure 5. Relationships between mean first and mean peak appearance dates and temperature. Open circles are first appearance dates, solid circle are peak appearance and are related to mean spring temperature (mean February-April Central England Temperature, CET) for a) **Orange Tip** and summer temperature (mean May-July Central England Temperature, CET) for b) **Meadow Brown**. Week 1 is the first week of April.



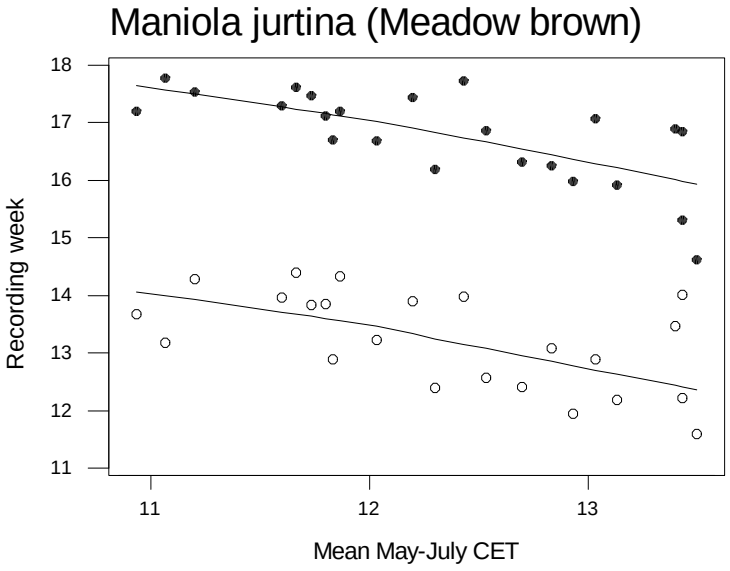


Table 2. The effect of temperature on mean first appearance and mean peak flight date. Values are number of days change in timing of appearance for each 1°C increase in temperature.

	First appearance date	Peak flight date
	Change(+1°C)	Change (+1°C)
a) species with one flight period each year		
Small Skipper	-4.9	-6.7
Large Skipper	-5.1	-5.0
Dingy Skipper	-6.2	-8.7
Grizzled Skipper	0.7	0.1
Orange Tip	-1.7	-5.7
Green Hairstreak	-1.8	-2.7
Purple Hairstreak	-2.1	-4.9
Chalkhill Blue	-7.7	-7.3
White Admiral	-4.8	-4.5
Small Pearl-bordered Fritillary	-1.9	-3.7
Pearl-bordered Fritillary	-1.9	-2.9
Dark Green Fritillary	-0.3	-3.1
Silver-washed Fritillary	-5.9	-5.5
Marbled White	-4.7	-8.7
Grayling	-3.3	-3.5
Hedge Brown (Gatekeeper)	-7.0	-5.7
Meadow Brown	-4.7	-5.4
Ringlet	-3.0	-2.1
b) species with two flight periods, but only one generation		
Brimstone	-4.4	-3.4
Peacock	-6.6	-9.9
c) species with two or more flight periods representing different generations		
Large White	-9.3	-2.4
Green-veined White	-0.4	-2.8
Small White	-3.9	-5.8
Small Copper	-2.4	1.0
Brown Argus	-3.7	-5.2
Common Blue	-2.5	1.3
Adonis Blue	-11.8	-9.2
Holly Blue	-	8.5
Red Admiral	-9.2	-3.7
Painted Lady	-	-
Small Tortoiseshell	-1.9	-3.0
Comma	-5.4	-
Speckled Wood	-10.2	-
Wall Brown	-8.2	-2.8
Small Heath	-2.5	1.8

Discussion

Our results support recent research suggesting that the timing of many natural events is occurring earlier in recent years and that climate is the most likely cause of change (Crick & Sparks, 1999, Menzel & Fabian, 1999). We have demonstrated that first appearance of most British butterflies has advanced over the last two decades and that there is a strong relationship between these changes and temperature. The Butterfly Monitoring Scheme is probably the longest running such scheme in the World. However, 23 years is still a relatively short time series with which to detect change and we are excited with the consistency of results reported here.

Together with early emergence, there is a concurrent advancement of peak appearance and longer flight duration. Therefore, advanced first appearance results in a more asymmetrical flight period distribution rather than a forward shift: for univoltine (one generation per year) species the tail of the flight period is lengthened; for multivoltine (two or more generations per year) species extra generations per year may be produced. As well as increasing the duration of each generation, earlier appearance may allow those species capable of multivoltinism to increase the frequency with which this occurs. Voltinism of several butterfly species can change under laboratory conditions, and it is likely that similar changes would occur with climate change. Species such as the **Common Blue** and **Small Heath** are at least partially bivoltine in southern Britain but univoltine in the north (Emmet & Heath 1989, Pollard & Greatorex-Davies 1997). Certain species which are univoltine in Britain, have more than one generation in warmer parts of their range, e.g. **Peacock** has two generations in central Europe. Duration of flight-period has also been shown to be longer in open (grassland) compared to closed (woodland) biotopes for **Meadow Brown** and **Small Heath** (Pollard 1979, Shreeve 1989, Pollard & Greatorex-Davies 1997). Other implication of earlier emergence of British butterflies may include increased abundance and range expansion northward for species restricted geographically by climate. Fourteen species have increased their range in Britain within the past two decades, the majority northwards (Asher *et al* 2001). An analysis by Ernie Pollard has shown a longer flight period and earlier mean flight date for the **Hedge Brown** during a period of range expansion (Pollard 1991).

Statistical analyses suggest a relationship between temperature and timing of first and peak appearance for most species. In particular, a positive effect of spring temperature on first appearance was detected for many species, a critical time for larval development. Predictions of advanced timing of appearance of British butterflies mostly vary between 1-10 days per ºC. In studies on birds, with each additional ºC, the advanced nesting of Long-tailed Tit, *Aegithalos caudatus*, by 4.1 days, early arrival of Blackcap, *Sylvia atricapilla*, from migration by 2.3 days and early leafing of Oak, *Quercus robur*, by 7.8 days reported by other studies also fall within this range (Sparks & Crick, 1999). However, there are clearly a large number of confounding factors such as food supply, desiccation, predation, possibly most strongly land use change, which will modify the impact of climate change as suggested here.

The effects of temperature on other aspects of butterfly ecology such as diversity, range and abundance are well recognised. Most predicted effects of climate change on butterflies are likely to be positive, mainly through the increase in flight-dependant activities such as mate-location, egg laying, nectaring, predator-evasion and dispersal. However, the propensity for drought associated with climate change predictions may have negative effects on some butterfly species (Pollard *et al* 1997). Dry summers are likely to affect egg survival, host plant growth and habitat structure.

Interactions with other organisms as well as abiotic factors add further complexity to prediction of the response of individual butterfly species to increased temperatures. A driving force for

climate warming is elevated level of 'greenhouse gases', notably CO_2. As well as indirectly raising temperature, increased levels of this gas have been shown to raise photosynthetic activity. This in turn can affect plant-insect herbivore interactions. Studies of Lepidoptera, however, have shown that the **Orange Tip** is likely to remain synchronised with one of its foodplants, garlic mustard and a similar synchrony is apparent between winter moth larvae and oak budburst (Buse & Good, 1996).

Most studies of the effects of climate change on the timing of biological events have utilised avian and botanical datasets. This paper has shown that historical change in the phenology of butterfly species demonstrate an impressive response to only two decades of climate change.