



**United Kingdom
Butterfly Monitoring Scheme**

Annual Report 2016



UKBMS Annual Report 2016

The UKBMS

The UKBMS is run by Butterfly Conservation (BC), the Centre for Ecology & Hydrology (CEH), and the British Trust for Ornithology (BTO), in partnership with the Joint Nature Conservation Committee (JNCC), and supported and steered by Forestry Commission (FC), Natural England (NE), Natural Resources Wales (NRW), Northern Ireland Environment Agency (DOENI), and Scottish Natural Heritage (SNH).

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This report can be downloaded from <http://www.ukbms.org/reportsandpublications.aspx>

Cover photograph of Grizzled Skipper. One of six species, which had their worst year since the start of monitoring in 1976. Photograph by Iain Leach

UKBMS partners



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British Trust for Ornithology, The Nunnery, Thetford, Norfolk, IP24 2PU www.bto.org



Joint Nature Conservation Committee, Monkstone House, City Road, Peterborough, PE1 1JY www.jncc.defra.gov.uk



Northern Ireland Environment Agency, Klondyke Building, Cromac Avenue, Gasworks Business Park, Belfast, BT7 2JA, Northern Ireland. <http://www.doeni.gov.uk/niea/>



Natural Resources Wales, Ty Cambria, 29 Newport Road, Cardiff, CF24 0TP www.naturalresourceswales.gov.uk



National Office Forestry Commission, 620 Bristol Business Park, Coldharbour Lane, Bristol, BS16 1EJ www.forestry.gov.uk



Head Office, Natural England, Foundry House, 3 Millsands, Riverside Exchange, Sheffield, S3 8NH www.naturalengland.org.uk



Scottish Natural Heritage, Great Glen House, Leachkin Road, Inverness, IV3 8NW www.snh.gov.uk

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Contents and online resources

News and research	4
Highlights in numbers	4
UKBMS funding secured for five more years	4
40 years of butterfly monitoring: a celebration	4
UKBMS online data entry system update	5
How butterflies are faring on National Trust land	5
European Butterfly Monitoring Scheme (eBMS) update	6
New citizen science survey to monitor pollinators	6
UKBMS Research uses in 2016	7
<i>Ongoing projects</i>	7
<i>Butterflies are vulnerable to warm winters</i>	7
<i>Peer reviewed research publications in 2016</i>	7
Background and methods	8
Species indices and trends	8
Composite measures of butterfly abundance	9
Sample coverage	10
UKBMS sites	10
Wider Countryside Butterfly Survey (WCBS) squares	10
The 2016 season	12
Summary	12
Seasonal and monthly round up	12
Long-term trends	16
United Kingdom	16
England	16
Scotland	17
Wales	18
Northern Ireland	18
Summary tables of species trends	19 - 23



2016 was the fourth worst year on record for butterflies. *Photograph by Zoe Caals*

Online resources

Further information on the UK Butterfly Monitoring Scheme, including individual species and site trends, and how to take part in butterfly monitoring can be found at:

<http://www.ukbms.org/>

For the Wider Countryside Butterfly Survey go to

<http://www.ukbms.org/wcbs.aspx>

For online data entry go to

<http://www.ukbms.org/mydata/>

For information on Biodiversity Indicators go to

<http://www.jncc.defra.gov.uk/page-1824>

The following links provide more information on the UKBMS delivery partner organisations:

Butterfly Conservation:

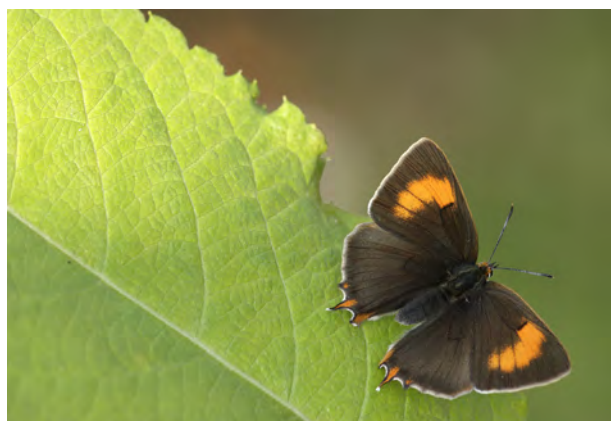
<http://www.butterfly-conservation.org/>

Centre for Ecology & Hydrology:

<http://www.ceh.ac.uk/>

British Trust for Ornithology:

<http://www.bto.org/>



Brown Hairstreak. One of 16 species which showed an annual increase in 2016. *Photograph by Iain Leach*

News and research

UKBMS HIGHLIGHTS IN NUMBERS

29,413



The number of transect visits made in 2016

1,233,840



The number of butterflies counted in 2016.

2,507



The UKBMS continues to grow, with a record 2,507 locations monitored in 2016

2,266



The online system continues to be developed with the facility to enter timed counts and full integration with the Wider Countryside Butterfly Survey (WCBS). There are now over 2,266 registered users of the system.

9



The number of major research publications in 2016 using UKBMS data.

24,116,305



The number of butterflies counted on transects since 1976

UKBMS FUNDING SECURED FOR FIVE MORE YEARS

We are pleased to announce that BC, CEH, BTO and JNCC have agreed a partnership for the continuation of the UKBMS for another five years, with substantial investment from all partners. This is excellent news, in particular to secure continued funding for five rather than three years which has been the norm in recent partnership renewals. The new partnership agreement runs from April 2017 until March 2022. The work programme will largely be as in recent years, though there are some small-scale efficiency savings being made. One important action is the full switch over to online data entry by 2019. We will also continue to seek additional funds to improve the online data entry and reporting system and develop analytical methods.

40 YEARS OF BUTTERFLY MONITORING: A CELEBRATION

On 12 November 2016, the 40th anniversary of the UKBMS was formally celebrated with a symposium hosted at CEH, Wallingford. The day, attended by 120 people, included a fantastic programme of talks covering the inception and history of the scheme; how the scheme has helped create and measure progress of environment policies; research on climate change; and the implications for conservation management. Global and future perspectives of the monitoring scheme

were also discussed as we start to plan the development of the scheme for the next 40 years. The tremendous scientific achievements of the UKBMS (used in over 150 peer-reviewed publications) were described and celebrated by a unique gathering of renowned contributors including Professor Jeremy Thomas, Professor Chris Thomas, Dr Chris van Swaay, Dr Keith Porter, Dr David Roy, Dr Tom Oliver, Dr Marc Botham, Professor Tom Brereton and not least originator Dr Ernie Pollard.

It was particularly fascinating to hear from Ernie Pollard, giving his first butterfly talk in over 20 years and his first with modern PowerPoint technology. Ernie rolled back the years in a remarkable performance talking through the inception of the scheme, the reasons why it was considered important back in the early seventies and how the scheme was piloted at Monks Wood and nearby localities to develop a suitable standardized methodology which could be replicated at sites across the UK. It was a real eye opener into the history of the scheme, some of the issues faced and the lack of technology we have all come to take for granted these days. Ernie was keen to point out that Norman Moore had inspired the idea and that he was helped by a fantastic team. Ernie also covered a small fraction of some of the interesting research he carried out on data collected in the early years of the scheme – indeed many of the research questions we address today Ernie had already started to ask and provide an insight to, providing a fantastic platform from which to work.



Dr Ernie Pollard with his Lifetime Achievement Award for contributions to the UKBMS. Photograph by Jim Asher

Following the talks, the achievements of some of the scheme's longest serving and most dedicated contributors were recognised. Awards were presented by Dr Martin Warren, retiring Chief Executive of Butterfly Conservation. Awards included:

- **Dr Ernie Pollard:** lifetime contribution;
- **John Rowell:** most butterflies counted – 222,259 at Whippingham and Parkhurst Forest transects;
- **Mike Slater:** most transects walked - 11 in Warwickshire, totalling 2816 visits since 1991;
- **Richard Williamson:** furthest walked - 5,795km at Kingley Vale National Nature Reserve and original BMS recorder;
- **Ian Woiwood** (Potton Wood) and **Dick Southwood** (Bure Marshes): original BMS recorders still walking transects.
- **Andy** and **Linda Barker** (Hampshire & Isle of Wight), **Bill Shreeves** (Dorset), **Ken Orpe** (East Midlands), **Laura Sivell** (Lancashire), **Mike Wilkins** (Upper Thames), **Andrew Graham** (Gwynedd & Anglesey), **Marjorie Brunt** (Somerset & Bristol) and **Rob Parker** (Suffolk) – transect co-ordinators continuously since 1998.

For those award winners not attending, Certificates of Achievement were sent in the post.



UKBMS ONLINE DATA ENTRY SYSTEM UPDATE

The full integration of WCBS data entry alongside other transects has been completed, so that all data are now submitted through a single portal and can be processed in tandem. This has resulted in a significant influx of new accounts being registered by WCBS/BTO volunteers through the year.

For long-term volunteers, the most significant developments over the last year have been the provision of further reporting and feedback facilities on the website. Two new reports are the **Section Plot** and the **Year Plot**, both of which can be found under the Reporting menu.

The Section Plot allows you to see how different species are distributed across your transect routes, section by section, viewing one year at a time. This facility can currently make use of data from any years that were entered directly on to the UKBMS website, but should be extended to included historic data in the future.

The Year Plot allows you to see how different species have fared on your transect across the years that you've been monitoring. You can look at the total counts for each species across all years where data have been entered directly on to the UKBMS website. Additionally, the historic UKBMS indices have been uploaded to the site, so you can see how those species indices have changed across all years that your transect has been monitored.



New reporting outputs from the UKBMS online system

HOW BUTTERFLIES ARE FARING ON NATIONAL TRUST LAND

The conservation charity, the **National Trust** was founded in 1895 and is dedicated to preserving and making accessible

the nation's heritage and open spaces. The Trust is a giant in terms of countryside management, looking after more than 250,000 hectares of countryside, 775 miles of coastline and hundreds of special places across England, Wales and Northern Ireland. These holdings support many populations of scarce and threatened butterfly species and the Trust is a vitally important player in the future conservation of butterflies. It is highly encouraging that the Trust has a major new initiative to conserve and enhance biodiversity through its new *Land Outdoors and Nature* programme. The Trust, has pledged to create 25,000 hectares of new 'priority' nature habitats by 2025, and also aims to restore numbers of farmland butterflies on its land. Specifically, the Trust has ambitious targets to conserve butterflies by 2025 including: i) restoring the number of butterflies counted on Trust farmland to 1976 levels, including positive trends for 50% of species; ii) maintaining a positive trend for habitat specialist butterfly species on Trust land, and range expansions for 50% of species.

The Trust is working closely with Butterfly Conservation to better manage butterfly sites and to monitor progress in delivering these targets, using UKBMS and other data. A new analysis, led by Tom Breerton of Butterfly Conservation has recently been completed of butterfly monitoring and butterfly performance on Trust land, in comparison to elsewhere covering the period 1978-2015.

The report shows that the Trust is continuing to make a substantial contribution to monitoring UK butterflies, hosting c.12% of all sites monitored each year across England, Northern Ireland and Wales. Monitoring effort shows a year on year increase with 157 sites monitored in 2015, including 140 transects. The majority of monitoring sites sample higher quality land for biodiversity, although this is supplemented by randomly selected Wider Countryside Butterfly Survey (WCBS) 1km squares, with 32 squares sampled on Trust land in 2015. To supplement site-based and WCBS monitoring and improve representation of ordinary/non nature Trust farmland, a design-based network of 75 (stratified) random 1km squares has been devised and the squares made available to volunteer recorders from 2016. The scheme was branded and launched more widely in 2017 as the National Trust Farmland Butterfly Survey (FBS). The long-term aim of the FBS is to combine the Trust farm data with WCBS data to assess how butterflies are faring on Trust farmland.



The Marsh Fritillary is one of seven Priority Species performing better on Trust land than elsewhere. Photograph by Tim Melling



The new analysis assessed long-term trends for 48 of the 58 regularly occurring species on Trust land, whilst a short-term trend (since 2010) was also possible for one additional species, the Lulworth Skipper. The analysis showed that on Trust land, more species had negative population trends (54% of species), than positive trends (46% of species). This result was not surprising, and reflects the situation for non-Trust land in the sampled countries (65% of species had negative trends) and for the UK as a whole (59% of species with negative trends). Of the 20 habitat specialist species assessed over the long-term (since 1990), there was twice the number of significantly increasing species (six versus three) at Trust sites compared with non-Trust sites and less than half the number of significantly decreasing species (11 versus five). Seven current and one former conservation Priority Species had more favourable trend classes on Trust land over the long term than elsewhere including: Adonis Blue, Dingy Skipper, Duke of Burgundy, Grizzled Skipper, Marsh Fritillary, Pearl-bordered Fritillary, Silver-studded Blue and Small Pearl-bordered Fritillary, whilst only one Priority Species, White Admiral, has a more favourable trend on non-Trust land. Five Priority species were continuing to decline on Trust land. These were Grayling, Heath Fritillary, High Brown Fritillary, Wall and White Admiral. However, this compares with nine declining Priority Species during the previous assessment up to 2011, suggesting an improved situation.

The composite measure for Habitat Specialist species showed that over the long-term, the group performed significantly better on Trust land than non-Trust land - an apparent (though not statistically significant) increase of 24% compared to a significant decline of 24% outside of Trust land. Improved targeting and tailoring of management are likely causal factors why the Trust is doing relatively well as a land management body for specialist species of conservation interest, but further research is needed in this area to fully understand the reasons.

Of the 25 Wider Countryside species assessed over the long-term (since 1978), there were substantially more species with stable trends on Trust sites compared with non-Trust sites (11 versus five) and fewer species with declining trends (eight versus 13). However, there were slightly fewer significantly increasing species (five versus seven) on Trust sites than non-Trust sites. Composite measures of butterfly abundance showed that wider countryside butterflies are stable (measured over 38 years) on both Trust land and elsewhere, with apparent declines of 5% of 4% respectively, which were not statistically



Two further schemes have applied to join the EBMS from Spain. Photograph by Tom Brereton

significant. Once again, this is a more favourable situation than up to 2011, when wider countryside species were in significant decline on Trust (and non-Trust) land.

This is a long-term monitoring project and an assessment of butterfly performance on Trust land will be updated on an annual basis.

EUROPEAN BUTTERFLY MONITORING SCHEME (eBMS) UPDATE

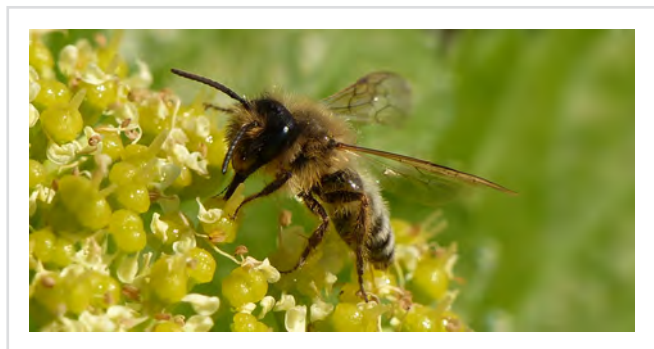
Under the auspices of Butterfly Conservation Europe, a partnership has been established to help co-ordination of Butterfly Monitoring Schemes across Europe. The founding partners in 2016 were Butterfly Conservation Europe, CEH (co-ordinators) and BMS partners in Catalonia, Finland, Germany, Netherlands and the UK. The eBMS partnership aims to support and promote butterfly monitoring schemes across the continent, whilst also providing a platform to collate data from the various schemes and support its provision for research.

Combining data from all these countries into a single database with standardised formatting has been completed by CEH. This will help to facilitate the timely provision of data to assist suitable research projects as and when required. Further schemes approved to join the scheme in 2017 are from Flanders, France, Ireland, Luxembourg, Sweden and two further schemes in Spain.

A new website is also being developed (<http://www.butterfly-monitoring.net/>) to enable the submission of butterfly monitoring data for recorders in areas of Europe (or elsewhere) which are not covered by existing national or regional schemes. The data entry process is largely based on the data entry site used by the UKBMS.

NEW CITIZEN SCIENCE SURVEY TO MONITOR POLLINATORS

BC, BTO and CEH are partners in a new project to develop pollinator monitoring methods and roll out of surveys across the UK. As part of this, a relatively simple method has been developed for naturalists – the FIT count. This involves a 10 minute timed count of pollinator groups on particular plants in flower. The scheme was launched in July 2017 and will run again in 2018. Further details including how to take part are available here: <https://www.ceh.ac.uk/our-science/projects/pollinator-monitoring>



Wider Countryside Butterfly Survey surveyors are being encouraged to undertake 'FIT' counts for pollinators on their survey squares. Photograph by Tom Brereton

Ongoing projects

The UKBMS data continues to be used for a wide range of research projects with, for example, nine peer-reviewed articles published in 2016. The biological impacts of warming temperatures and extreme weather associated with climate change were major themes. Other topics included (1) understanding other drivers of change in butterfly populations, such as the impacts of different types of land use and management and (2) new analytical developments, including the development of biodiversity indicators to monitor climate change impacts and a new, more efficient way to analyse trends in butterfly populations for the UKBMS. Here, by example, lead author Osgur Mcdermott, University of East Anglia describes the findings of a paper published in October 2016 on the impacts of extreme weather on butterfly populations.

Butterflies are vulnerable to warm winters

We live in a world today that is subject to climate change, a trend which is set to continue into the near future. Recent research has demonstrated some of the negative impacts this can have on our biodiversity, but less is known about the impact of variation in the weather and in particular climate extremes. Climate scientists predict the UK will be subject to increased rates and magnitude of extreme weather events, hence it is important to understand how this might affect the UK's biodiversity.

During my PhD at the University of East Anglia I examined the effect of extreme weather events on butterflies. Butterflies are excellent study species because they are indicators of how other species may respond, they are exothermic and have a short life span so respond quickly to stressors. They have an unrivalled dataset, thanks to thousands of citizen butterfly recorders, making detailed attribution models possible. Butterflies are particularly important because they are a threatened taxonomic group in the UK, 70% of butterflies have declined in their occurrence and 57% in their abundance since 1976 so there is need for urgent action to halt this decline.

In addition to habitat loss, fertilizer and herbicide use, climate change has been shown to impact UK butterflies. Until recently there was very little information available on the potential impacts of extreme weather. My work has shown that extreme heat plays

a fundamental role in determining species decline. The study identified that extreme heat during the overwintering period has the potential to cause substantial and dramatic declines. Extreme heat is beneficial during summer period, clearly not reaching detrimental tipping points. Extreme cold winters were also found to be beneficial to the majority of UK butterflies.

The results of my work corroborate and explain some of the recent population declines. For example, between December 1st 2015 and 24th of February 2016 the UK was subjected to the third warmest winter since records began in 1910. Later in 2016 the big butterfly count reported that of the 16 species it targeted, 9 had declined in their abundance. This decline was a surprise taking into account the warm spring and summer conditions in 2016 that were beneficial to butterflies. My work published in *Journal of Animal Ecology*, provided a likely explanation for the declines, 8 of the 9 species that suffered population declines were predicted to decline due to the unusually warm winter. My results suggest many butterflies may be vulnerable to warm winters.

The UK is predicted to be subjected to warmer, drier summers and warmer, wetter winters in the future. The effects of heat in these two periods lead to opposite outcomes and it remains to be seen whether warmer winters will outweigh the beneficial warm summers. This study has highlighted that there is need to account for the effects of extreme weather on all butterfly life stages to be able to predict its impacts.

For further information regarding the sensitivity of UK butterflies to extreme heat, cold, drought and precipitation see: McDermott Long, O. et al., 2017 (full citation below)



Extreme rainfall during the pupal stage can be damaging for butterflies, especially for single-brooded species such as the Heath Fritillary. Photograph by Peter Eeles

Peer-reviewed research published in 2016

Burns, F., Eaton, M.A., Barlow, K.E., Beckmann, B.C., Brereton, T., Brooks, D.R., Brown, P.M.J., Al Fulaiij, N., Gent, T., Henderson, I., Noble, D.G., Parsons, M., Powney, G.D., Roy, H.E., Stroh, P., Walker, K., Wilkinson, J.W., Wotton, S.R. and Gregory, R.D. (2016) Agricultural Management and Climatic Change Are the Major Drivers of Biodiversity Change in the UK. *PLoS ONE* 11. e0151595. <https://doi.org/10.1371/journal.pone.0151595>

Dennis, E. B., Morgan, B. J. T., Freeman, S. N., Brereton, T. M. and Roy, D. B. (2016) A generalized abundance index for seasonal invertebrates. *Biometrics*, 72: 1305–1314. doi:10.1111/biom.12506

Dennis, E.B., Morgan, B. J.T., Freeman, S.N., Roy, D.B. and Brereton, T. (2016) Dynamic models for longitudinal butterfly data. *Journal of Agricultural, Biological, and Environmental Statistics*, 21: 1-21. doi: 10.1007/s13253-015-0216-3

Martay, B., Brewer, M. J., Elston, D. A., Bell, J. R., Harrington, R., Brereton, T. M., Barlow, K. E., Botham, M. S. and Pearce-Higgins, J. W. (2016), Impacts of climate change on national biodiversity population trends. *Ecography*, 39: 1-13. doi:10.1111/ecog.02411

Martay, B., Monteith, D.T., Brewer, M.J., Brereton, T., Shortall, C.R. and Pearce-Higgins, J.W. (2016) An indicator highlights seasonal variation in the response of Lepidoptera communities to warming. *Ecological Indicators*, 68: 126-133. doi:10.1016/j.ecolind.2016.01.05

McDermott Long, O., Warren, R., Price, J., Brereton, T. M., Botham, M. S. and Franco, A. M. A. (2017), Sensitivity of UK butterflies to local climatic extremes: which life stages are most at risk? *Journal of Animal Ecology*, 86: 108–116. doi:10.1111/1365-2656.12594

Redhead, J.W., Fox, R., Brereton, T. and Oliver, T.H. (2016) Assessing species' habitat associations from occurrence records, standardised monitoring data and expert opinion: a test with British butterflies. *Ecological Indicators*, 62: 271-278. doi:10.1016/j.ecolind.2015.11.004

Schmucki, R., Pe'er, G., Roy, D. B., Stefanescu, C., Van Swaay, C. A.M., Oliver, T. H., Kuussaari, M., Van Strien, A. J., Ries, L., Settele, J., Musche, M., Carnicer, J., Schweiger, O., Brereton, T. M., Harpke, A., Heliölä, J., Kühn, E. and Julliard, R. (2016) A regionally informed abundance index for supporting integrative analyses across butterfly monitoring schemes. *Journal of Applied Ecology*, 53: 501–510. doi:10.1111/1365-2664.12561

Thackeray, S.J., Henrys, P.A., Hemming, D., Bell, J.R., Botham, M.S., Burthe, S., Helauet, P., Johns, D.G., Jones, I.D., Leech, D.I., Mackay, E.B., Massimino, D., Atkinson, S., Bacon, P.J., Brereton, T.M., Carvalho, L., Clutton-Brock, T.H., Duck, C., Edwards, M., Elliott, J.M., Hall, S.J.G., Harrington, R., Pearce-Higgins, J.W., Høye, T.T., Kruuk, L.E.B., Pemberton, J.M., Sparks, T.H., Thompson, P.M., White, I., Winfield, I.J. and Wanless, S. (2016) Phenological sensitivity to climate across taxa and trophic levels. *Nature*, 535, 241-245. doi:10.1038/nature18608

Background and methods

Trends in butterfly populations were compiled from a network of 2,507 sample locations in 2016 and 4,662 locations across all years.

Species indices and trends

In the UKBMS, data on the population status of UK butterflies is derived from a wide-scale program of site-based monitoring and sampling in randomly selected 1km squares.

The majority of sites are monitored by butterfly transects. The 'traditional' transect method, which was developed from 1973-75 and launched in 1976, involves weekly butterfly counts along fixed routes through the season made under strict weather, recording area and time of day criteria (Pollard & Yates 1993). Weekly counts for each species are summed to generate site annual abundance indices. For sites with missing weekly counts, a statistical model (a Generalised Additive Model, 'GAM') is used to impute the missing values and to calculate a site index (Rothery & Roy 2001).

For a number of habitat-specialist species (especially the fritillaries) 'reduced effort' methods are also used to monitor annual abundance at the site level, especially in more remote parts of the UK, for example; adult timed counts for fritillaries (Warren et al. 1981), larval web counts for Marsh Fritillary (Lewis & Hurford 1997) and egg counts for Large Blue (Thomas et al. 2009). For timed count and larval search methods, systematic recording is made on single days in suitable weather (when UKBMS recording criteria are met), with the counts converted to a site index that accounts for both the size of the colony and the time in the season when the count was made. From 2015, winter egg counts for Brown Hairstreak have been incorporated into the UKBMS, see http://www.ukbms.org/Downloads/NG3_Brown%20Hairstreak%20Egg%20Count%20Guidance.pdf

The Wider Countryside Butterfly Survey (WCBS) was established in 2009 to improve the representativeness of assessments of the population status of butterflies across the countryside as a whole. This is important given that most site-based monitoring is biased towards good quality semi-natural habitat relatively rich in butterflies. In the WCBS, BC recorders are allocated randomly selected 1km squares within the BC branch in which they live, whilst BTO recorders are given the opportunity to survey their existing Breeding Bird Survey squares. Both sets of surveyors are asked to survey these squares at least twice over the July and August period with visits spaced at least ten days apart. Optional visits are encouraged, especially in the spring to sample Orange-tip and for the first generation of bivoltine species. On each visit, recorders survey two parallel 1km survey lines evenly spaced ca300m apart. Along the survey lines, recorders count butterflies, day-flying moths and dragonflies using the same time of day, recording width and weather condition criteria used in transect monitoring. Due to the low level of sampling



Late summer larval web counts are the main method for monitoring the Marsh Fritillary in Wales. Photograph by George Tordoff

effort (and unlike conventional transects), WCBS data is not routinely used to derive local measures of butterfly abundance.

In 2013 we implemented a new analysis method for the 25 wider countryside species, to make better use of available transect data, and to incorporate WCBS data in order to compile more representative national and UK indices. Briefly, the new method (Dennis et al. 2013) uses a two-stage model. Firstly, all butterfly counts in a season from both traditional UKBMS transects and wider countryside squares are used to estimate the seasonal pattern of butterfly counts for that year. This stage relies heavily on the traditional UKBMS data with good coverage throughout the season. A second stage of the model is then applied to the full set of annual counts, accounting for where the counts occur within the flight season, to then calculate annual population indices and trends.

Work to apply this method to habitat specialist species has not been completed, because not all required raw data (weekly counts) are available from earlier in the time series. Hence, analyses for habitat specialists, currently uses the old method (Rothery & Roy 2001). Regular migrants are also analysed using the old method due to high annual variability in abundance. In this method, site index data from all past and present transects and timed counts/larval webs at monitored sites is combined each year to derive national and UK 'Collated' Indices (CI) and to estimate trends over time. Because not all sites are

monitored each year, a statistical model (using log-linear regression) is needed to estimate missing values and to produce national indices and trends. The model takes into account the fact that for a particular butterfly species, some years are better than others (a year effect), typically due to the weather, and some sites support larger populations than others (a site effect).

Analysis methods are constantly evolving and testing of a new analysis method is currently underway, with the aim to implement the same method for both wider countryside and habitat specialist species for reporting trends. The new method being tested, called the Generalised Abundance Index (GAI) approach (Dennis et al. 2016), works in a similar way to previous analysis methods, where all counts are used to estimate the seasonal pattern of butterfly counts for each year in order to estimate the missing weekly counts, and annual population indices and trends are then calculated. However a key advantage of the new method is its computational efficiency which is important when analysing large amounts of data. This also means that confidence intervals can be more readily produced for the population indices and trends for all species, which is vital for appropriately assessing changes, but impractical using current methods.

Composite measures of butterfly abundance

Multi-species (composite) indices of butterfly abundance are calculated using a generalised linear model accounting for species and year. Grouped measures have been compiled for all resident species, wider countryside species, habitat specialists and the three regular migrants. In addition, England is further categorised by broad habitat groupings (farmland and woodland) (Brereton *et al.* 2011).

To identify underlying patterns in population trends in these grouped measures, assessment of change is based on trends in the underlying smoothed indices. Calculation of smoothed indices and trends and confidence intervals in them are assessed by structural time-series analysis and the Kalman Filter as implemented in the program TrendSpotter (Soldaat *et al.* 2007). A statistical test is performed using the software TrendSpotter to compare the difference in the smoothed index in the latest year versus other years in the series. Within the measures, each individual species trend is given equal weight, and the annual figure is the geometric mean of the component species indices for that year. Populations of individual species within each measure may be increasing or decreasing, irrespective of the overall trends.

The composite measures provided in this report are derived in the same way as biodiversity indicators previously published by UK, English and Scottish Governments. However, they may differ (usually in a small way) in terms of species composition and the sites used in the analysis. For reasons of consistency, published indicators have used a fixed set of species (from the start year), with the same species/year combinations in annual updates¹. Composites in this report, where possible include additional species, reflecting improvements in monitoring

coverage since the development of indicators, whilst analytical methods to produce indicators are likely to be revised in 2018, as part of a process to harmonise ways in which bird, butterfly and bat indicators are compiled.

Brereton T.M., Roy D.B., Middlebrook, I., Botham, M. and Warren, M. (2011). The development of butterfly indicators in the United Kingdom and assessments in 2010. *Journal of Insect Conservation* 15: 139-151.

Dennis E.B., Freeman, S.N., Brereton, T. & Roy, D.B. (2013). Indexing butterfly abundance whilst accounting for missing counts and variability in seasonal pattern. *Methods in Ecology and Evolution* 4:637-645.

Dennis, E.B., Morgan, B.J.T., Freeman, S.N., Brereton, T.M. & Roy, D.B. (2016). A generalized abundance index for seasonal invertebrates. *Biometrics* 72: 1305-1314.

Lewis, O.T. & Hurford, C. (1997). Assessing the status of the Marsh Fritillary (*Eurodryas aurinia* Rott.) – an example from Glamorgan (UK). *Journal of Insect Conservation* 1:159-161.

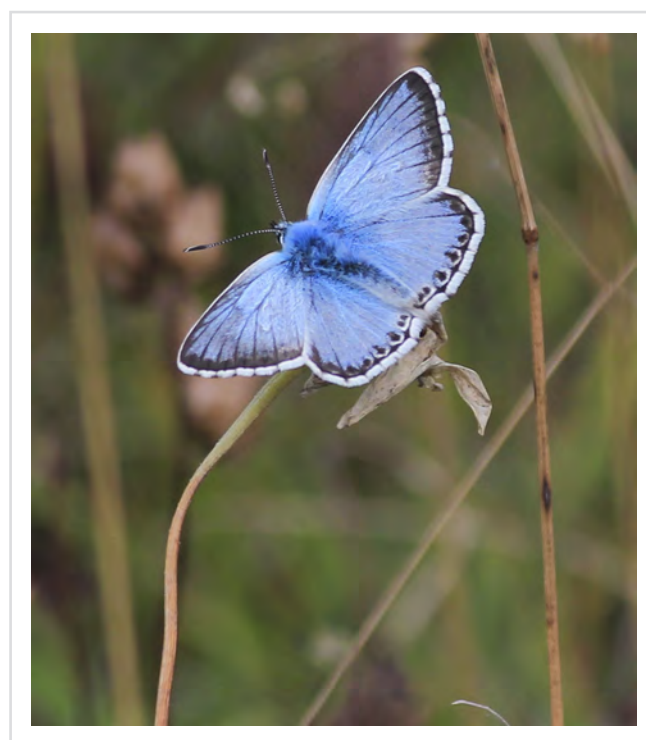
Pollard, E. & Yates, T.J. (1993). *Monitoring Butterflies for Ecology and Conservation*. Chapman and Hall, London 2.

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Soldaat, L.L., Visser, P., van Roomen, M. & van Strien, A. (2007). Smoothing and trend detection in waterbird monitoring data using structural time-series analysis and the Kalman filter. *Journal of Ornithology* Vol. 148 suppl. 2: Dec. 2007.

Warren, M., Thomas, C.D. & Thomas, J.A. (1981). The Heath Fritillary. Survey and conservation report. Unpublished report to the Joint Committee for the Conservation of British Insects. Butterfly Conservation, Wareham.

¹ Due to user requirements and to avoid the possibility of annual changes in indicators being attributable to changes in the component species



Chalk Hill Blue. Photograph by Zoe Caals



Sample coverage

UKBMS sites

Since 1976, an overall total of 2,846 sites have contributed data to the scheme. In 2016, 1,492 transects, and 244 non-transect sites were monitored, with the total of 1,706 sites representing a rise of 4% over the previous best ever total in 2015. Of these, 91% of sites (1351) produced indices for at least one species.

At the Country-level there were 1,427 monitored sites in England, 107 sites in Wales, 157 sites in Scotland, 29 sites in Northern Ireland, and 16 from the Channel Islands.

In 2016, 144 new sites were established and monitored for the first time. Ten of these were in Scotland, nine in Wales and one in Northern Ireland, whilst the rest were in England. Additionally, 188 sites were either re-established or were brought into the scheme with additional data pre-dating 2016. Data from Brown Hairstreak egg counts contributed to the scheme for the first time.

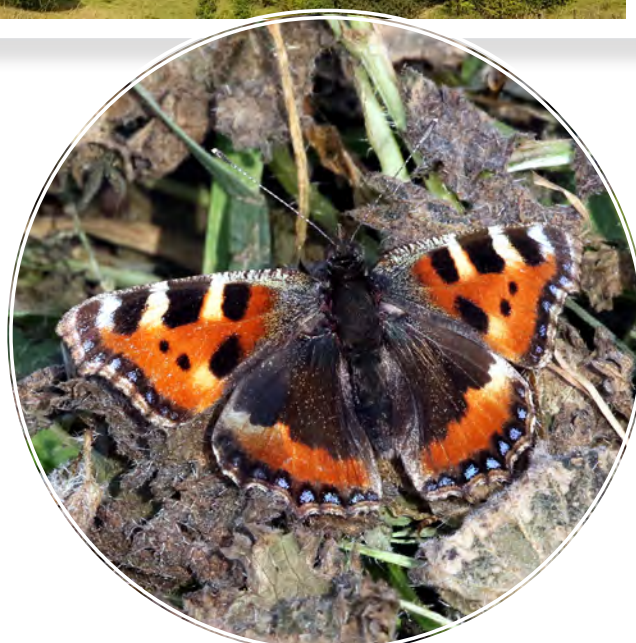
Wider Countryside Butterfly Survey (WCBS) squares

The WCBS ran for an eighth year in 2016, supplying count data for compilation of collated indices for common and widespread species. In total, over 3,000km of survey line was walked by nearly 700 recorders who made 1,646 visits to 771 squares (61% by BC, 39% BTO BBS). Eighty-four percent of squares received the required two visits over the core July and August period. From April-June, 188 visits were made to 151 squares to target early flyers such as Orange-tip.

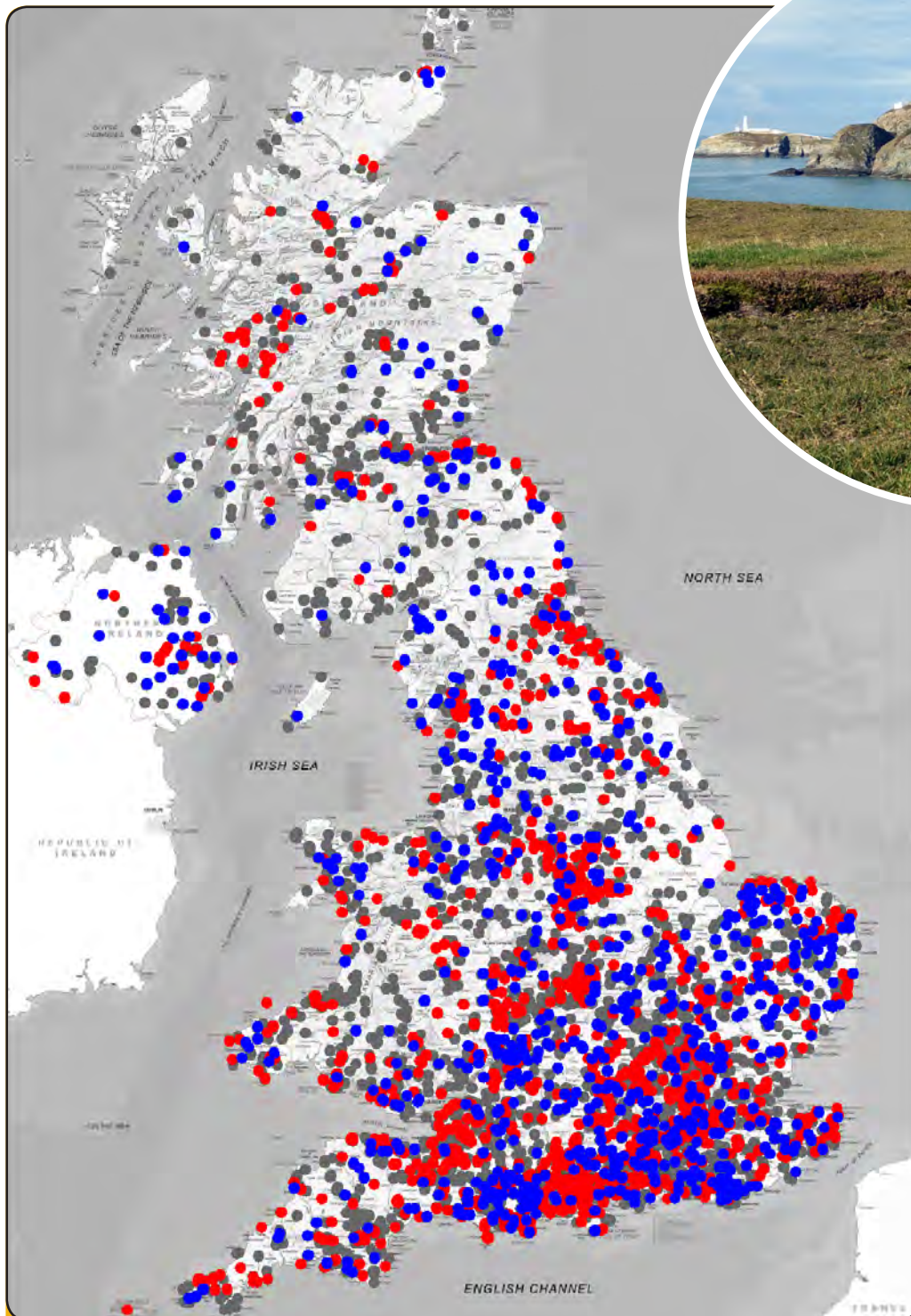
Overall, there was a net loss of 31 squares (-4%) from 2015. Participation by BC and BBS recorders dropped by 4% and 3% respectively. On the positive side, 71 new squares were established (BC 27 and BTO BBS 44), whilst monitoring was re-instated in a number of squares with at least five years of data.



Old Winchester Hill, Hampshire. Photograph by Zoe Caals



Small Tortoiseshell.
Photograph by Tom Brereton



NORTH SEA

IRISH SEA

REPUBLIC OF IRELAND

ENGLISH CHANNEL

South Stack Ranges.
Photograph by
Tom Brereton



Figure 2: Location of monitored sites in 2016. UKBMS sites producing a site index (red circles), WCBS squares walked (blue circles), sites and squares not walked or not producing a site index in 2016 (grey circles)



The 2016 season

SUMMARY

- 2016 was a particularly bad year for butterflies; the fourth worst year on record in the 41-year series (2015 was the 10th worst year).
- 40 of the 57 species assessed declined in abundance from 2015 levels, whilst 16 species showed an increase and one showed no change.
- A warm wet winter followed by a cold snap in spring and a dull and wet early summer period were thought to be important weather factors causing the annual decline in many of the UK's resident butterflies.
- The highly threatened **Heath Fritillary** had its worst year on record for the second year running, with annual abundance down by 27%.
- Five other species, **Grizzled Skipper**, **Wall**, **Grayling**, **White-letter Hairstreak** and **White Admiral** also recorded their worst years since the scheme began.
- **Grizzled Skipper** numbers tumbled by 24%. This spring-flying butterfly emerges from April, a month that was around a degree colder than the long-term average in 2016.
- The **Grizzled Skipper's** struggles mirrored a bad year overall for the skippers with all but one of the UK's eight species suffering a falling in numbers from 2015.
- The **White Admiral**, **White-letter Hairstreak**, **Grayling** and **Wall** slumped by 59%, 42%, 27% and 31% respectively.
- 2016 was also a very poor year for some common species familiar in gardens. The **Peacock** had a 46% lower index than 2015, whilst for **Small Tortoiseshell**, the annual change was - 47%.
- 2016 was a poor year for 'browns' in all countries across the UK. **Gatekeeper**, **Meadow Brown**, and **Scotch Argus**, which all showed level or increasing population indices in 2015, had a bad year in 2016, having their second, third, and eighth worst year on record in the UK respectively
- Some species bucked the trend to record reasonable years. The previously extinct **Large Blue**, one of the UK's rarest butterflies, recorded its second best year in terms of relative abundance, up 38% on 2015, whilst total abundance was likely higher than in any other year.
- **Speckled Wood** was the one species of brown that bucked the trend, showing an increase on 2015 values in all countries in the UK, but particularly in Northern Ireland and Scotland, where the population index showed an increase of 44% and 62% on the previous year.
- The migratory **Red Admiral** was another species that did well, and was the species that showed the largest increase in numbers over 2015 levels, of 86%. **Clouded Yellow**, another mainly migrant species, saw its numbers rise by 35%.
- It was a late season overall compared with recent years, with almost two-thirds of species appearing later than the 10-year average (2005-2014) and 90% having a later mean flight date than in 2014. The mean flight date across all species was four days later than the series average, compared with seven days earlier in 2014.
- 42 of the 51 species assessed (82%) emerged earlier than the long-term average, though conversely 40 of the 51 species emerged later than the last ten years average.
- As in 2015, overall butterfly abundance peaked in mid-July, around two weeks earlier than the long-term average.
- As in 2015, the mean abundance of butterflies at sites in August was about half that of the long-term average.



White Admiral. Photograph by Iain Leach

SEASONAL AND MONTHLY ROUND-UP

Winter

JANUARY was generally mild, dull, wet and windy, though there was a cold snap mid-month. The UK mean temperature was c.1°C above the 1981-2010 average, peaking at 16.5°C in Highland on the 24th and dipping to -12.4°C in Sutherland on the 19th. Rainfall was above average by 148%, making it the equal-fourth wettest January since 1910, whilst sunshine was 79% of the 1981-2010 average. At the end of the month Storm 'Gertrude' brought winds of up to 105mph to Shetland. Two species were seen on New Year's Day, these were **Red Admiral** in *Hampshire*² and **Small Tortoiseshell** in *Northants*. On the 4th there were sightings of **Peacock** (*Norfolk* and *Suffolk*) and **Speckled Wood** (*Hertfordshire*). Two other species were seen over the month, with a **Comma** on the 6th in *Cheshire* and **Brimstone** on the 17th in *Dorset*.



Clouded Yellow. Photograph by Tim Melling

² Where only the county names are given, data is from the BNM per Richard Fox, Butterfly Conservation

After an unsettled start **FEBRUARY** turned dry, sunny and cold. Overall it was warmer, wetter and sunnier than average, though there were marked regional variations. Temperatures climbed as high as 16°C in Norfolk, although no new butterflies were seen over the month.

Spring

There were some unsettled spells at the start and end of the month but otherwise **MARCH** was characterized by some fine spells of dry and sunny weather, where temperatures were around the seasonal average. The temperature rose to nearly 19°C in Aberdeenshire on the 17th, whilst 57 mm of rain fell in Gwynedd on the 27th. The first butterflies to be recorded on full transects were **Peacock** and **Small Tortoiseshell** on the 11th at *Whippingham (fields), Isle of Wight*. The six newly emerging species over the month were **Large White** (14th Devon), **Green-veined White** (16th Buckinghamshire), **Holly Blue** (22nd Hertfordshire), **Clouded Yellow** (25th Dorset), **Orange-tip** (26th Surrey) and **Green Hairstreak** (30th Sussex).

Unsettled weather at the start of **APRIL** gave way to a predominantly cold month, though rainfall and sunshine levels were slightly above average. The average April temperature was c.1°C below the long-term average, with a low of -5.6°C in Sutherland on the 28th. In spite of the cold weather, nine species had their first sightings over the course of the month. These were **Wall** (3rd Durlston Country Park, Dorset), **Dingy Skipper** and **Small Heath** (5th Folkestone Escarpment, Kent), **Small Copper** (10th Blakeney Point, Norfolk), **Grizzled Skipper** (12th Sussex and Aldbury Nowers, Hertfordshire), **Duke of Burgundy** (13th Hampshire), **Pearl-bordered Fritillary** (19th Devon), **Small Blue** (23rd Dorset), **Common Blue** (24th Watch House Field & Penlee Battery, Cornwall & Isles of Scilly). The effect of the cold weather was apparent on the timing of emergence, with several species emerging much later on monitored sites in 2016, than 2015. These included **Common Blue** and **Duke of Burgundy** (by 8 days), **Wall** (12 days) and **Pearl-bordered Fritillary** (15 days). Curiously, **Small Heath** was first seen 10 days earlier.

The weather was much better in **MAY**, which was characterized by plenty of fine, warm and sunny weather. It was drier, sunnier and warmer than average, with temperatures

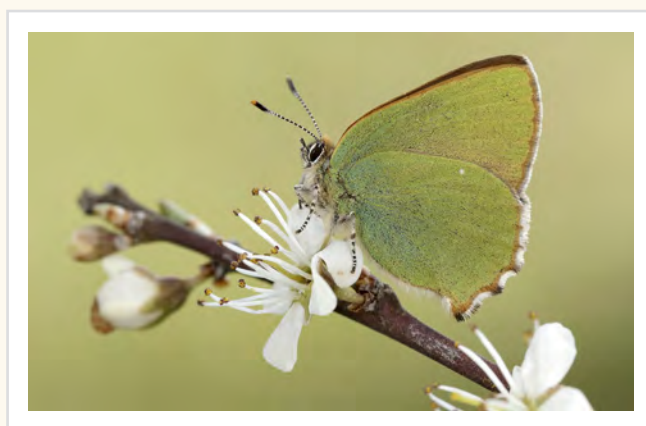


Peacock. Photograph by Iain Leach

peaking at nearly 28°C in Ross & Cromarty on the 9th. Over the month 20 species emerged (five more than in 2015). These were **Glanville Fritillary** (1st Isle of Wight), **Brown Argus** (4th Lincolnshire), **Marsh Fritillary** (4th Tice's Meadow, Surrey and Welshmoor, Swansea), **Small Pearl-bordered Fritillary** (4th Devon), **Wood White** (4th Bury Ditches, Shropshire), **Heath Fritillary** (5th Lockett Wood, Cornwall), **Cryptic Wood White** (6th Craigavon Lakes, Armagh), **Large Skipper** (8th Catherington Down, Hampshire), **Adonis Blue** (12th Denbies Landbarn, Surrey), **Chequered Skipper** (12th Argyll), **Swallowtail** (19th Norfolk), **Small Skipper** (22nd The Holt-Soakfield Row and Broadwalk, Hampshire), **Silver-studded Blue** (24th Gogarth, Clwyd), **Gatekeeper** (25th Dorset), **Northern Brown Argus** (25th Lancashire), **Lulworth Skipper** (26th Dorset), **Marbled White** (27th Gunpowder Park, Essex), **Large Blue** (29th Green Down, Somerset), **Mountain Ringlet** (30th Cumbria) and **Ringlet** (30th Hartlebury Common and Charlton, Worcestershire). Despite good weather during the month, butterflies were playing catch up, with most species emerging later on transects than in 2015. These included **Chequered Skipper** (by 10 days), **Brown Argus** (13 days) **Cryptic Wood White** (16 days) and **Wood White** (20 days). Species emerging earlier than 2015 included **Heath Fritillary** (by 11 days), **Meadow Brown** (12 days) and **Marbled White** (24 days).



Wall. Photograph by Iain Leach



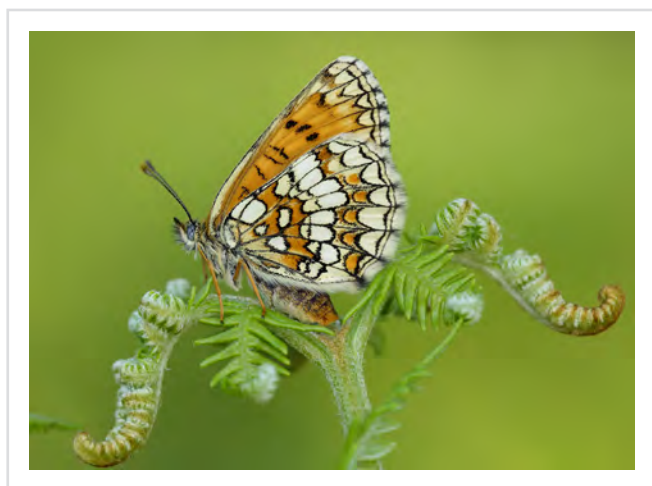
Green Hairstreak. Photograph by Iain Leach



Summer

Good weather continued into the early part of **JUNE** thereafter it was largely unsettled with above average rainfall and well below average levels of sunshine, especially in south-east and central southern England where it was the dullest June on record. There were some extreme weather events, with heavy downpours and thunderstorms leading to flash flooding in several places. Temperatures held up though, especially at night and the month was c.1°C warmer than the long-term average. The twelve species that emerged in June were **Large Heath** (2nd *Cors Fochno*, *Ceredigion* and *Cumbria*), **Grayling** (4th *Conwy*), **Dark Green Fritillary** (5th *Hucker's Bow*, *Sand Point*, *Somerset* and *Bossington*, *Somerset*), **Essex Skipper** (5th *Levin Down*, *West Sussex*), **High Brown Fritillary** (7th *Alun Valley*, *Glamorgan*), **Black Hairstreak** (15th *Monks Wood*, *Cambridgeshire* and *Rushbeds Wood*, *Buckinghamshire*), **White-letter Hairstreak** (15th *Surrey*), **Purple Hairstreak** (18th *Essex*), **Silver-washed Fritillary** (21st *Devon* and *Dorset*), **White Admiral** (21st *Dorset*), **Purple Emperor** (27th *Surrey* and *Sussex*) and a very early **Silver-spotted Skipper** (28th *Lullington Heath*, *East Sussex*). The majority of June emerging species were seen later on monitored sites than in 2015, including **Chequered Skipper** and **Swallowtail** (by 10 days) **High Brown Fritillary** (13 days) and **Essex Skipper** (16 days).

The combination of a cold spring and a wet and dull early summer period, were likely causal factors in several single-brooded spring-flying species having poor years. These included **Grizzled Skipper** (worst year in the 41-year series), **Pearl-bordered Fritillary** (2nd worst), **Small Pearl-bordered Fritillary** (2nd worst) and **Green Hairstreak** (3rd worst). For the **Grizzled Skipper** there were no substantial annual increases noted, whilst declines in annual indices included from 62 to 17 at *Levin Down*, *West Sussex* and from 40 to 6 at *Ryton Pools Country Park*, *Warwickshire*. Substantial annual declines in the **Pearl-bordered Fritillary** included at *Mabie Forest North*, *Dumfries and Galloway* (from 174 to 92) and *Eyarth Rocks Butterfly Conservation Reserve*, *Denbighshire* (181 to 88), though sites which bucked the trend included *Ewyas Harold Common*, *Herefordshire* (25 to 155) and *Cwm Soden A*, *Ceredigion* (18 to 39).



Heath Fritillary. Photograph by Iain Leach



Scotch Argus. Photograph by Tim Melling

However, it was a good year for the spring-flying **Duke of Burgundy**, the 11th best in the series (starting in 1979). There were some noteworthy annual increases in *West Sussex*, where there has been a lot of conservation effort and positive management in recent years including at *Heyshott Escarpment* (from 86 to 200), *Chantry Hill*, *Post Site KMP7* (16 to 82) and *Chantry Hill*, *Coombe Site KMP6* (28 to 51).

JULY brought 'typical British summer' weather, it being unsettled both in the first half and at the end of the month, with a warm and sunny spell in between. Temperature and rainfall levels were around average, though sunshine was 10% below. In a hot spell from the 18th to 20th, the temperature peaked at 33.5°C in *Oxfordshire*. Completing the emergence of UK butterfly species, there were first sightings of **Chalk Hill Blue** (2nd *Hertfordshire*) and **Scotch Argus** (14th *Argyll*). **Chalk Hill Blue** emerged nine days later on monitored sites than in 2015.

Three species which fly chiefly in June and July had good years, the **Large Blue** (2nd best in 41 year series), **Ringlet** (7th best) and **Black Hairstreak** (10th best). The highest **Black Hairstreak** abundance index of 15 was at *Monks Wood*, *Cambridgeshire* up from three in 2014 and nine in 2015. For many other species that are primarily on the wing during this period, it was a poor year. The **Heath Fritillary** had a bad year, especially in *Kent* where abundance was down substantially at every site except *Clowes Wood*. The **White-letter Hairstreak** abundance index at *Alners Gorse*, *Dorset* tumbled by more than 90%. On the positive side, the maximum **White-letter Hairstreak** index of 23 at *Benfleet*, *Essex* was the highest at any monitored site since 2014. The **White Admiral** did not do especially well at any site, whilst large annual decreases were noted at many sites including *Pamber Forest*, *Hampshire*, *Bubbenhall Wood*, *Warwickshire*, *Piddles Wood* (*DTNC*), *Dorset* and *Spearywell North*, *Hampshire*.

Although it was quite unsettled and windy for much of **AUGUST**, temperature and sunshine levels were above average, whilst rainfall was below average. Temperature values



Green-veined White. Photograph by Jain Leach

peaked at 34°C in Kent on the 24th and dropped below freezing in Perthshire on the 10th. Average butterfly abundance per transect peaked in mid-July and was 1-2 weeks earlier and c.20% below the long-term average. By mid-August, butterfly numbers were greatly reduced, with average abundance per site around a third of the long-term average.

The summer-flying 'golden' skippers had a poor year, with annual abundance of **Lulworth Skipper**, **Small Skipper**, **Large Skipper**, **Essex Skipper** and **Silver-spotted Skipper** down by 75%, 46%, 38%, 52% and 44% respectively. The decline in the **Lulworth Skipper** was chiefly being driven by changes at *Durlston Country Park*, where combined annual abundance from the two transects was a quarter of the 2015 total. Curiously at the *Swanage, Ballard Down* transect which is nearby, annual abundance actually increased by a third. There were also considerable local variations in annual abundance for the **Silver-spotted Skipper**, suggesting management or habitat factors were key drivers of change. For example, at *Box Hill, Surrey* the butterfly collapsed at the *Dukes and Lower (Viewpoint)* transects, but increased at the *Zig Zag*.

It was a dire year for almost all of the summer-flying brown species, especially **Wall** and **Grayling**, which had their worst years in the UKBMS. For **Wall**, just three sites logged annual abundance increases of five or more individuals, compared with 30 sites which recorded declines. The **Wall** decline at *Dyfi, Dyfed* was alarming, with abundance dropping from 73 in 2015 to just three in 2016, whilst at *Brass Castle - Waldrige North, Co Durham* there were 17 in 2015 but none in 2016. For **Grayling**, there were also some alarming annual declines, especially in Suffolk where at *Minsmere* and *North Warren* annual indices went from 279 to 54 and from 129 to 48 respectively. The common and widespread browns fared badly as well. On average, almost a third fewer *Meadow Browns* were seen at each monitored site than in 2015. Annual declines of more than 80% were noted at 20 sites including *Burton Fell, Cumbria* (360 to 38) and *Cinderhill, Shipley Country Park, Derbyshire* (1837 to 282). **Gatekeeper** declines were equally severe, with annual abundance dropping by more than 90% at 15 monitored sites including at *Greenfield Valley Nature Reserve, Flintshire* (389 to 28) and *Kingcombe Redholm 'B' (DTNC), Dorset* (167 to 16).

Autumn

In **SEPTEMBER** the weather continued to be warm and rather changeable, with sunshine and rainfall levels around average. The UK mean temperature was 2.0°C above average, making it the equal second warmest September since 1910. On the 13th, the temperature soared to 34.4°C in Kent. Late season spells of good weather saw surges of **Speckled Wood** and **Red Admiral**, both of which had good years. **Red Admiral** had its 8th best year in the UKBMS, with the maximum index being 321 at *Minsmere, Suffolk*. It was also an above average year for the **Clouded Yellow**, another mainly migrant species, with abundance up by 35% from 2015. **Clouded Yellow** was recorded on 206 transects, with the maximum index being 40 at *Levin Down, West Sussex*.

Overall though, the good weather in early autumn was too late to benefit the majority of September flying species. Two familiar garden butterflies, **Small Tortoiseshell** and **Peacock**, both declined in annual abundance by almost 50%. Large falls in annual abundance for the **Small Tortoiseshell** included at *Avenue Washlands NR, Derbyshire* (201 to 39), *Butterfly World, Herts* (204 to 39) and *Ewelme Watercress LNR, Bedfordshire* (198 to 44). The most substantial drop in annual abundance of the **Peacock** occurred at *Weston and Waverley Wood, Warwickshire* where the index went from 371 to 64.

In **OCTOBER** there were some good spells of fine weather. It was a dry month, with rainfall 37% of the average whilst temperature and sunshine were above average overall. The last day of the month saw the month's highest temperature, with 22.2°C recorded in Dyfed. Though the formal transect recording season had finished, there were 204 visits to 133 sites with 1,249 butterflies counted of 18 species, including sightings of **Chalk Hill Blue** and **Wall**.

Winter

Although no transects were walked in **NOVEMBER** and **DECEMBER**, butterflies continued to be reported to Butterfly Conservation with at least 12 species recorded, including **Speckled Wood**, **Common Blue**, **Holly Blue** and **Clouded Yellow**.



Red Admiral. Photograph by Tim Melling



Long-term trends

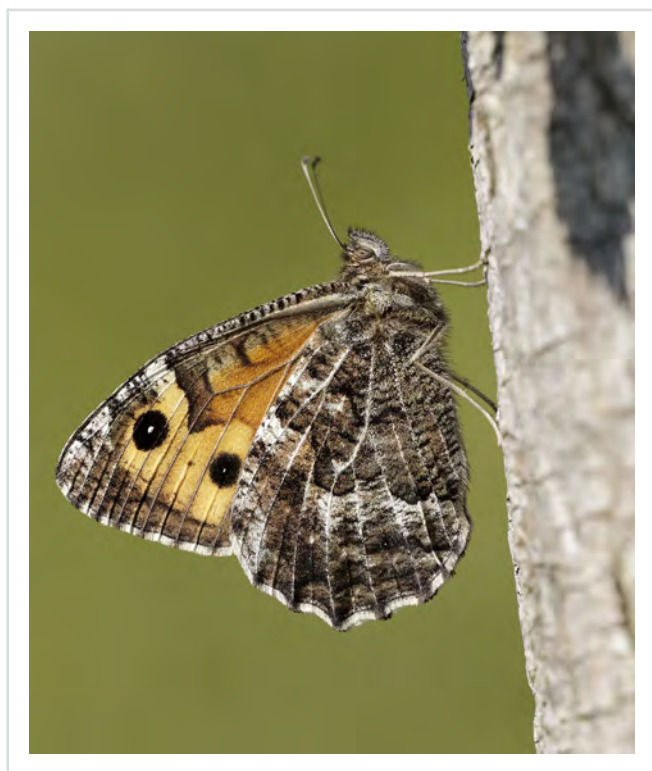
UK-wide and country level trends are described below, whilst further information on each species, including individual collated index plots, are available at the UKBMS website www.ukbms.org.

UNITED KINGDOM

For the UK we are able to report on long-term and ten-year trends for 57 of the 59 regularly occurring species, including 29 habitat specialist species, 25 wider countryside species and the three regular migrants (Table 1). Long-term trends are not calculable for **Cryptic Wood White** and **Mountain Ringlet**. Since 1976, 42% of species show positive trends, whilst 58% show negative trends. Of the species with a significant trend, 13 species show a long-term increase, whilst 22 are in significant decline. The top ten species showing the most acute long-term decline (in rank order, most rapidly declining first) are **White-letter Hairstreak**, **Heath Fritillary**, **Wood White**, **Wall**, **Essex Skipper**, **Chequered Skipper**, **Small Skipper**, **Lulworth Skipper**, **Small Tortoiseshell** and **Pearl-bordered Fritillary**.

The top ten species showing the greatest population increase since 1976 (in rank order, largest first) are **Large Blue**, **Silver-spotted Skipper**, **Clouded Yellow**, **Ringlet**, **Red Admiral**, **Dark Green Fritillary**, **Large Heath**, **Silver-washed Fritillary**, **Adonis Blue** and **Comma**.

Over the last decade the overall picture is quite different, with 49% of species showing negative trends including all three regular migrants, whilst 51% show positive trends. This is a



Grayling. Photograph by Iain Leach

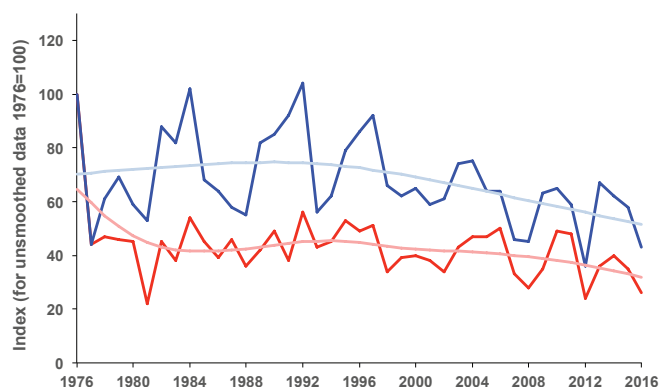


Figure 3. Trends in butterfly populations for habitat specialists (red) and species of the wider countryside (blue) 1976 to 2016. For each species group, darker lines are unsmoothed indices, paler lines are smoothed trends.

similar picture to the previous years' assessment. **Marbled White** and **Duke of Burgundy** have increased significantly over the last decade, whilst **White-letter Hairstreak**, **Chequered Skipper** and **Heath Fritillary** have significantly decreased.

A combined measure of butterfly abundance including index data from 26 habitat specialist and 25 wider countryside species is used as a Governmental butterfly biodiversity indicator <http://jncc.defra.gov.uk/page-4236>. Since 1976, habitat specialists and wider countryside species show apparent declines of 76% and 57% respectively. Analysis of the underlying smoothed trends shows that both habitat specialists and species of the wider countryside have undergone significant 'moderate' declines since 1976.

In 2016, the unsmoothed measure of habitat specialist butterfly abundance decreased by nine percentage points from the previous year, whilst wider countryside species decreased by 15 percentage points.

ENGLAND

For England, we are able to report on long-term and ten-year trends for 55 of the 57 regularly occurring species, including 27 habitat specialist species, 25 wider countryside species and three regular migrants (Table 2). Since 1976, 33% of species show positive trends, whilst 65% have a negative trend. Of the species showing significant trends, 12 species (one more than in 2015) show a long-term increase, whilst 23 are in decline. The ten species in most severe long-term decline (in rank order, largest first) are **White-letter Hairstreak**, **Wall**, **Heath Fritillary**, **Wood White**, **Essex Skipper**, **Marsh Fritillary**, **Scotch Argus**, **Small Skipper**, **Lulworth Skipper** and **Small Tortoiseshell**. Of the 13 species showing a significant population increase, the top ten species (greatest first) are **Large Blue**, **Silver-spotted Skipper**, **Clouded Yellow**, **Ringlet**, **Dark Green Fritillary**, **Red Admiral**, **Silver-washed Fritillary**, **Adonis Blue**, **Painted Lady** and **Comma**.



White-letter Hairstreak. Photograph by Tim Melling

Over the last decade, butterfly population changes for England are much improved with 55% of species showing positive trends, whilst 45% show negative trends including the three regular migrants. Species which have increased significantly include **Duke of Burgundy** and **Marbled White**, whilst species in significant decline are **White-letter Hairstreak** and **Heath Fritillary**.

Composite indices of butterfly abundance have been calculated for 23 wider countryside and 26 habitat specialist species. Since 1976, habitat specialists and wider countryside species show apparent declines of 68% and 56% respectively. Analysis of the underlying smoothed trends shows that since 1976 both habitat specialist and wider countryside species have declined significantly. In 2016, the unsmoothed composite index for habitat specialist butterflies was up by 8 percentage points from the previous year, whilst the wider countryside species index was down 14 percentage points.

Since 1990, composite measures for 15 habitat specialist and 23 wider countryside butterflies in woodland habitats in England, show apparent declines of 64% and 66% respectively. Analysis of the underlying smoothed trend shows these declines to be statistically significant. Of the species showing significant trends, two species show a long-term increase, whilst 19 are in decline. The ten species in most severe long-term decline (in rank order, largest first) are **Duke of Burgundy**, **Wall**, **White-letter Hairstreak**, **High Brown Fritillary**, **Small Copper**, **Grizzled Skipper**, **Small Tortoiseshell**, **Pearl-bordered Fritillary**, **Small Heath** and **Common Blue**. Species which have increased significantly over the long-term are **Ringlet** and **Silver-washed Fritillary**. In 2016, habitat specialist and wider countryside unsmoothed composite indices in woodland habitats were down by seven and 13 percentage points respectively.

In English farmland habitats, composite measures of abundance in 2016 for 21 habitat specialist and 21 wider countryside butterflies, were respectively 33% and 64% of the 1990 baseline. The underlying analysis of smoothed trends indicates a progressive 'moderate' decline in both measures. In farmland habitats, 18 species show a significant long-term decline, whilst five species have increased significantly. The ten species in most severe long-term decline (in rank order, largest first) are **Heath Fritillary**, **High Brown Fritillary**, **White-letter Hairstreak**, **Brown Hairstreak**, **Wall**, **Pearl-bordered Fritillary**, **Lulworth Skipper**, **Small Tortoiseshell**, **Northern Brown Argus** and **Grayling**. Species which have increased significantly over the long-term are **Brimstone**, **Speckled Wood**, **Ringlet**, **Silver-spotted Skipper** and **Dark Green Fritillary**. In 2016, there was a drop of 6 percentage points in the habitat specialist index, whilst the wider countryside measure was down markedly, by 25 percentage points.

SCOTLAND

For Scotland we are able to report on long-term and ten-year trends for 24 of the 34 regularly occurring species, including eight habitat specialist species, 14 wider countryside species and two regular migrants, **Red Admiral** and **Painted Lady** (Table 3). Since 1979, there is an even number of species showing positive and negative trends, whilst two species show no change. Of the seven species showing significant long-term trends, **Chequered Skipper**, **Small Tortoiseshell** and **Grayling** have declined, whilst **Orange-tip**, **Small Heath**, **Peacock** and **Ringlet** have increased.

Over the last decade 58% of monitored species have negative trends, whilst 42% show an increase. **Grayling**, **Chequered Skipper** and **Dark Green Fritillary** have declined significantly over the period, whilst no species have significantly increased.



Dark Green Fritillary. Photograph by Tim Melling

WALES

In Wales, long-term trends can be assessed for 33 of the 43 regularly occurring butterfly species in the country including nine habitat specialists, 21 wider countryside species and three regular migrants (Table 4). Over the long-term, 45% of species have positive trends (one more species than in 2015), whilst 55% have negative trends (one less species). Of the 16 species showing significant long-term change, 11 species are in decline (69%), whilst five (31%) are increasing. The declining species are (most severely declining first) **Purple Hairstreak, Dingy Skipper, Red Admiral, Small Pearl-bordered Fritillary, Common Blue, Painted Lady, Brown Argus, Comma, Small Copper, Small White, Green-veined White** and **Wall**. The increasing species (most rapid first) are **Holly Blue, Marsh Fritillary, Large White, Small Skipper** and **Large Skipper**.

Over the last decade 45% of species show positive trends, including **Red Admiral, Small Tortoiseshell** and **Large White** which have increased significantly, whilst 55% of species show negative trends, including the **Small Copper** and **Gatekeeper**, which declined significantly.

NORTHERN IRELAND

In Northern Ireland, 'long-term' trends (8-13 year periods) are calculable for 13 species (Table 5). Over the period, three species have increased, whilst ten species have decreased. Species which show significant changes (all declines) are **Small Copper, Large White, Orange-tip** and **Marsh Fritillary**.



Pearl-bordered Fritillary. Photograph by Iain Leach



Cryptic Wood White. Photograph by James O'Neill

Notes on Summary Tables 1-4

In the following summary tables the number of sites monitored is a count of all sites on which a species has been monitored in the current analysis year, including those sites on which a species was absent but has been formerly recorded, and thus contribute to the calculation of the national index. For habitat specialist and regular migrant species only sites with sufficient data to calculate a site-level index for each species are included. As with wider countryside species this includes sites where a species was absent in the most recent year but was formerly recorded, if the site has been sufficiently well recorded during the flight period of that species.

For species where at country level there are insufficient data to calculate accurate trends the number of sites refers to the total number of sites at which the species was recorded in the current analysis year.

Note: some country-level changes are based on relatively small sample sizes and thus should be interpreted with caution.



Table 1. Summary of species abundance changes in the UK from 2015 to 2016 and long-term (over the entire time series: no. yrs max = 41) and short-term (last 10-years) changes. The mean flight date is calculated as the weighted mean date of counts and is highly correlated to both first appearance and the peak flight date (Botham et al. 2008). Significance of trends: *P < 0.05 (significant), **P < 0.01 (highly significant), *P < 0.001 (very highly significant). Red text has been used to highlight those species that had their worst year of the series in 2015 and blue text best year in the series.**

Species	Start Year	No. years with Index in 2016	No. sites monitored in 2016	2016 Rank	% change 2015-2016	Series trend (%)	10-year trend (%)	Mean flight date 2016	Series Mean flight date
Swallowtail	1976	37	4	34	-22	45	-28	01-Jul	01-Jul
Dingy Skipper	1976	41	338	22	-23	-13	51	26-May	01-Jun
Grizzled Skipper	1976	41	227	41	-24	-43**	-38	25-May	28-May
Chequered Skipper	2003	10	21	8	28	-86***	-76*	01-Jun	04-Jun
Essex Skipper	1977	40	850	37	-52	-88***	45	22-Jul	24-Jul
Small Skipper	1976	41	1623	36	-46	-75***	94	19-Jul	20-Jul
Lulworth Skipper	1992	25	15	19	-61	-75**	252	24-Jul	27-Jul
Silver-spotted Skipper	1979	38	44	17	-44	839***	66	15-Aug	15-Aug
Large Skipper	1976	41	1632	36	-38	-19	28	07-Jul	05-Jul
Wood White	1979	38	49	30	7	-90***	5	19-Jun	17-Jun
Cryptic Wood White	N/A	N/A	5	N/A	N/A	N/A	N/A	03-Jun	03-Jun
Orange-tip	1976	41	1524	18	-7	10	43	16-May	16-May
Large White	1976	41	2117	28	-7	-31	-21	21-Jul	21-Jul
Small White	1976	41	2109	28	11	-29	6	23-Jul	21-Jul
Green-veined White	1976	41	2112	27	12	-12	4	11-Jul	08-Jul
Clouded Yellow	1979	38	406	16	35	777*	225	23-Aug	09-Aug
Brimstone	1976	41	1480	15	-28	9	59	01-Jun	08-Jun
Wall	1976	41	657	41	-31	-89***	-26	21-Jul	27-Jul
Speckled Wood	1976	41	1985	18	12	76***	-9	03-Aug	26-Jul
Large Heath	1990	27	3	25	-50	177**	-71	13-Jul	07-Jul
Small Heath	1976	41	1387	39	-26	-58***	13	11-Jul	09-Jul
Mountain Ringlet	N/A	N/A	3	N/A	N/A	N/A	N/A	19-Jul	12-Jul
Scotch Argus	1979	38	46	31	-22	132**	3	10-Aug	08-Aug
Ringlet	1976	41	1976	7	-13	374***	44	13-Jul	14-Jul
Meadow Brown	1976	41	1935	39	-31	-4	11	21-Jul	21-Jul
Gatekeeper	1976	41	1822	40	-48	-44**	-7	31-Jul	01-Aug
Marbled White	1976	41	1015	13	-22	60**	120**	13-Jul	15-Jul
Grayling	1976	41	164	41	-27	-66***	-29	03-Aug	05-Aug
Pearl-bordered Fritillary	1976	41	138	40	-45	-72***	20	29-May	01-Jun
Small Pearl-bordered Fritillary	1976	41	99	40	-6	-63***	-14	17-Jun	25-Jun
Silver-washed Fritillary	1976	41	487	18	-45	146***	17	28-Jul	26-Jul
Dark Green Fritillary	1976	41	333	20	-32	183***	-2	19-Jul	21-Jul
High Brown Fritillary	1978	39	61	25	0	-66*	120	15-Jul	15-Jul
White Admiral	1976	41	223	41	-59	-65***	-52	19-Jul	16-Jul
Purple Emperor	1979	38	73	28	-16	44	-24	23-Jul	20-Jul
Red Admiral	1976	41	908	8	86	251***	-2	08-Aug	05-Aug
Painted Lady	1976	41	749	17	-7	134	-57	24-Jul	30-Jul
Peacock	1976	41	2065	36	-46	11	-4	12-Jun	30-Jun
Small Tortoiseshell	1976	41	2053	38	-47	-75***	123	27-Jun	08-Jul
Comma	1976	41	1771	27	-28	138***	-23	19-Jul	20-Jul
Marsh Fritillary	1981	36	89	30	-32	-25	-50	29-May	05-Jun
Glanville Fritillary	1989	25	7	11	7	-31	-51	05-Jun	09-Jun
Heath Fritillary	1981	36	34	36	-27	-91***	-82***	30-Jun	02-Jul
Duke of Burgundy	1979	37	104	11	19	-40*	90*	28-May	29-May
Small Copper	1976	41	1559	39	6	-47**	-43	09-Aug	01-Aug
Brown Hairstreak	1983	34	96	18	12	10	-9	01-Sep	24-Aug
Purple Hairstreak	1976	41	474	32	13	-56*	-15	31-Jul	30-Jul
Green Hairstreak	1976	41	355	39	-38	-39**	-11	24-May	28-May
White-letter Hairstreak	1976	41	204	41	-42	-97***	-72*	27-Jul	25-Jul
Black Hairstreak	1995	21	11	10	-47	-30	-59	24-Jun	28-Jun
Small Blue	1978	39	166	15	45	4	2	25-Jun	30-Jun
Holly Blue	1976	41	1464	22	-34	44	-25	28-Jun	29-Jun
Large Blue	1983	34	27	2	38	1472***	111	24-Jun	25-Jun
Silver-studded Blue	1979	38	71	19	16	12	48	12-Jul	15-Jul
Brown Argus	1976	41	827	32	-27	-25	28	02-Aug	31-Jul
Northern Brown Argus	1979	38	32	26	18	-53*	47	03-Jul	10-Jul
Common Blue	1976	41	1800	38	-52	-24	27	22-Jul	24-Jul
Adonis Blue	1979	38	92	27	-18	140*	-32	28-Jul	26-Jul
Chalk Hill Blue	1976	41	188	39	-40	8	56	07-Aug	08-Aug



Table 2. England summary of species abundance changes from 2015 to 2016 and long-term (over the entire time series: no. yrs max = 41) and short-term (last 10-years) changes. Significance of trends: *P < 0.05 (significant), **P < 0.01 (highly significant), *P < 0.001 (very highly significant). Red text has been used to highlight those species that had their worst year of the series in 2015 and blue text best year in the series.**

Species	Start Year	No. years with Index in 2016	No. sites monitored in 2016	2016 Rank	% change 2015-2016	Series trend (%)	10-year trend (%)
Swallowtail	1976	37	4	34	-22	45	-28
Dingy Skipper	1976	41	323	22	-19	-8	54
Grizzled Skipper	1976	41	221	41	-23	-43**	-36
Essex Skipper	1977	40	843	37	-53	-88***	40
Small Skipper	1976	41	1556	37	-47	-76***	87
Lulworth Skipper	1992	25	15	19	-61	-75**	252
Silver-spotted Skipper	1979	38	44	17	-44	839***	66
Large Skipper	1976	41	1563	36	-38	-16	27
Wood White	1979	38	49	30	7	-90***	5
Orange-tip	1976	41	1336	18	-5	1	56
Large White	1976	41	1879	27	-4	-29	-18
Small White	1976	41	1869	27	13	-25	6
Green-veined White	1976	41	1804	27	9	-16	2
Clouded Yellow	1979	38	391	16	34	799*	231
Brimstone	1976	41	1444	15	-28	7	60
Wall	1976	41	592	41	-28	-91***	-30
Speckled Wood	1976	41	1800	18	12	77**	-9
Large Heath	N/A	N/A	2	N/A	N/A	N/A	n/a
Small Heath	1976	41	1186	38	-24	-64***	19
Mountain Ringlet	N/A	N/A	1	N/A	N/A	N/A	N/A
Scotch Argus	1995	22	12	20	-18	-77***	-16
Ringlet	1976	41	1735	6	-11	393***	43
Meadow Brown	1976	41	1880	39	-31	-6	11
Gatekeeper	1976	41	1735	40	-48	-47**	-7
Marbled White	1976	41	1009	13	-22	59*	121**
Grayling	1976	41	145	41	-25	-49***	-17
Pearl-bordered Fritillary	1978	39	87	38	-47	-63***	-15
Small Pearl-bordered Fritillary	1978	39	82	35	-9	-46**	9
Silver-washed Fritillary	1976	41	477	19	-46	164***	13
Dark Green Fritillary	1976	41	304	17	-34	393***	8
High Brown Fritillary	1978	39	52	26	0	-66*	116
White Admiral	1976	41	223	41	-59	-65***	-52
Purple Emperor	1979	38	73	28	-16	44	-24
Red Admiral	1976	41	851	8	90	258***	1
Painted Lady	1976	41	702	19	-8	139	-56
Peacock	1976	41	1808	36	-48	13	-2
Small Tortoiseshell	1976	41	1779	37	-47	-75***	146
Comma	1976	41	1669	27	-28	139***	-23
Marsh Fritillary	1982	35	58	31	-17	-79**	-79
Glanville Fritillary	1989	25	7	11	10	-31	-51
Heath Fritillary	1981	36	34	36	-27	-91***	-82***
Duke of Burgundy	1979	37	104	11	19	-40*	90*
Small Copper	1976	41	1379	40	7	-44*	-46
Brown Hairstreak	1983	34	78	33	-50	-26	-14
Purple Hairstreak	1976	41	461	32	12	-58*	-11
Green Hairstreak	1976	41	343	40	-25	-46**	-28
White-letter Hairstreak	1976	41	211	41	-45	-96***	-72*
Black Hairstreak	1995	21	11	10	-47	-30	-59
Small Blue	1979	38	158	16	44	-33	17
Holly Blue	1976	41	1385	21	-36	46	-24
Large Blue	1983	34	27	2	38	1472***	111
Silver-studded Blue	1984	33	67	18	10	-27	54
Brown Argus	1976	41	812	32	-27	-25	29
Northern Brown Argus	1979	35	27	28	10	-67***	40
Common Blue	1976	41	1607	38	-53	-22	36
Adonis Blue	1979	38	92	27	-18	140*	-32
Chalk Hill Blue	1976	41	188	39	-40	8	56

Table 3. Scotland summary of species abundance changes from 2015 to 2016 and long-term (over the entire time series: no. yrs max = 38) and short-term (last 10-years) changes. Significance of trends: *P < 0.001 (very highly significant). Red text has been used to highlight those species that had their worst year of the series in 2015 and blue text best year in the series.**

Species	Start Year	No. years with Index in 2016	No. sites monitored in 2016	2016 Rank	% change 2015-2016	Series trend (%)	10-year trend (%)
Dingy Skipper	N/A	N/A	1	N/A	N/A	N/A	N/A
Chequered Skipper	2003	10	21	8	28	-86***	-76*
Small Skipper	N/A	N/A	3	N/A	N/A	N/A	N/A
Large Skipper	N/A	N/A	0	N/A	N/A	N/A	N/A
Orange-tip	1999	18	109	7	-21	213**	6
Large White	1979	38	100	38	-13	-25	-75
Small White	1979	38	102	36	-12	-28	-48
Green-veined White	1979	38	169	23	41	19	25
Clouded Yellow	N/A	N/A	0	N/A	N/A	N/A	N/A
Wall	1999	18	10	11	62	-71	47
Speckled Wood	2001	16	46	9	62	0	-18
Large Heath	N/A	N/A	10	N/A	N/A	N/A	N/A
Small Heath	1979	38	113	25	-43	186***	-26
Mountain Ringlet	N/A	N/A	2	N/A	N/A	N/A	N/A
Scotch Argus	1990	27	34	21	-28	32	36
Ringlet	1999	18	125	14	-40	64*	3
Meadow Brown	1979	38	136	31	-41	-4	-24
Grayling	1990	18	5	18	-61	-82***	-79*
Pearl-bordered Fritillary	2002	11	37	8	-54	54	1
Small Pearl-bordered Fritillary	1979	34	8	1	109	40	4
Dark Green Fritillary	1979	36	11	31	8	-38	-66*
Red Admiral	1980	30	15	22	-15	73	-49
Painted Lady	1980	22	15	10	362	-69	-82
Peacock	1995	22	132	18	-40	140*	-44
Small Tortoiseshell	1979	38	139	36	-48	-49*	2
Comma	2006	11	33	10	-73	-61	-67
Marsh Fritillary	N/A	N/A	4	N/A	N/A	N/A	N/A
Small Copper	1979	38	82	27	13	-37	-41
Green Hairstreak	N/A	N/A	12	N/A	N/A	N/A	N/A
Small Blue	2005	12	3	8	161	0	-42
Holly Blue	N/A	N/A	2	N/A	N/A	N/A	N/A
Northern Brown Argus	1981	21	5	5	38	57	5
Common Blue	1979	38	90	24	-29	95	31



Table 4. Wales summary of species abundance changes from 2015 to 2016 and long-term (over the entire time series: no. yrs max = 41) and short-term (last 10-years) changes. Significance of trends: *P < 0.05 (significant), **P < 0.01 (highly significant), *P < 0.001 (very highly significant). Red text has been used to highlight those species that had their worst year of the series in 2015 and blue text best year in the series.**

Species	Start Year	No. years with Index in 2016	No. sites monitored in 2016	2016 Rank	% change 2015-2016	Series trend (%)	10-year trend (%)
Dingy Skipper	2004	7	13	6	-38	-63	-57
Grizzled Skipper	N/A	N/A	3	N/A	N/A	N/A	N/A
Essex Skipper	N/A	N/A	2	N/A	N/A	N/A	N/A
Small Skipper	1984	33	65	19	-53	19	252*
Large Skipper	1977	40	54	29	-29	-73***	93
Orange-tip	1978	39	49	11	-21	314***	9
Large White	1976	41	85	35	46	-61***	-61*
Small White	1976	41	83	40	43	-75***	-20
Green-veined White	1976	41	84	24	12	67	-19
Clouded Yellow	N/A	N/A	0	N/A	N/A	N/A	N/A
Brimstone	1998	19	29	7	-7	1	59
Wall	1976	41	48	41	-48	-49*	-11
Speckled Wood	1978	39	81	16	14	103**	-10
Large Heath	N/A	N/A	2	N/A	N/A	N/A	N/A
Small Heath	1976	41	61	39	-43	14	15
Ringlet	1983	34	75	4	-24	239***	133*
Meadow Brown	1976	41	84	39	-54	13	10
Gatekeeper	1978	39	73	31	-39	27	-11
Marbled White	N/A	N/A	5	N/A	N/A	N/A	N/A
Grayling	1976	30	11	30	-80	-86***	-44
Pearl-bordered Fritillary	1997	19	14	10	-23	208**	121
Small Pearl-bordered Fritillary	1993	17	9	17	-59	-54**	-37
Silver-washed Fritillary	1995	16	9	11	24	-91**	34
Dark Green Fritillary	1979	22	16	18	-43	-71***	69
High Brown Fritillary	1995	13	9	8	-47	16	70
Red Admiral	1976	41	27	18	24	125	-45
Painted Lady	1977	28	21	10	10	-37	-33
Peacock	1976	41	79	39	-53	-55**	19
Small Tortoiseshell	1976	41	82	35	-44	-42	49
Comma	1992	25	55	16	-54	106	-30
Marsh Fritillary	1990	27	21	20	-60	-78*	613*
Small Copper	1976	41	65	40	-48	-61**	-26
Brown Hairstreak	2004	13	18	7	17	-15	-7
Purple Hairstreak	2002	15	11	14	-52	-75	-80
Green Hairstreak	1993	22	9	3	10	268*	26
White-letter Hairstreak	N/A	N/A	2	N/A	N/A	N/A	N/A
Small Blue	N/A	N/A	5	N/A	N/A	N/A	N/A
Silver-studded Blue	N/A	N/A	6	N/A	N/A	N/A	N/A
Holly Blue	1999	18	48	16	-44	-48	-62*
Brown Argus	1977	20	13	13	5	31	-31
Common Blue	1976	41	71	40	-44	-26	-34

Table 5. Northern Ireland summary of species abundance changes from 2015 to 2016 and long-term (over the entire time series: no. yrs max = 13) and short-term (last 10-years) changes. Significance of trends: *P < 0.05 (significant), **P < 0.01 (highly significant), *P < 0.001 (very highly significant). Red text has been used to highlight those species that had their worst year of the series in 2015 and blue text best year in the series.**

Species	Start Year	No. years with Index in 2016	No. sites monitored in 2016	2016 Rank	% change 2015-2016	Series trend (%)	10-year trend (%)
Dingy Skipper	N/A	N/A	1	N/A	N/A	N/A	N/A
Cryptic Wood White	N/A	N/A	5	N/A	N/A	N/A	N/A
Orange-tip	2007	10	26	6	9	-41	-41
Large White	2006	11	35	10	7	-53	-59
Small White	2006	11	37	10	44	-69*	-67*
Green-veined White	2005	12	41	8	38	67	10
Speckled Wood	2007	10	39	5	44	5	5
Small Heath	2006	11	21	8	0	-71*	-70*
Ringlet	2006	11	42	7	-24	128	176*
Meadow Brown	2009	8	40	7	-13	-35	-35
Grayling	N/A	N/A	1	N/A	N/A	N/A	N/A
Silver-washed Fritillary	N/A	N/A	3	N/A	N/A	N/A	N/A
Dark Green Fritillary	N/A	N/A	6	N/A	N/A	N/A	N/A
Red Admiral	N/A	N/A	11	N/A	N/A	N/A	N/A
Painted Lady	N/A	N/A	6	N/A	N/A	N/A	N/A
Peacock	2006	11	30	10	-21	-79*	-64
Small Tortoiseshell	2010	7	41	7	-43	-71**	-71**
Marsh Fritillary	2004	13	9	11	-11	-28	-61
Small Copper	2005	12	21	12	-33	-70	-68
Green Hairstreak	N/A	N/A	2	N/A	N/A	N/A	N/A
Holly Blue	N/A	N/A	3	N/A	N/A	N/A	N/A
Common Blue	2005	12	15	8	-61	-24	77



Speckled Wood
Photograph by Martin Warren



Green-veined White. Photograph by Steve Palmer



The Centre for Ecology & Hydrology (CEH) is the UK's Centre of Excellence for integrated research in terrestrial and freshwater ecosystems and their interaction with the atmosphere. As part of the Natural Environment Research Council (NERC) CEH works in partnership with the research community, policymakers, industry and society, to deliver world-class solutions to the most complex environmental challenges facing humankind.



Butterfly Conservation (BC) is the charity aimed at securing a lasting future for butterflies, moths and their habitats. It works in partnership with thousands of volunteers and a wide range of organisations in the UK and Europe to secure a healthy environment where we all can live.



The British Trust for Ornithology (BTO) is an independent charitable research institute combining professional and citizen science aimed at using evidence of change in wildlife populations, particularly birds, to inform the public, opinion-formers and environmental policy- and decision-makers.



The Joint Nature Conservation Committee (JNCC) is the statutory adviser to Government on UK and international nature conservation. Its work contributes to maintaining and enriching biological diversity, conserving geological features and sustaining natural systems. JNCC delivers the UK and international responsibilities of the four country nature conservation agencies - Council for Nature Conservation and the Countryside, Natural Resources Wales, Natural England and Scottish Natural Heritage.



Natural Resources Wales (NRW) is the principle adviser to the Welsh Government on the environment, enabling the sustainable development of Wales' natural resources for the benefit of people, the economy and wildlife.



The Forestry Commission (FC) is the government department for forestry in Great Britain. It works to improve people's lives through the many benefits provided by sustainably managed woods and forests, including timber production, public recreation, nature conservation, and rural and community development. It does this by supporting woodland managers with grants, tree felling licences, regulation and advice, and advising Ministers in the UK, Scottish and Welsh Assembly Governments on forestry policy. It manages more than 1 million hectares (2.5 million acres) of public forest land owned or leased by Ministers to provide the above benefits, and through its Forest Research agency, it conducts world-class scientific research and technical development relevant to forestry.



Natural England is an independent public body whose purpose is to protect and improve England's natural environment, for its intrinsic value, the wellbeing and enjoyment of people and the economic prosperity that it brings.



Scottish Natural Heritage (SNH) is the government body that looks after all of Scotland's nature and landscapes, across all of Scotland, for everyone.



Northern Ireland Environment Agency (NIEA) is the agency for the protection and conservation of the natural and built environment in Northern Ireland

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