Butterfly Conservation

Saving butterflies, moths and our environment

The State of the UK's Butterflies 2022

Although its population levels have increased since the 1970s, Adonis Blue numbers have taken a sharp downturn recently leading it to be listed as Vulnerable on the GB Red List.

FRONT COVER: Small Pearl-bordered Fritillary has decreased severely in the UK since 1976, with a 66% drop in abundance and 71% decrease in distribution (image: Mark Searle).

Summary

Seven years on from the last State of UK's Butterflies report, the plight of insects has become a common concern. However, conserving "the little things that run the world"[1] remains an enormous challenge. Although the four UK nations are among the most ecologically degraded globally[2], we lead the world in monitoring our remaining wildlife[3]. This report presents the latest assessment of the UK's 59 species of breeding butterfly derived from long-running, countrywide schemes using millions of citizen-science observations to chart the changing abundance and distribution of these iconic insects. The results provide a robust evidence-base for conservation, policy development and scientific research focussed on UK butterflies. Further, they indicate the state of the environment and wider biodiversity in the UK and afford important insights into the global phenomenon of insect decline.

The key findings are:

▶ **In the UK, long-term trends show that 80% of butterfly species have decreased in abundance or distribution**, or both since the 1970s. By comparison, 56% of species increased in one or both trends. These findings are very similar to the headline results of the previous assessment in 2015[4]. As then, we find that there are winners and losers but, on average, UK butterflies[5] have lost 6% of their total abundance at monitored sites and 42% of their distribution over the period 1976-2019.

Considering only the changes that we have most confidence in (those that are statistically significant), almost twice as many UK species have decreased in at least one measure than have increased: 61% have decreased and 32% increased.

▶ **Most habitat specialist species, those restricted to particular habitats such as flower-rich grassland, heathland and woodland clearings, have declined dramatically in the UK.** As a group, their abundance has decreased by over one-quarter (-27%) and their distribution by over two-thirds (-68%) since 1976.

▶ **Wider countryside species, butterflies that can breed in the farmed countryside and in urban areas, have fared less badly**, although as a group they have decreased since 1976 (-17% in abundance and -8% in distribution).

ADONIS BLUE: MARK SEARLE

[1] Wilson 1987

▶ **Of the four UK countries, England's butterflies have fared the worst** with an overall distribution change of -45% since 1976, largely driven by a very steep (-75%) decrease in the distributions of habitat specialist species. The abundance of habitat specialists also decreased (-25% over the same period), although the abundance of all species combined has shown little change. 36% of species decreased significantly in abundance and 61% in distribution, compared to 24% that increased significantly in abundance and 17% in distribution.

▶ **Multi-species indicators for Northern Ireland's butterflies show a change of -17% in abundance** (2006-2019) and -10% in distribution (1993-2019), although these indicators exclude many rarer species that do not yet have sufficient data to produce reliable trends. Of the species with long-term trends, 14% (two species) decreased significantly in abundance and 47% decreased significantly in distribution. No species increased significantly in abundance and two species (13%) increased significantly in distribution.

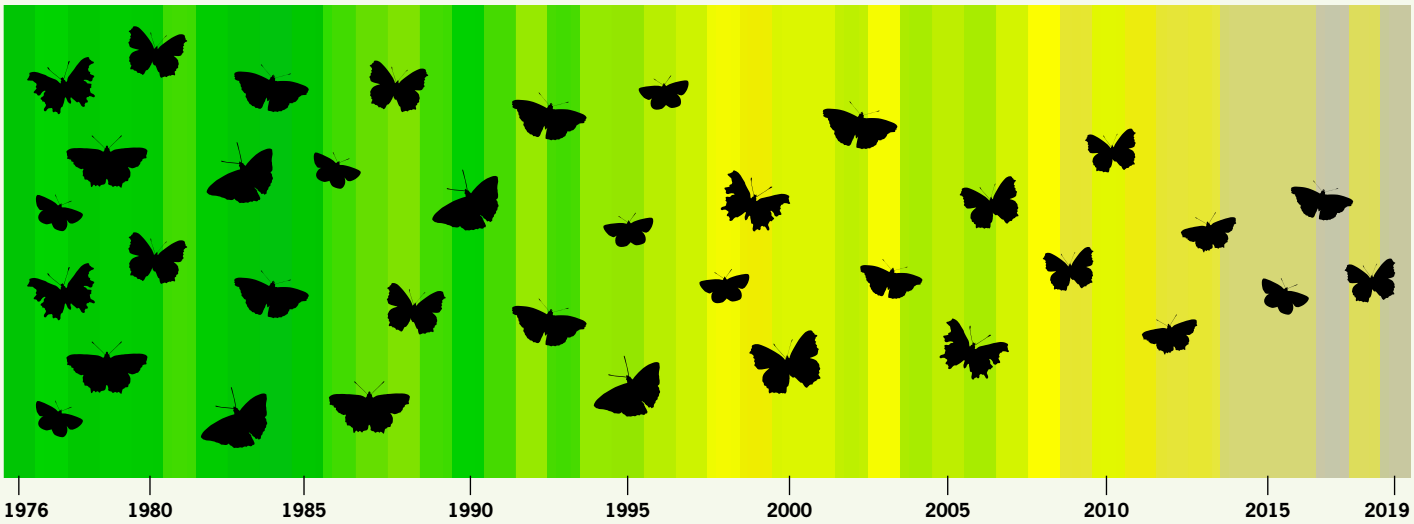
▶ **Scotland is the only UK country in which butterflies show a pattern of overall long-term increases**, +37% abundance (1979-2019) and +3% distribution (1992-2019). However, while wider countryside species have increased in abundance (+26% 1979-2019) and distribution (+31% 1992-2019), habitat specialists have declined in abundance (-27% 1990-2019) and distribution (-26% 1995-2019). Of the species with long-term trends, 8% decreased significantly in abundance and 36% increased. However, 38% of species showed significant decreases in distribution and 23% significant increases.

▶ **The all-species butterfly abundance indicator for Wales has changed little** (-8% 1978-2019), but this masks a major decline of habitat specialists (-45% 1993-2019) offset by an increase in wider countryside species (+18% 1978-2019). In terms of distribution, butterflies are declining in Wales, with an overall decrease of almost one-quarter (-24% 1988-2019), and reductions for both habitat specialists (-39% 1993-2019) and wider countryside species (-14% 1988-2019). 18% of species have decreased significantly in abundance and 55% in distribution, while 24% have increased significantly in abundance and just 6% in distribution.

▶ **Despite the gloomy picture painted by the long-term trends, numerous examples show that targeted species conservation action can turn around the fortunes of threatened butterflies** at site, landscape and national levels. However, the resources currently available for such work are woefully inadequate to address the scale of the task and to stem the ongoing decline of the UK's butterflies.

▶ **Continuing to increase the recording and monitoring of the UK's butterfly populations is essential** to document wider biodiversity change, understand its causes, help develop and measure effective solutions, and to engage people in citizen science. Thanks to the ongoing growth of Butterflies for the New Millennium and the UK Butterfly Monitoring Scheme, we can now provide country-level species trends and composite indicators of overall butterfly change in distribution and abundance, in addition to the UK-level assessment. However, more investment is required to ensure that we can report on all species, especially those that are threatened or rare, in each UK country and to develop additional, policy-relevant indicators.

This 'butterfly stripes' graphic represents the declining distribution of UK butterflies 1976-2019. The colour of each stripe represents the annual index value of the unsmoothed UK all-species butterfly distribution indicator (see p.13).



[2] According to the Biodiversity Intactness Index (www.nhm.ac.uk/our-science/data/biodiversity-indicators), which estimates how much of an area's natural biodiversity remains, England ranks seventh worst out of 240 countries/territories assessed worldwide, Northern Ireland is 12th worst, Wales 16th and Scotland 28th.

[3] Burns *et al.* 2018

[4] Fox *et al.* 2015

[5] The species included in the overall butterfly trends are not simply a sum of those included in the habitat specialist and wider countryside groups. For example, common migrant species are included in the overall trends but not in either of the other groups.

Introduction, evidence and analysis

Since the previous assessment of the state of the UK's butterflies in 2015[6], much has been published, discussed and speculated about the decline of insect populations around the world[7]. While some of the wilder claims have been rightly criticised by the scientific community[8], there is substantial evidence for the rapid decline of terrestrial insects, at least in western Europe and North America[9], and including butterflies[10].

UK butterflies are among the most comprehensively monitored insects in the world, with spatially extensive data on species' distribution and population abundance dating back to the 1970s. These citizen science data have mainly been contributed by volunteers, thanks to a long tradition of natural history study and recording, that is more popular in the UK today than it has ever been. This incredible effort is encouraged and channelled through two main recording schemes, the UK Butterfly Monitoring Scheme (UKBMS) and Butterflies for the New Millennium (BNM), which gather data on species' abundance and distribution respectively. Sampling methodology differs substantially between these two schemes, requiring separate data analysis techniques. Ultimately, however, the schemes provide equally useful, important and complementary information on how each species is faring.

These data have revealed long-term declines in many UK butterfly species[11] and have been used to assess extinction risk, prioritise species for conservation action and legal protection, measure the success of projects and policies, and enable informed land planning decisions. Half of Britain's remaining butterfly species are listed as threatened (Endangered or Vulnerable: 24 species) or Near Threatened (5 species) on the latest GB Red List[12]. In response, Butterfly Conservation has developed a new Threatened Species Programme, targeting 12 butterfly species (and 59 moths) for concerted action over the next few years. These UK Priority Species of butterflies are Chequered Skipper, Lulworth Skipper, Wood White, Cryptic Wood White, Large Heath, Pearl-bordered Fritillary, High Brown Fritillary, Marsh Fritillary, Heath Fritillary, Duke of Burgundy, Large Blue and Northern Brown Argus.

Most insects, including butterflies, have very short life cycles and their population sizes can vary hugely from generation to generation[13] in response to competition for resources[14], natural enemies[15], weather events[16] and changes in habitat quality[17] (e.g. due to changing management). Numerous studies have highlighted the unreliability of estimating species trends over short periods or from snapshot surveys, because of such population variability[18], stressing the need for long-term data to detect genuine change in insect populations[19]. The data on UK butterflies gathered by the UKBMS and BNM schemes thus provide a gold standard for assessing insect population change over many decades and we focus on long-term trends in this assessment.

Lulworth Skipper

LULWORTH SKIPPER: MARK SEARLE

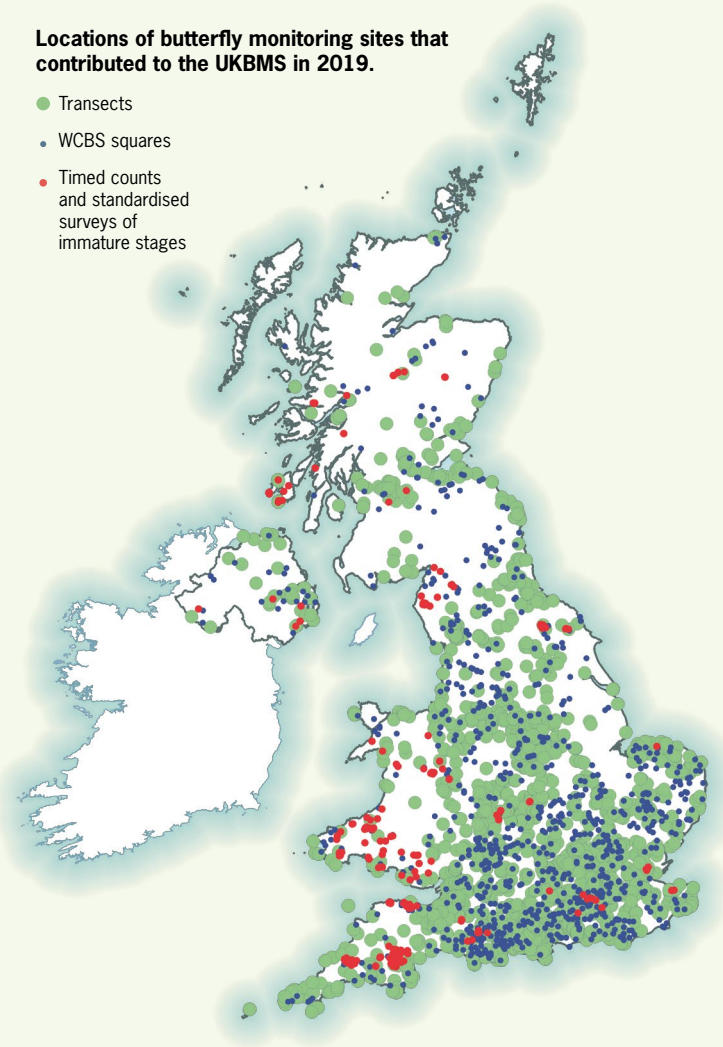
Population monitoring

Standardised monitoring of UK butterfly populations is carried out under the UKBMS. The main method used is the butterfly transect count developed by Ernie Pollard and colleagues in the early 1970s[20], in which recorders walk a fixed route (transect) in good weather each week from 1 April to 30 September and count every butterfly in an imaginary 5m box. In a minority of cases, transects are focussed on a single target species and are only walked during its flight period. The UKBMS network of butterfly transects was established in 1976 and has grown considerably over the years, with transects walked at 1,824 sites in 2019.

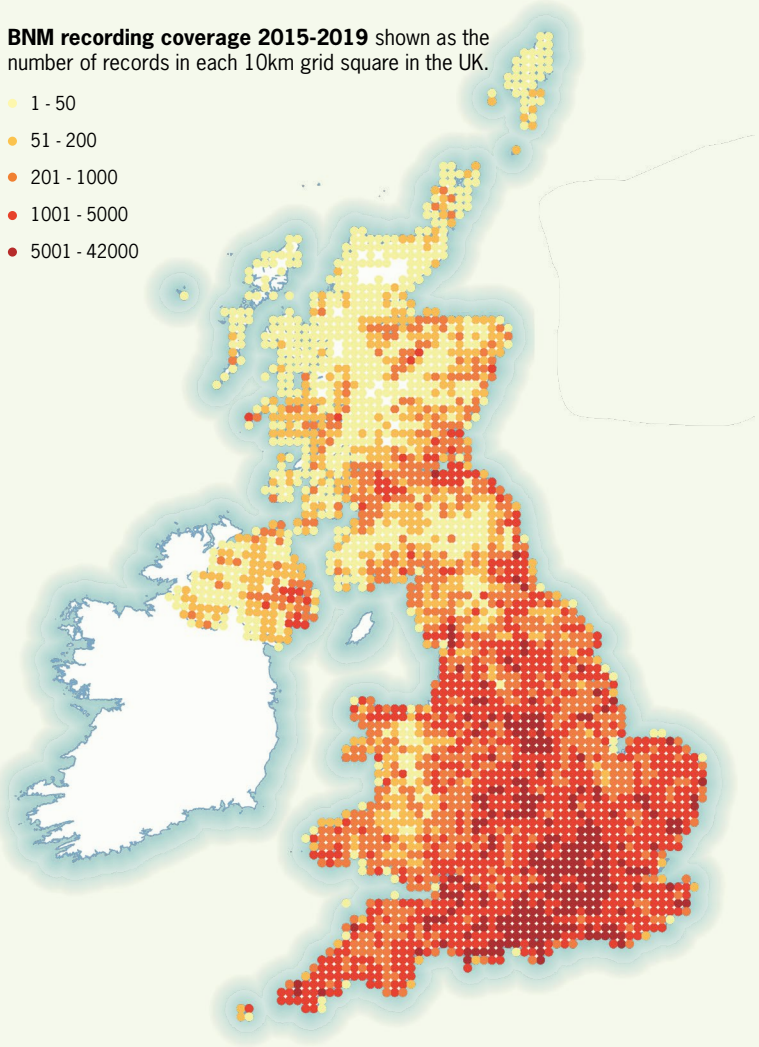
Transect routes are set up by volunteer recorders or by site managers and are heavily biased towards sites managed (at least in part) for nature conservation. This is highly beneficial in ensuring sufficient coverage of scarce and rare butterfly species, as well as in informing and monitoring site management. However, to make sure that the UKBMS also reflects the changing populations of butterflies living away from protected areas, a second method was developed and rolled out in 2009 as the Wider Countryside Butterfly Survey (WCBS). This uses the same standardised transect method but with reduced effort (a minimum of just two visits per year during the peak of the butterfly season) and in a selection of randomly chosen 1km x 1km grid squares.

Species counts from these different forms of transects, along with additional data from timed counts of adults and searches for immature stages, are all undertaken using standardised methodology, in good weather and with an estimate of the area sampled. Thus, counts can be combined across weeks for individual sites and then across sites to

Locations of butterfly monitoring sites that contributed to the UKBMS in 2019.



BNM recording coverage 2015-2019 shown as the number of records in each 10km grid square in the UK.



produce an annual measure of abundance for each monitored species. Missing counts, for example if the weather is unsuitable or the recorder is unavailable, are estimated using modelled species' flight curves, ensuring that all counts undertaken by recorders can contribute to the annual index for each species[21]. However, sites with more visits during the peak flight period have a greater weighting in the annual index for a species compared to sites with fewer.

We used all UKBMS data from UK sites (England, Northern Ireland, Scotland and Wales), comprising 8.3 million species records, to calculate long-term trends in relative abundance of species using linear regression through the logged annual index values. Trends were calculated at the UK level and separately for each of the four UK countries, where there were sufficient data, with statistical significance assessed by linear regression. While the abundance trends for most species start in 1976, some rarer species do not have enough data in the early years to produce a statistically robust estimate, so these trends start later. Results are therefore presented as both total percentage change over the trend period and as average 10-year rates of change that allow for direct comparison of species with trends measured over different time periods. Trends were estimated for 58 species, all but one (Mountain Ringlet) of the UK's resident and regular breeding butterfly species. Apart from Cryptic Wood White (11 years) and Chequered Skipper (17 years), all other species had trends calculated over at least 25 years at the UK level (though the figures are different for the separate UK countries).

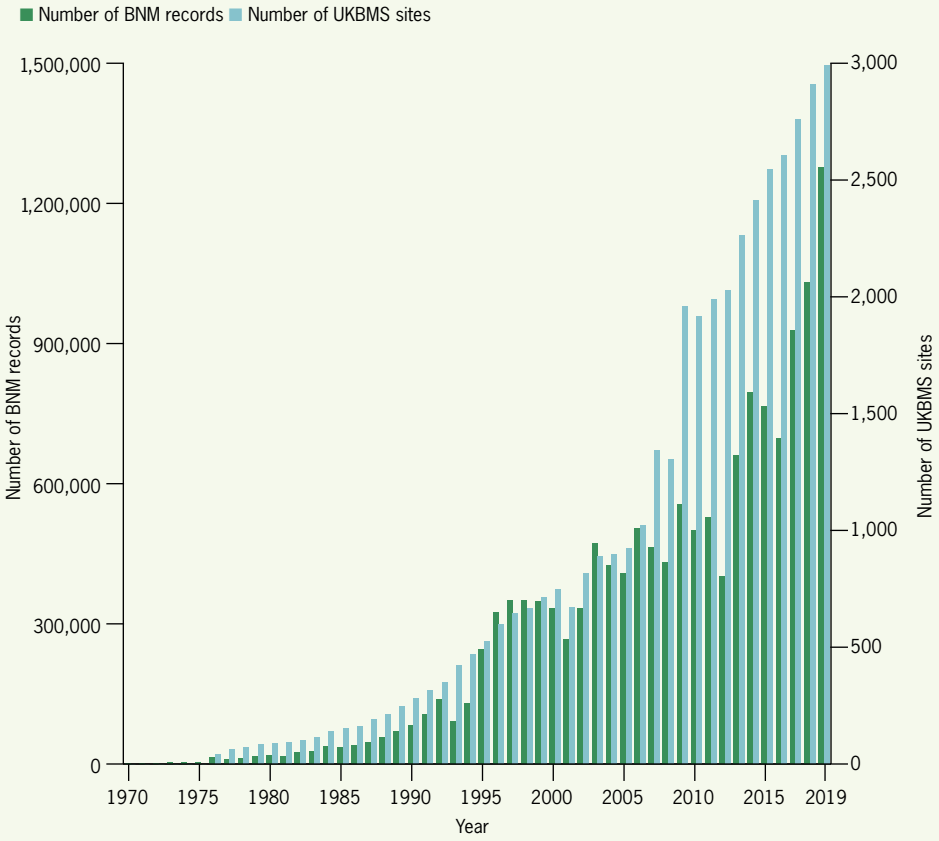
Abundance indices were also combined into multi-species indicators at UK and country levels to see how butterflies as a whole are faring and also to look at group differences between habitat specialists and wider countryside species. The methods and results are presented on p.12-13.

Distribution recording

The distribution of each butterfly species in the UK is measured from records submitted through the BNM scheme. Such records are typically non-standardised;

6 Fox *et al.* 2015
7 Wagner 2020
8 Thomas *et al.* 2019, Saunders *et al.* 2020
9 Dirzo *et al.* 2014, Harris *et al.* 2019, Pilotto *et al.* 2020, Van Klink *et al.* 2020, Welti *et al.* 2020, Wagner *et al.* 2021
10 Habel *et al.* 2019, Wepprich *et al.* 2019, Forister *et al.* 2021, Warren *et al.* 2021
11 Warren *et al.* 2001, Thomas *et al.* 2004, Fox *et al.* 2015, Warren *et al.* 2021
12 Fox *et al.* 2022
13 Taylor & Taylor 1977
14 Dempster 1983
15 Stefanescu *et al.* 2022
16 McDermott Long *et al.* 2017, van Bergen *et al.* 2020
17 Bourn & Thomas 2002
18 Connors *et al.* 2014, Fox *et al.* 2019, Didham *et al.* 2020, Cusser *et al.* 2021, Schowalter *et al.* 2021
19 Harvey *et al.* 2020, Montgomery *et al.* 2020
20 Pollard *et al.* 1975, Pollard 1977
21 Dennis *et al.* 2016

The growth of citizen science butterfly recording in the UK 1970-2019 shown by the number of distribution records per year in the BNM recording scheme (green) and number of abundance monitoring sites per year contributing to the UKBMS (blue).



participants can record any life cycle stage of any butterfly species, anywhere in the UK on any day of the year. This flexibility encourages large numbers of contributors leading to very widespread coverage of the UK landscape every year. However, because effort is not standardised in time or space, the BNM data have to be analysed carefully to ensure that estimated trends represent real changes in species distributions and not just haphazard changes in where and when people recorded butterflies[22].

The BNM recording scheme began in 1995 and aims to achieve a complete survey of UK butterfly distributions every five years. In addition to general distribution recording, the BNM also incorporates verified records from other surveys such as the Big Butterfly Count and Garden Butterfly Survey. This report presents, for the first time, analyses including the 2015-2019 BNM recording period. The BNM also incorporates historical records, with good spatial and temporal coverage back to the 1970s.

We analysed 14.4 million BNM records of adult butterflies for the UK (England, Northern Ireland, Scotland and Wales) from the period 1970-2019, using occupancy modelling[23]. This approach calculates the probability that each species was present in each 1km x 1km square using the existence of other records from that square and the flight period of the species to take account of variable recording effort. Probability values are then averaged across 1km squares to give an annual occupancy index for each species and then distribution (occupancy) trends over time are estimated for each species using weighted logistic regression though the annual index values, accounting for the probability scale[24].

We set a minimum threshold of 30 records of each species per year to ensure that the occupancy indices were robust. We also examined the modelled output for each species individually, considering outlying annual index values and the size of confidence intervals (CI) around annual indices. Cases were decided individually, considering the overall pattern for each species as well as other data (e.g. from the UKBMS) but, in general, annual occupancy indices were excluded from trend calculations where the index value lay outside CI for all other years, where the index value was more than three standard deviations from the mean index for the species or where the CI width of an annual index was greater than three standard deviations from the mean CI width for the whole series. When an annual index value was excluded for any of these reasons, the trend was estimated from the subsequent year onwards. Thus, the distribution trend over time was always calculated from a continuous series of years, but the duration of the series varied from species to species. In general, because recording effort has increased greatly over time in the BNM, annual index values tended to be excluded in the early years of the series, although in a few cases the final value in the series (i.e. 2019) was also excluded. This approach was used to estimate trends at the UK level and separately for each of the four UK countries.

Long-term UK distribution trends were estimated for 58 species, all but one (Large Blue) of the resident and regularly breeding species. Apart from Glanville Fritillary (15 years), Black Hairstreak (18 years) and Lulworth Skipper (19 years), all other species had trends calculated over at least 20 years at the UK level (though the figures are different for the separate UK countries). Each long-term species trend was also converted into an average 10-year change, so that species could be directly compared despite change being measured over different time periods.

Multi-species distribution indicators at UK and country levels were also constructed by combining occupancy indices in three ways: for all species, for habitat specialists and for wider countryside butterflies (see p.12). This is the first time that distribution indicators for the separate UK countries have been included in a State of the UK's Butterflies report, and is possible thanks to the ongoing increase in recording coverage.

[22] Isaac & Pocock 2015
[23] Dennis *et al.* 2017, Dennis *et al.* 2019
[24] Dennis *et al.* 2019

UK butterfly species trends

Long-term UK abundance trends

Analysing the standardised count data from the UKBMS generated long-term trends for 58 species. Overall, more species decreased than increased in abundance: 30 species (52% of the total) had negative trends and 28 species (48%) positive trends.

The statistical significance of trends provides a measure of the confidence that we should place in the changes they show. We can be much more certain that species with statistically significant trends have genuinely changed in abundance, irrespective of how large or small the change is. The UK long-term trends show that 19 species (33% of the total) have decreased significantly in abundance, 15 species (26%) have increased significantly and 24 species (41%) have non-significant trends. Only slightly more species decreased in abundance than increased at UKBMS monitored sites. This represents a small improvement in the fortunes of UK butterflies compared to the previous assessment in 2015, when 36% of species with long-term abundance trends had decreased significantly and 23% had increased significantly.

Long-term UK distribution trends

Occupancy modelling of BNM species occurrence records was used to produce long-term UK distribution trends for 58 species. Overall, 43 species (74%) had negative distribution trends and 15 species (26%) positive trends. Far more species have decreased in distribution than have increased. The same pattern is found just for those species with statistically significant distribution trends: 30 species (52% of the total) had significant decreases in distribution, eight species (14%) significant increases and 20 species (34%) showed changes in distribution that were not statistically significant. Nearly four times as many species have decreased significantly in distribution as have increased.

The occupancy modelling approach used differs from that in the 2015 assessment, so a direct comparison is less valid than for the abundance trends. However, fewer species show significant distribution trends (both decreases and increases) now compared to the 2015 report.

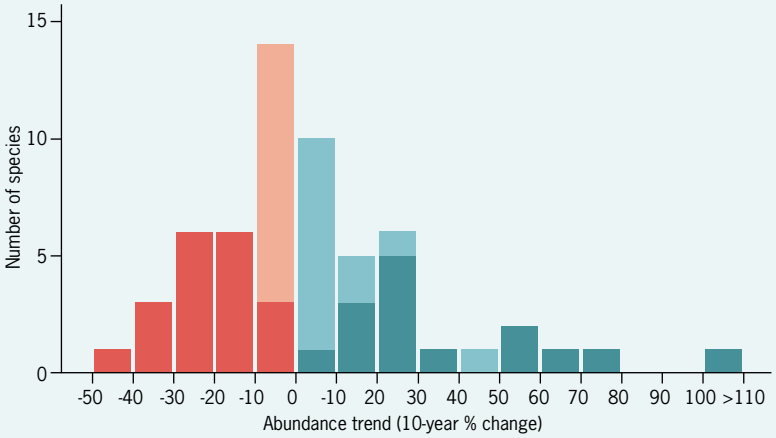
Combined assessment

As in previous studies, the combined assessment of long-term abundance and distribution trends provides a complex picture of winners and losers. Many species are in decline, but others are increasing and, for some, the abundance and distribution changes show opposite trends. Overall, 47 species (80%) decreased in one or both measures, while 33 species (56%) increased in one or both, which is very similar to the overall findings of the 2015 report.

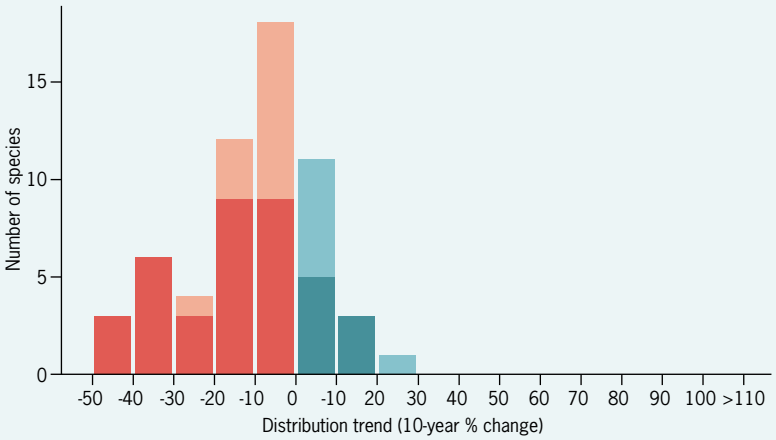
However, considering just the statistically significant trends, 36 species (61%) had decreased significantly in one or both trends and 19 species (32%) had increased significantly in one or both. Almost twice as many species had a significant negative trend in at least one measure than had a significant positive trend in one or both.

COMMON BLUE: MARK SEARLE

Long-term UK abundance trends of 58 butterfly species. For each species, the size of the abundance change is given as the average 10-year rate of change across the time period assessed, which varies from 11–44 years depending on the species. Statistically significant trends are shown in darker shades and non-significant trends in paler shades.



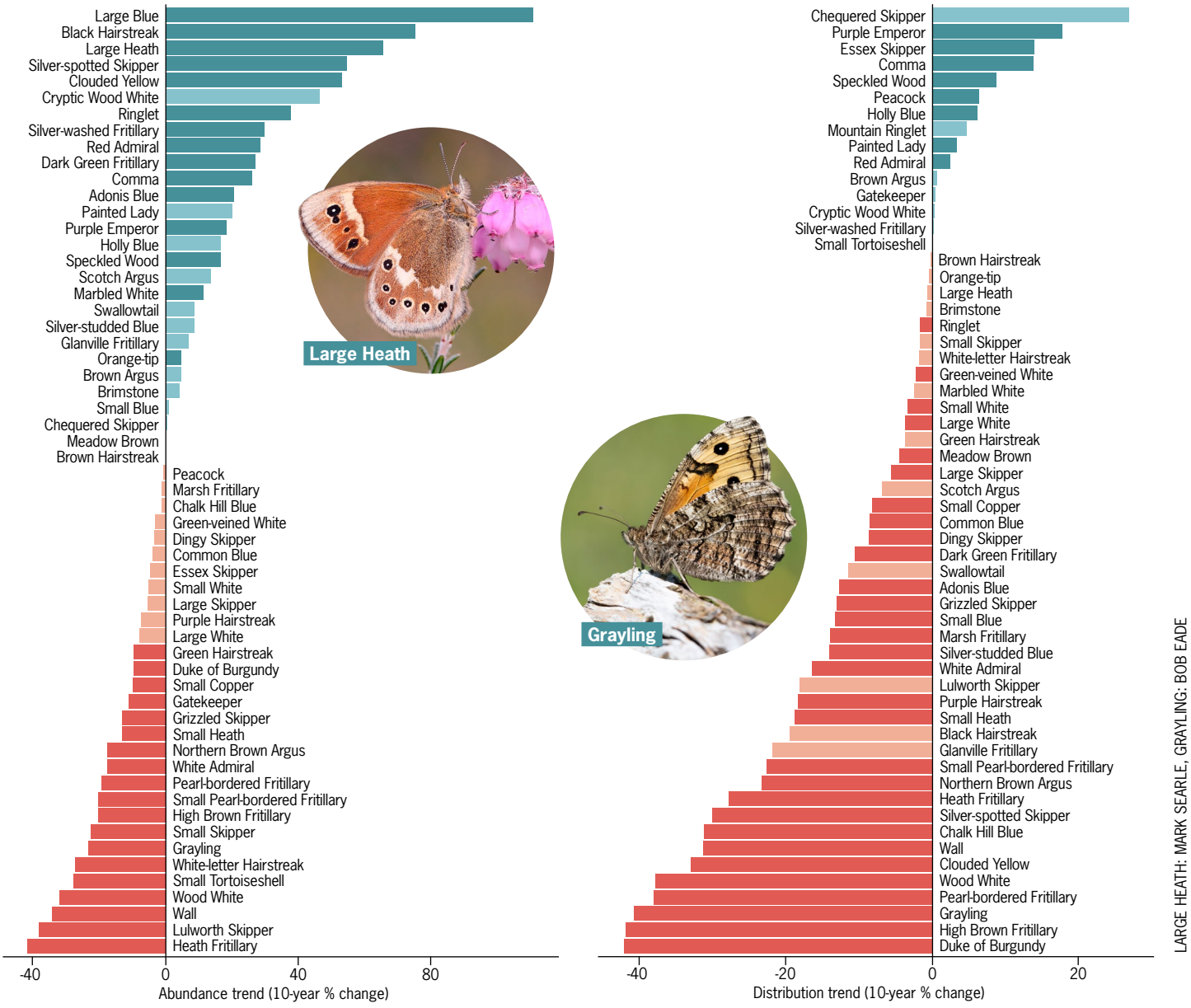
Long-term UK distribution trends of 58 butterfly species. For each species, the size of the distribution change is given as the average 10-year rate of change across the time period assessed, which varies from 15–50 years depending on the species. Statistically significant trends are shown in darker shades and non-significant trends in paler shades.



For the 12 UK Priority Species, nine have negative long-term trends in abundance, distribution or both, and four show positive trends in one or both. Considering only the trends that we have high confidence in, eight Priority Species have decreased significantly in one or both measures while two species have increased significantly.

The UK butterfly indicators (see p.12) confirm this overall picture of decrease. Multi-species indicators for both habitat specialist species (-27% abundance, -68% distribution) and (non-migrant) wider countryside species (-17% abundance, -8% distribution) show decreases since 1976. However, in comparison to the previous assessment in 2015, most of these indicator results show an improved situation i.e. the addition of the last five years of recording and monitoring data has reduced the overall long-term decrease, which in turn suggests that the fortunes of some butterflies improved during the most recent period. The only indicator that shows the opposite pattern is the distribution indicator for habitat specialists, which shows a greater long-term trend now and a wider disparity between the abundance and distribution indicator trends. The implication is that while the decline of habitat specialist butterflies is being, at least partially, addressed at sites monitored by the UKBMS (many of which are nature reserves or other sites managed for biodiversity), populations of these species continue to disappear from the wider landscape.

UK butterfly species average 10-year trends in abundance (left) and distribution (right). Statistically significant trends are shown in darker shades and non-significant trends in lighter shades. Note that the horizontal scales differ.



LARGE HEATH: MARK SEARLE, GRAYLING: BOB EADE

Species	Abundance trends (UKBMS)			Distribution trends (BNM)		
	Period	Total % abundance change over trend period	Average 10-year % abundance change	Period	Total % distribution change over trend period	Average 10-year % distribution change
Swallowtail (*Papilio machaon*)	1976-2019	51	9	1996-2019	-27	-12
Dingy Skipper (*Erynnis tages*)	1976-2019	-15	-3	1976-2019	**-35*****	**-9*****
Grizzled Skipper (*Pyrgus malvae*)	1976-2019	**-49*****	**-13*****	1976-2019	**-48*****	**-13*****
Chequered Skipper (*Carterocephalus palaemon*)	2003-2019	1	0.4	2000-2019	66	27
Essex Skipper (*Thymelicus lineola*)	1977-2019	-20	-5	1978-2019	**82*****	**14*****
Small Skipper (*Thymelicus sylvestris*)	1976-2019	**-71*****	**-23*****	1973-2019	-8	-2
Lulworth Skipper (*Thymelicus acteon*)	1992-2019	**-76*****	**-38*****	2001-2019	-33	-18
Silver-spotted Skipper (*Hesperia comma*)	1979-2019	**596*****	**55*****	1989-2019	**-70*****	**-30*****
Large Skipper (*Ochlodes sylvanus*)	1976-2019	-23	-5	1970-2019	**-27*****	**-6*****
Wood White (*Leptidea sinapis*)	1979-2019	**-82*****	**-32*****	1992-2019	**-76*****	**-38*****
Cryptic Wood White (*Leptidea juvernica*)	2009-2019	53	47	1994-2019	1	0.3
Orange-tip (*Anthocharis cardamines*)	1976-2019	**26***	**5***	1975-2019	-1	-0.2
Large White (*Pieris brassicae*)	1976-2019	-32	-8	1973-2019	**-18*****	**-4*****
Small White (*Pieris rapae*)	1976-2019	-22	-5	1975-2019	**-15*****	**-3*****
Green-veined White (*Pieris napi*)	1976-2019	-14	-3	1973-2019	**-11*****	**-2*****
Clouded Yellow (*Colias croceus*)	1979-2019	**568***	**53***	1994-2019	**-67*****	**-33*****
Brimstone (*Gonepteryx rhamni*)	1976-2019	22	4	1976-2019	-3	-1
Wall (*Lasiommata megera*)	1976-2019	**-86*****	**-34*****	1970-2019	**-87*****	**-31*****
Speckled Wood (*Pararge aegeria*)	1976-2019	**108*****	**17*****	1974-2019	**53*****	**9*****
Large Heath (*Coenonympha tullia*)	1990-2019	**407*****	**66*****	1993-2019	-2	-1
Small Heath (*Coenonympha pamphilus*)	1976-2019	**-49*****	**-13*****	1971-2019	**-67*****	**-19*****
Mountain Ringlet (*Erebia epiphron*)	-	-	-	1995-2019	13	5
Scotch Argus (*Erebia aethiops*)	1979-2019	76	14	1991-2019	-20	-7
Ringlet (*Aphantopus hyperantus*)	1976-2019	**361*****	**38*****	1975-2019	**-7*****	**-2*****
Meadow Brown (*Maniola jurtina*)	1976-2019	1	0.1	1970-2019	**-22*****	**-4*****
Gatekeeper *(Pyronia tithonus)*	1976-2019	**-42****	**-11****	1974-2019	2	0.4
Marbled White (*Melanargia galathea*)	1976-2019	**70****	**12****	1977-2019	-11	-2
Grayling (*Hipparchia semele*)	1976-2019	**-72*****	**-23*****	1976-2019	**-92*****	**-41*****
Pearl-bordered Fritillary (*Boloria euphrosyne*)	1976-2019	**-64*****	**-19*****	1979-2019	**-88*****	**-38*****
Small Pearl-bordered Fritillary (*Boloria selene*)	1976-2019	**-66*****	**-20*****	1976-2019	**-71*****	**-23*****
Silver-washed Fritillary (*Argynnis paphia*)	1976-2019	**248*****	**30*****	1976-2019	1	0.3
Dark Green Fritillary (*Speyeria aglaja*)	1976-2019	**214*****	**27*****	1977-2019	**-40*****	**-10*****
High Brown Fritillary (*Fabriciana adippe*)	1978-2019	**-65****	**-20****	1985-2019	**-87*****	**-42*****
White Admiral (*Limenitis camilla*)	1976-2019	**-60*****	**-18*****	1976-2018	**-57*****	**-16*****
Purple Emperor (*Apatura iris*)	1979-2019	**110****	**18****	1994-2019	**58***	**18***
Red Admiral (*Vanessa atalanta*)	1976-2019	**234*****	**29*****	1973-2019	**14*****	**3*****
Painted Lady (*Vanessa cardui*)	1976-2019	141	20	1975-2019	**18*****	**3*****
Peacock (*Aglais io*)	1976-2019	-3	-1	1975-2019	**36*****	**6*****
Small Tortoiseshell (*Aglais urticae*)	1976-2019	**-79*****	**-28*****	1973-2019	0.2	0.05
Comma (*Polygonia c-album*)	1976-2019	**203*****	**26*****	1973-2019	**94*****	**14*****
Marsh Fritillary (*Euphydryas aurinia*)	1981-2019	-4	-1	1985-2019	**-43****	**-14****
Glanville Fritillary (*Melitaea cinxia*)	1989-2019	25	7	2005-2019	-32	-22
Heath Fritillary (*Melitaea athalia*)	1981-2019	**-90*****	**-42*****	1995-2019	**-58****	**-28****
Duke of Burgundy (*Hamearis lucina*)	1979-2019	**-36***	**-10***	1982-2019	**-89*****	**-42*****
Small Copper (*Lycaena phlaeas*)	1976-2019	**-39***	**-10***	1970-2019	**-37*****	**-8*****
Brown Hairstreak (*Thecla betulae*)	1983-2019	0.4	0.1	1994-2019	-0.3	-0.1
Purple Hairstreak (*Favonius quercus*)	1976-2019	-30	-7	1981-2019	**-57*****	**-18*****
Green Hairstreak (*Callophrys rubi*)	1976-2019	**-38***	**-10***	1977-2019	-16	-4
White-letter Hairstreak (*Satyrium w-album*)	1976-2019	**-78*****	**-27*****	1991-2019	-5	-2
Black Hairstreak (*Satyrium pruni*)	1995-2019	**348***	**76***	2002-2019	-33	-19
Small Blue (*Cupido minimus*)	1978-2019	5	1	1983-2019	**-43*****	**-13*****
Holly Blue (*Celastrina argiolus*)	1976-2019	109	17	1976-2019	**34*****	**6*****
Large Blue (*Phengaris arion*)	1983-2019	**1883*****	**111*****	-	-	-
Silver-studded Blue (*Plebejus argus*)	1979-2019	45	9	1984-2019	**-44*****	**-14*****
Brown Argus (*Aricia agestis*)	1976-2019	25	5	1978-2019	4	1
Northern Brown Argus (*Aricia artaxerxes*)	1979-2019	**-57****	**-17****	1990-2018	**-56*****	**-23*****
Common Blue (*Polyommatus icarus*)	1976-2019	-17	-4	1972-2019	**-37*****	**-9*****
Adonis Blue (*Polyommatus bellargus*)	1979-2019	**130***	**21***	1980-2019	**-44*****	**-13*****
Chalk Hill Blue (*Polyommatus coridon*)	1976-2019	-5	-1	1978-2019	**-82*****	**-31*****

Species trends that are statistically significant are shown in bold. * p<0.05, ** p<0.01, *** p<0.001.

Species in decline


Small Pearl-bordered Fritillary

Long-term trends show that many butterfly species have declined over the past five decades: 52% of species are significantly less widespread in the UK and 33% significantly less abundant at monitored sites now compared to the 1970s. As has been found in previous assessments[25], these declines disproportionately affect habitat specialist species – butterflies that tend to have highly specialised ecological requirements and which are restricted to particular semi-natural habitats (such as unimproved species-rich grassland, bogs and lowland heathland).


Northern Brown Argus

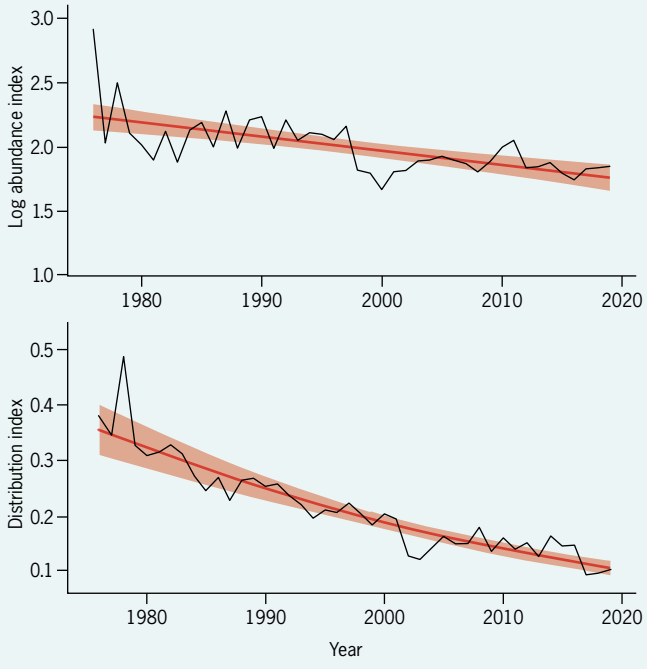
Northern Brown Argus is one of Butterfly Conservation's Priority Species and is listed as Vulnerable on the GB Red List. It has undergone substantial decreases in both abundance (-57%, 1979-2019) and distribution (-56%, 1990-2018) at the UK level. Distribution losses of this species are very similar in both England and Scotland (-20% and -21% average 10-year rates of change, respectively), but the species has decreased much more sharply in abundance at English sites (-18% average 10-year rate of change, compared to no significant trend at Scottish sites). In response, a major resurvey of colonies is underway and conservation projects have been developed, for example as part of the ambitious new Species on the Edge programme in Scotland. Northern Brown Argus is dependent on careful management (e.g. light grazing) of its unimproved grassland habitat, but many colonies are now small and isolated as a result of land-use change and, in many cases, habitat quality has deteriorated due to unsuitable grazing levels. Populations are further threatened by tree planting schemes where ecological surveys have not been carried out or have failed to recognise the high environmental value of these grasslands. As a species adapted to cooler, wetter climatic conditions, it is also at risk from climate change, both through direct effects[26] and indirectly through hybridization with Brown Argus[27]. The latter has rapidly extended its range northwards in response to warming conditions[28], and now overlaps with the distribution of Northern Brown Argus in Co. Durham and Northumberland.

Although it remains widely distributed, mainly around the UK coastline, there is increasing concern about Grayling, which has suffered a severe long-term decline. Since 1976, the abundance of this species has decreased by 72% and its distribution by 92% at the UK level, and with major declines in both measures in England, Scotland and Wales[29]. These ongoing, rapid declines recently led to Grayling being upgraded from Vulnerable to Endangered on the GB Red List. Dependent on fine-leaved grasses growing in sparse vegetation with much open ground or rock[30], the butterfly faces threats from habitat degradation due to ecological succession[31] and nitrogen deposition[32], and from consequent small population size and increasing isolation[33].

Small Pearl-bordered Fritillary

Small Pearl-bordered Fritillary is another habitat specialist species in trouble. Trends show a 66% decrease in abundance and 71% decrease in distribution at the UK level since 1976, and the species is now listed as Vulnerable on the GB Red List. Its distribution has decreased severely in all three countries in which it occurs. Although it currently remains widely distributed in Scotland and Wales, it is much more localised now in northern and western parts of England. Distribution trends for average 10-year periods are -24% in England, -18% in Scotland and -28% in Wales. Its abundance has also decreased significantly at monitored sites in England (10-year average trend = -16%) and, in particular, Wales (-38%) but not in Scotland, where the number of Small Pearl-bordered Fritillaries has actually increased on transects (10-year average trend = +11%). The loss of this species from woodlands in south-east England since the 1970s directly relates to reduced management and, as a result, fewer open areas where this butterfly and its relatives such as Pearl-bordered Fritillary and High Brown Fritillary can breed. However, the ongoing declines in the open, damp grasslands, moors and Bracken-mosaic habitats of northern and western Britain are more perplexing. Intermediate grazing levels are probably vital to maintain abundant violets and, perhaps most importantly, warm microclimates for Small Pearl-bordered Fritillary caterpillars[34]. There are also some indications, from initial unpublished analyses, that climate change may be impacting this species, with abundance levels reduced following high summer and winter temperatures, but this requires further research.

Small Pearl-bordered Fritillary UK abundance and distribution indices (black) and trends (red lines) with shaded confidence intervals (red).



NORTHERN BROWN ARGUS, SMALL PEARL-BORDERED FRITILLARY: MARK SEARLE

[25] Warren *et al.* 2001
[26] Franco *et al.* 2006
[27] Mallet *et al.* 2011
[28] Pateman *et al.* 2012
[29] Data for Northern Ireland were insufficient to produce trends.
[30] Loram *et al.* 2003, Robinson 2008
[31] Schirmel & Fartmann 2014
[32] WallisDeVries & van Swaay 2017
[33] De Ro *et al.* 2021
[34] Ellis *et al.* 2011

Species faring well

The stark declines of UK butterflies and the huge conservation challenges that they pose often overshadow the true, more complex situation. For a range of reasons, including the warming climate, conservation successes and greater recording effort, the long-term trends for some species reveal a much more positive picture. At the UK level, 26% of species have increased significantly in abundance and 14% in distribution. Among habitat specialist butterflies, any species trend bucking the widespread pattern of long-term decrease could be seen as a good outcome.

Although its long-term trends are not statistically significant (probably due to the relatively small number of sites and years in which it is monitored), there has been much to celebrate about Chequered Skipper, a Butterfly Conservation Priority Species, in recent years. In Scotland, species distribution modelling was used to identify areas likely to be suitable for the butterfly, but which had no previous records. Targeted surveys of these areas by volunteers discovered the species in over 100 new 1km grid squares. Most were probably pre-existing colonies, but there also appears to be some genuine range expansion westwards on the Ardnamurchan peninsular and onto Mull, where the island's first ever confirmed sighting occurred in 2022. Chequered Skipper became extinct in England in 1976 but is breeding again in Northamptonshire thanks to an ambitious project led by Butterfly Conservation. Starting in 2018, Belgian butterflies, shown to be ecologically closer to the extinct English populations than those from Scotland[35], were reintroduced into Fineshade Wood following many years of planning and habitat management to create open, sunny, flower-rich rides. The species has bred successfully and the population has expanded naturally through the site, topped up with a further introduction in 2019. In 2022, there were nearly 150 Chequered Skipper sightings along 6.6km of woodland rides. The next steps are to establish other populations in the landscape to ensure long-term resilience.

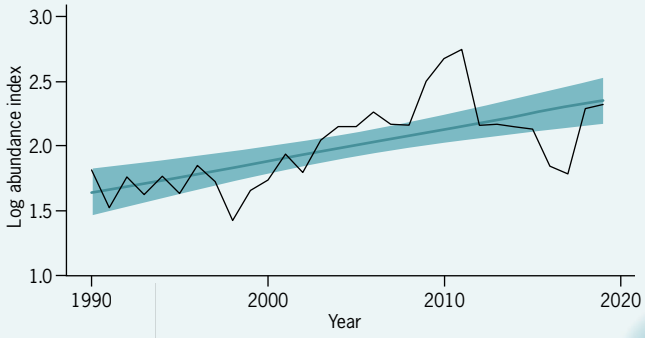
Chequered Skipper

CHEQUERED SKIPPER: ANDY WYLDES

Large Heath

The trends for Large Heath, another Priority Species, provide a positive picture, with a very large (407%) increase in abundance at monitored sites and little change in distribution (-2%) since the 1990s. Although present in all four UK countries, the remote location of most colonies means that few are monitored, and data are only sufficient to produce a UK-level abundance trend. Many of the monitored sites are managed for biodiversity and Large Heath populations have benefitted, for example from peatland restoration on lowland bogs in Scotland. However, there are concerns elsewhere in its range. For example, at some sites on the North York Moors and in Northumberland, there has been a substantial reduction in the amount of cottongrasses, the Large Heath's larval foodplants, perhaps due to climate change. In many other areas, particularly in the uplands, data on how the butterfly and its habitats are faring are lacking.

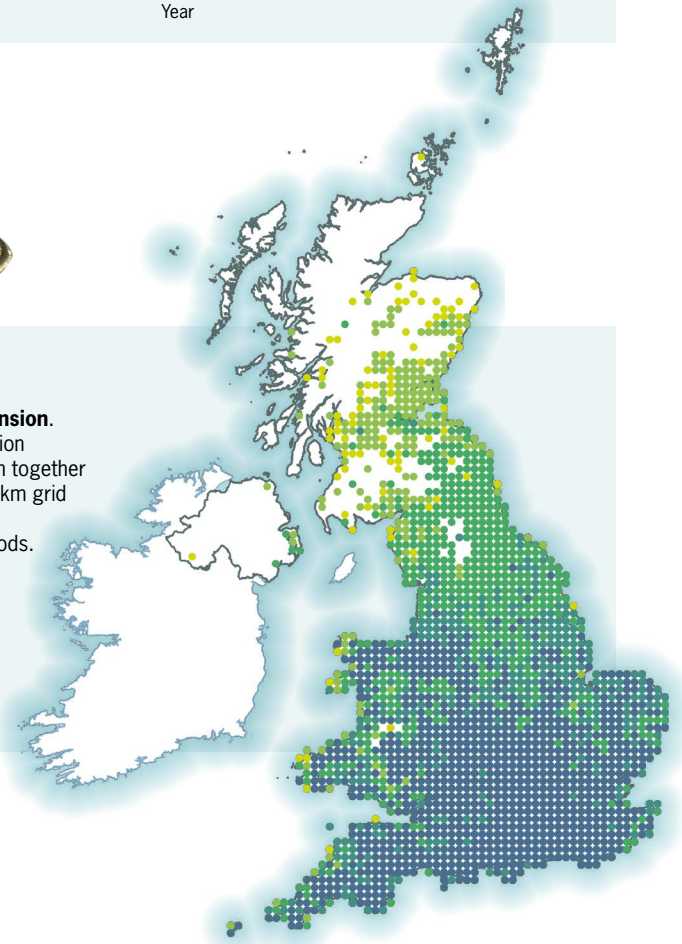
Large Heath UK abundance index (black line) and trend (blue line) with shaded confidence intervals (blue).



Spreading North

On average UK butterfly species with a southerly distribution have extended their distributions northwards since the 1970s in response to climate change and the rate of these range margin shifts has accelerated over time[36]. Comma has undergone one of the largest range expansions and its UK trends show a 203% increase in abundance (1976-2019) and 94% increase in distribution (1973-2019). The most mobile, generalist species like the Comma have been able to expand rapidly as the climate has warmed, while other species have been constrained by the amount and configuration of suitable habitat within colonisation distance of their current range margin[37].

The Comma's expansion. The baseline distribution (1970-1982) is shown together with the additional 10km grid squares occupied in subsequent time periods.



[35] Maes *et al.* 2019a
[36] Mason *et al.* 2015
[37] Platts *et al.* 2019, Hodgson *et al.* 2022

Butterfly indicators

Multi-species indicators provide an overall summary of changes in either abundance or distribution by combining species-level indices for groups of butterflies sharing particular attributes. We constructed abundance and distribution indicators for all butterfly species (including the common migrants), and separately for resident species classified as habitat specialists or wider countryside species, at the UK level and for each of the UK countries, where there were sufficient data. Multi-species indicators for abundance and distribution were also produced for Butterfly Conservation's Priority Species at the UK level.

The abundance indicators in this report were calculated following the same methods used for butterflies in the official UK Biodiversity Indicators[38]. The annual indicator values were the geometric means of the annual indices for each included species. A smoothed indicator was then fitted using structural time series analysis as implemented in the TrendSpotter software[39]. The change of the indicator over time was estimated from a linear regression through the smoothed annual values.

Multi-species indicators of butterfly distribution were also constructed from the geometric mean of the species' annual occupancy indices. Unlike for the abundance indicators, however, smoothed distribution indicators were created by fitting a generalised additive model to these annual indices. Trends over time were calculated using linear regression through the smoothed indicators. We estimated 95% confidence intervals for the indicators and trends using a parametric bootstrap approach[40].

Since the duration of trends (in abundance and distribution) varies among species, the number of species contributing to the indicators each year also varied, and typically increased over time. We set a threshold of at least five species per year in all indicators to ensure a basic level of representativeness. In addition, for Northern Ireland, Scotland[41] and Wales, where there are fewer species and sparser data, indicators had to contain at least half of the species with available trends[42].

Indicator	Trend	Period	Number of species included
Abundance			
UK all species	-6%	1976-2019	58
UK habitat specialists[43]	-27%	1976-2019	26
UK wider countryside species[43]	-17%	1976-2019	25
UK Priority Species	-35%	1981-2019	12
Distribution			
UK all species	-42%	1976-2019	58
UK habitat specialists	-68%	1976-2019	30
UK wider countryside species	-8%	1976-2019	25
UK Priority Species	-71%	1990-2019	11

Small Blue

SMALL BLUE: MARK SEARLE

[38] Brereton *et al.* 2011, www.jncc.gov.uk/our-work/uk-biodiversity-indicators-2021

[39] Visser 2004

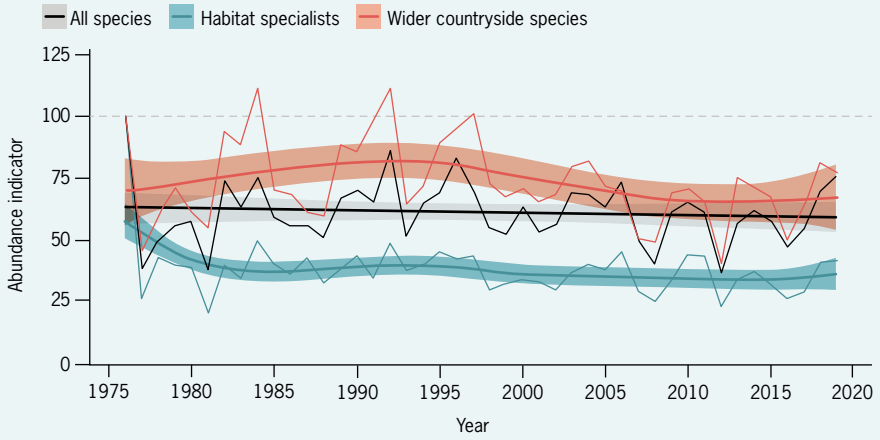
[40] following the approach of Dennis *et al.* 2019

[41] Note that the approach used here to construct multi-species indicators across the UK countries differs from that used to produce the official Scotland butterfly abundance indicator published by NatureScot.

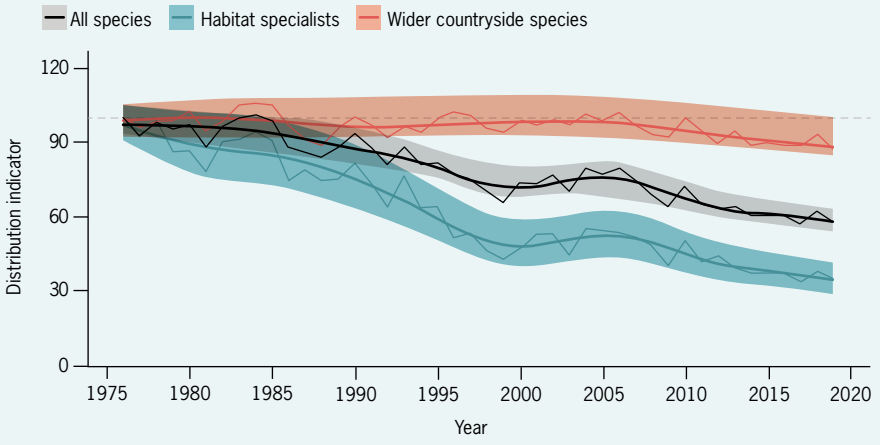
[42] Where half (rounded up when a fraction) of the available species in a given year was <5, the indicator was not started until the year in which a minimum of five species could be included.

[43] The results for abundance change for the UK habitat specialists and UK wider countryside species differ from those published as the official UK Biodiversity Indicators, despite the same species being included and the same methods being used to derive the indicator annual values and to fit the smoothed indicator. These differences result from the exclusion of Isle of Man and Channel Islands data from the results presented here (but their inclusion in the official UK Biodiversity Indicators) and from the way trends over time have been estimated – the trends presented here are estimated from the entire time series of the smoothed indicator, whereas the official indicators measure change as the difference between the (unsmoothed) annual value in the first year and the final year.

UK butterfly abundance indicators for all species (black), habitat specialists (blue) and wider countryside species (red). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



UK butterfly distribution indicators for all species (black), habitat specialists (blue) and wider countryside species (red). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.

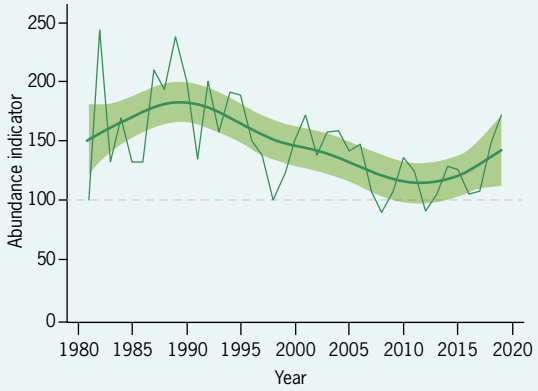


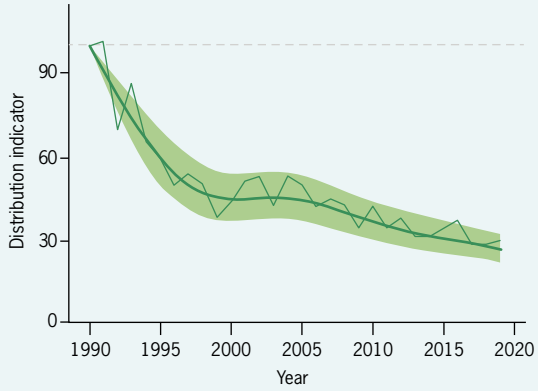
In addition to showing how species abundance or distribution have changed since a baseline year, multi-species indicators can also be used to measure progress towards environmental targets. A new generation of targets is being developed that will be more specific, leading to greater scrutiny of the indicators used to assess them. For example, the 2021 Environment Act created a mechanism for legally-binding targets for England, including a target to halt the loss of species abundance by 2030. Placing such targets into legislation is expected to create a focus on which actions would do most to "bend the curve" of biodiversity, from site-management for threatened species to large-scale land-use policies (e.g. agri-environment schemes). The methodologies used to compile and analyse such indicators continue to evolve rapidly. In part this is to enable standardisation across different taxa and in part to ensure that biases in trend estimates are minimised and uncertainty around trends is correctly interpreted.

Heath Fritillary

UK butterfly abundance and distribution indicators for Butterfly Conservation Priority Species.

Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values. The abundance indicator contains all 12 Priority Species, but Large Blue is not included in the distribution indicator (as no distribution trend could be estimated for that species).





HEATH FRITILLARY: MARK SEARLE

Marsh Fritillary is the focus of conservation efforts in all four UK countries. Its distribution has decreased by 43% since 1985.

MARSH FRITILLARY: MARK SEARLE

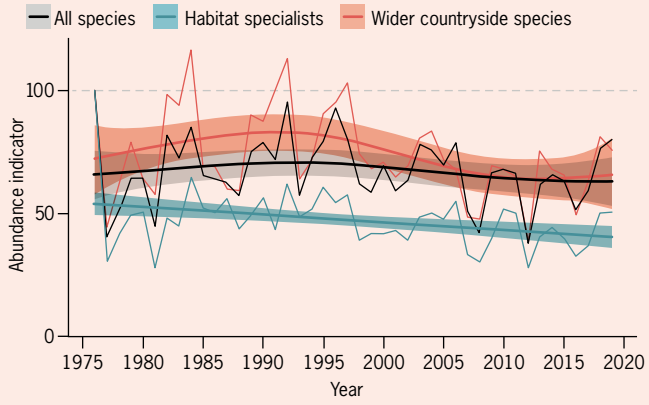
England
butterfly species trends

England's butterflies have fared badly since the 1970s. The distribution indicator shows an overall decrease of 45% since 1976, largely driven by a very steep (75%) decrease in the distributions of habitat specialist species. The abundance of habitat specialists has also dropped by 25% over the same period, although the abundance of all species combined shows minimal change (-8%).

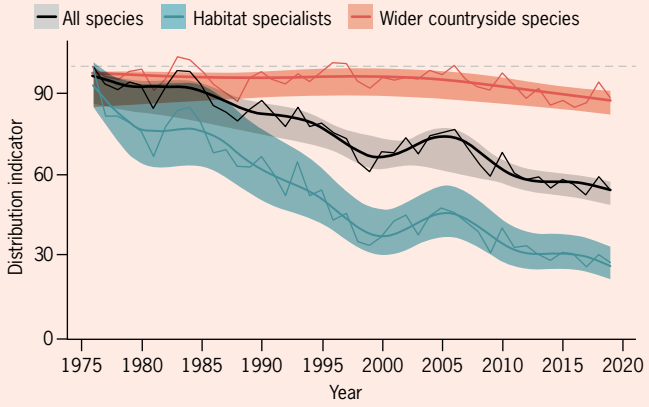
Of the 55 species with long-term abundance trends in England (all resident and regularly breeding species except Chequered Skipper, Large Heath and Mountain Ringlet), 34 species (62%) decreased in abundance and 21 species (38%) increased. Considering just those changes in which we have greatest confidence, 20 species (36%) decreased significantly, 13 species (24%) increased significantly and 22 species (40%) had non-significant trends.

Among the 54 species with long-term English distribution trends (Chequered Skipper, Mountain Ringlet, Scotch Argus and Large Blue do not have trends), 41 species (76%) decreased compared to 13 species (24%) that increased. For those species with strong evidence of change (statistically significant trends), nearly four times as many have decreased as have increased: 33 species (61%) decreased significantly in distribution and only nine species (17%) increased significantly, while the remaining 12 species (22%) had trends that did not show clear change.

England butterfly abundance indicators for all species (black, 55 species), habitat specialists (blue, 25 species) and wider countryside species (red, 25 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



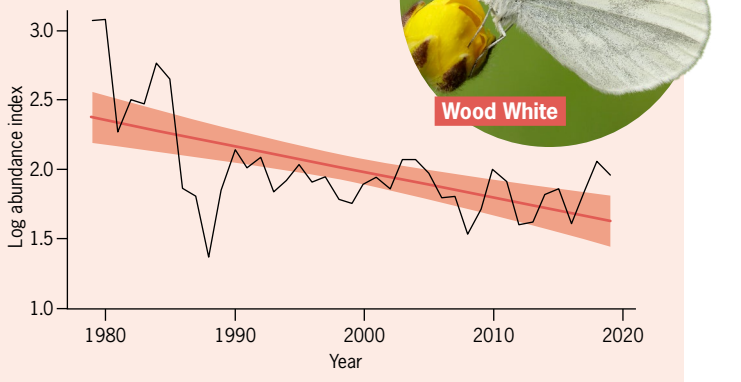
England butterfly distribution indicators for all species (black, 54 species), habitat specialists (blue, 27 species) and wider countryside species (red, 24 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



Wood White

Wood White has decreased by 82% in abundance (1979-2019) and by 77% in distribution (1992-2019), is classed as Endangered on the Red List and is a Priority Species for Butterfly Conservation. Most of the long-term abundance decline took place during the 1980s and recent signs are more positive, thanks to intensive conservation efforts in many parts of the Wood White's range. Butterfly Conservation staff have made over 1,600 advisory visits to Wood White sites since 2001, and there has been a succession of successful long-term conservation projects, particularly in the West Midlands. A recent review found that Wood White occupied 610.2ha across 62 UK sites (almost all of which are in England) in 2015-2019 compared to 215.8ha across 36 sites in 2005-2009[44].

Wood White abundance index for England (black line) and trend (red line) with shaded confidence intervals (red).



WOOD WHITE: IAIN LEACH

[44] Cook *et al.* 2021

Species	Abundance trends (UKBMS)			Distribution trends (BNM)		
	Period	Total % abundance change over trend period	Average 10-year % abundance change	Period	Total % distribution change over trend period	Average 10-year % distribution change
Swallowtail (*Papilio machaon*)	1976-2019	51	9	1996-2019	-26	-11
Dingy Skipper (*Erynnis tages*)	1976-2019	-10	-2	1977-2019	**-36*****	**-9*****
Grizzled Skipper (*Pyrgus malvae*)	1976-2019	**-49*****	**-13*****	1976-2019	**-51*****	**-14*****
Essex Skipper (*Thymelicus lineola*)	1977-2019	-20	-5	1978-2019	**74*****	**13*****
Small Skipper (*Thymelicus sylvestris*)	1976-2019	**-72*****	**-23*****	1973-2019	**-15*****	**-3*****
Lulworth Skipper (*Thymelicus acteon*)	1992-2019	**-76****	**-38****	2001-2019	-38	-21
Silver-spotted Skipper (*Hesperia comma*)	1979-2019	**596*****	**55*****	1989-2019	**-70*****	**-30*****
Large Skipper (*Ochlodes sylvanus*)	1976-2019	-21	-5	1978-2017	**-22*****	**-6*****
Wood White (*Leptidea sinapis*)	1979-2019	**-82*****	**-32*****	1992-2019	**-77*****	**-39*****
Orange-tip (*Anthocharis cardamines*)	1976-2019	13	3	1976-2019	-2	-0.4
Large White (*Pieris brassicae*)	1976-2019	-33	-8	1973-2019	**-8*****	**-2*****
Small White (*Pieris rapae*)	1976-2019	-19	-4	1975-2019	**-11*****	**-2*****
Green-veined White (*Pieris napi*)	1976-2019	-18	-4	1973-2019	**-12*****	**-2*****
Clouded Yellow (*Colias croceus*)	1979-2019	**625***	**56***	1994-2019	**-63*****	**-30*****
Brimstone (*Gonepteryx rhamni*)	1976-2019	20	4	1976-2019	**-10***	**-2***
Wall (*Lasiommata megera*)	1976-2019	**-88*****	**-36*****	1973-2019	**-85*****	**-31*****
Speckled Wood (*Pararge aegeria*)	1976-2019	**107*****	**16*****	1974-2019	**67*****	**11*****
Large Heath (*Coenonympha tullia*)	-	-	-	2005-2019	-36	-25
Small Heath (*Coenonympha pamphilus*)	1976-2019	**-54*****	**-15*****	1975-2019	**-70*****	**-22*****
Scotch Argus (*Erebia aethiops*)	1995-2019	**-73*****	**-39*****	-	-	-
Ringlet (*Aphantopus hyperantus*)	1976-2019	**361*****	**38*****	1980-2019	**25*****	**5*****
Meadow Brown (*Maniola jurtina*)	1976-2019	-1	-0.2	1970-2019	**-18*****	**-3*****
Gatekeeper (*Pyronia tithonus*)	1976-2019	**-46****	**-12****	1974-2019	**13*****	**3*****
Marbled White (*Melanargia galathea*)	1976-2019	**68****	**11****	1977-2019	-11	-3
Grayling (*Hipparchia semele*)	1976-2019	**-60*****	**-17*****	1976-2019	**-89*****	**-37*****
Pearl-bordered Fritillary (*Boloria euphrosyne*)	1978-2019	**-72*****	**-24*****	1982-2019	**-91*****	**-44*****
Small Pearl-bordered Fritillary (*Boloria selene*)	1978-2019	**-55*****	**-16*****	1982-2019	**-68*****	**-24*****
Silver-washed Fritillary (*Argynnis paphia*)	1976-2019	**270*****	**32*****	1977-2019	13	3
Dark Green Fritillary (*Speyeria aglaja*)	1976-2019	**416*****	**41*****	1976-2019	**-45*****	**-12*****
High Brown Fritillary (*Fabriciana adippe*)	1978-2019	**-65****	**-21****	1985-2019	**-82*****	**-36*****
White Admiral (*Limenitis camilla*)	1976-2019	**-60*****	**-18*****	1976-2018	**-57*****	**-17*****
Purple Emperor (*Apatura iris*)	1979-2019	**110****	**18****	1994-2019	**58***	**18***
Red Admiral (*Vanessa atalanta*)	1976-2019	**240*****	**29*****	1976-2019	**17*****	**3*****
Painted Lady (*Vanessa cardui*)	1976-2019	143	20	1978-2019	**14*****	**3*****
Peacock (*Aglais io*)	1976-2019	-4	-1	1975-2019	3	1
Small Tortoiseshell (*Aglais urticae*)	1976-2019	**-79*****	**-28*****	1976-2019	**-7*****	**-2*****
Comma (*Polygonia c-album*)	1976-2019	**201*****	**26*****	1976-2019	**80*****	**13*****
Marsh Fritillary (*Euphydryas aurinia*)	1982-2019	**-60***	**-20***	1985-2019	**-35***	**-11***
Glanville Fritillary (*Melitaea cinxia*)	1989-2019	25	7	2005-2019	-30	-21
Heath Fritillary (*Melitaea athalia*)	1981-2019	**-90*****	**-42*****	1995-2019	**-63*****	**-31*****
Duke of Burgundy (*Hamearis lucina*)	1979-2019	**-36***	**-10***	1982-2019	**-89*****	**-42*****
Small Copper (*Lycaena phlaeas*)	1976-2019	-35	-9	1975-2019	**-45*****	**-12*****
Brown Hairstreak (*Thecla betulae*)	1983-2019	0.3	0.1	1994-2019	2	1
Purple Hairstreak (*Favonius quercus*)	1976-2019	-32	-8	1981-2019	**-57*****	**-18*****
Green Hairstreak (*Callophrys rubi*)	1976-2019	**-41***	**-11***	1976-2019	**-30****	**-7****
White-letter Hairstreak (*Satyrium w-album*)	1976-2019	**-78*****	**-27*****	1991-2019	-2	-1
Black Hairstreak (*Satyrium pruni*)	1995-2019	**348***	**76***	2002-2019	-33	-19
Small Blue (*Cupido minimus*)	1979-2019	-24	-6	1983-2019	**-45*****	**-14*****
Holly Blue (*Celastrina argiolus*)	1976-2019	117	18	1976-2019	**15***	**3***
Large Blue (*Phengaris arion*)	1983-2019	**1883*****	**111*****	-	-	-
Silver-studded Blue (*Plebejus argus*)	1984-2019	-14	-4	1984-2019	**-38****	**-11****
Brown Argus (*Aricia agestis*)	1976-2019	27	5	1978-2019	16	3
Northern Brown Argus (*Aricia artaxerxes*)	1979-2019	**-58****	**-18****	1997-2019	**-43***	**-20***
Common Blue (*Polyommatus icarus*)	1976-2019	-14	-3	1974-2019	**-35*****	**-8*****
Adonis Blue (*Polyommatus bellargus*)	1979-2019	**130***	**21***	1980-2019	**-45*****	**-13*****
Chalk Hill Blue (*Polyommatus coridon*)	1976-2019	-5	-1	1978-2019	**-82*****	**-31*****

Species trends that are statistically significant are shown in bold. * p<0.05, ** p<0.01, *** p<0.001.

Several Butterfly Conservation Priority Species, such as Heath Fritillary and Duke of Burgundy, show similar patterns of severe long-term decline in England but with notable recent improvements due to conservation action, demonstrating the success of targeted, species-focussed approaches to conservation. Of course, for such approaches to be effective, we require a detailed understanding of species' ecological requirements and how to provide them through habitat management. In the case of Lulworth Skipper, another Priority Species, careful management of grazing intensity is essential to maintain the medium to tall clumps of Tor-grass used as caterpillar foodplants[45]. Some habitat patches cannot be managed with livestock for safety reasons (e.g. cliff tops), so Butterfly Conservation and partners are researching alternative ways to maintain such areas, which may be important refuges for Lulworth Skipper colonies when the quality of grazed sites is low (e.g. due to drought or too much grazing). Maximising habitat quality is vital for the conservation of this species, which has a very small UK range and has decreased in abundance by 76% (1992-2019).

The reintroduction and ongoing conservation of Large Blue is one of the clearest success stories amidst the overall picture of butterfly decline in England. Although it remains rare and a Priority Species, the Red List status of Large Blue has moved from Regionally Extinct through Critically Endangered and, now, Near Threatened over the past 40 years. Reintroductions to two landscapes, the Poldens and Cotswolds, have thrived thanks to enormous efforts by a partnership of scientists, landowners and conservation organisations[46], resulting in a 1,883% increase in abundance (1983-2019).

Marsh Fritillary, another Butterfly Conservation Priority Species, has also benefitted from a carefully planned programme of reintroductions, this time in Cumbria. By 2004, the species was down to a single larval web in the county but successful reintroductions and subsequent natural spread, backed by management to restore high quality habitat[47], resulted in 2,475 webs at 15 sites in five separate landscapes in 2019. More broadly, a recent review of Marsh Fritillary in England[48] indicated that colony loss in the core areas had stabilised after many years of decline, following major conservation efforts in most of the key landscapes for the species[49].

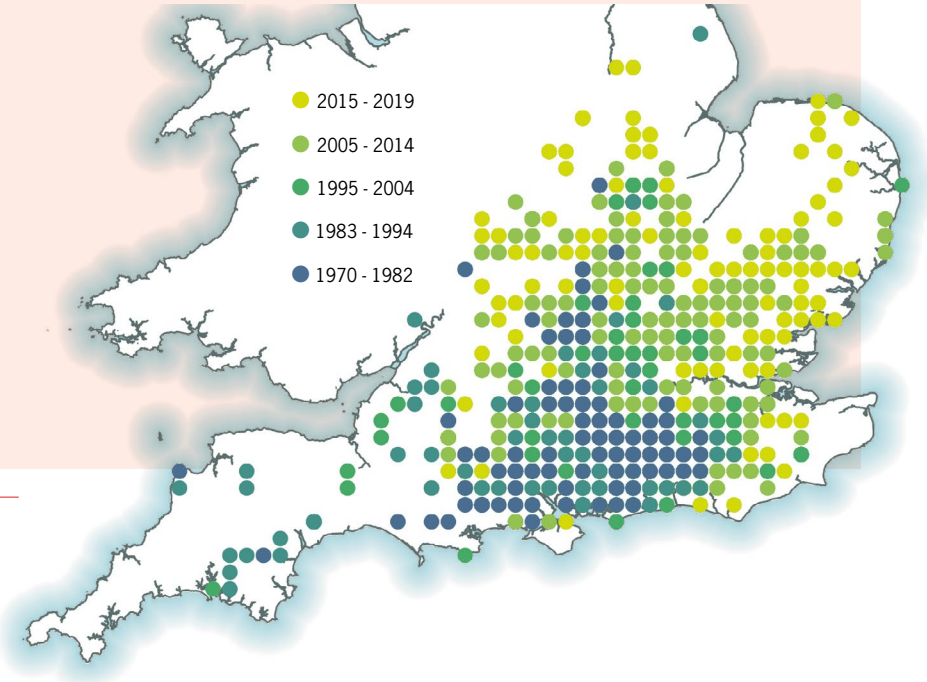
Large Blue

LARGE BLUE: NEIL HULME

Purple Emperor

Purple Emperor has experienced one of the (proportionally) largest range expansions of any butterfly species in England in recent decades, a 58% increase in distribution (1994-2019), while also increasing significantly in abundance at monitored sites (110% increase 1979-2019). While some of this apparent range expansion is due to targeted recording of woodlands where the species has probably long been present, and some due to unofficial releases, the Purple Emperor has also undoubtedly spread under its own steam, colonising many woods within and outside of its historical range. One spectacular example has occurred at the Knepp Estate, a rewilding project on former intensive farmland in the butterfly's historical heartland in West Sussex, where 388 Purple Emperors were counted on a single day in 2018.

Expansion of the Purple Emperor's distribution. The baseline distribution (1970-1982) is shown together with the additional 10km grid squares occupied in subsequent time periods.



[45] Bourn & Thomas 2002
[46] Thomas *et al.* 2009
[47] Porter & Ellis 2011
[48] Jones *et al.* 2019
[49] Bourn *et al.* 2013

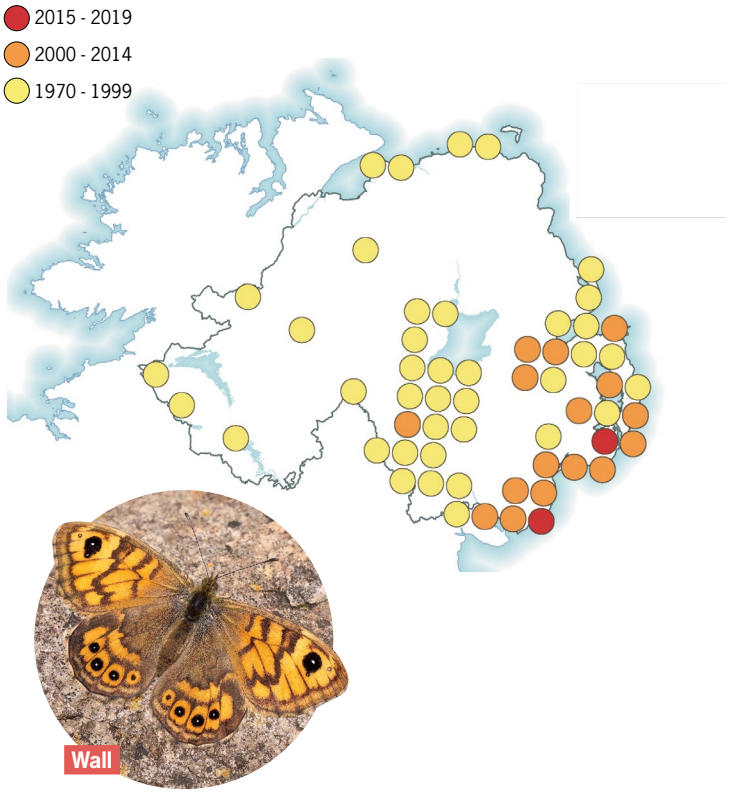
Northern Ireland butterfly species trends

The multi-species indicators for Northern Ireland's butterflies show decreases of 17% in abundance (2006-2019) and 10% in distribution (1993-2019)[50]. However, only about half of the resident and regularly breeding butterfly species in Northern Ireland had sufficient data to calculate long-term trends up to 2019, so these indicators are not necessarily representative of all butterflies. In particular, habitat specialist species that are of conservation concern in Northern Ireland, such as Large Heath, Small Blue and Dingy Skipper do not, as yet, have sufficient monitoring coverage to produce trends.

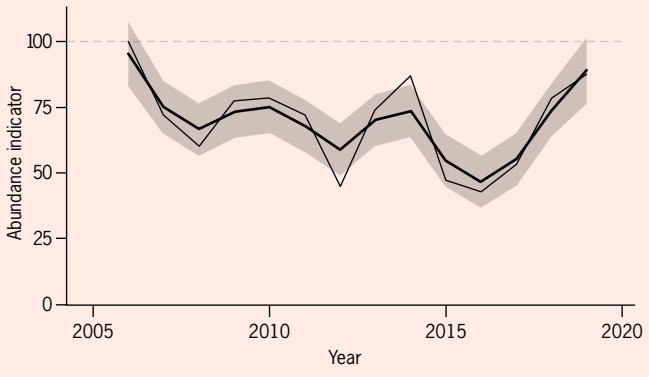
Of the 14 species with long-term abundance trends in Northern Ireland, nine species (64%) decreased and five species (36%) increased. Only two species showed strong evidence of decline (14% of species with abundance trends) and all other trends were not statistically significant. In terms of distribution, 15 species have long-term trends with 10 species (67%) having decreased and five species (33%) increased. There was strong evidence of distribution decline for seven species (47%) and strong evidence of increases for two species (13%), with the remaining six species (40%) having non-significant trends.

The Wall butterfly has suffered a precipitous decline in Northern Ireland and appears to be on the verge of extinction. Formerly found in all six counties, a rapid decline since the 1990s reduced the species to the coastline of Co. Down, where there were only three records in the period 2015-2019. A single Wall was also seen in 2021, so the species is still clinging on. The cause is not known with any certainty[51], but the decline mirrors that experienced by Wall in England and Wales, where it is also among the most severely declining butterfly species, and in other parts of Europe.

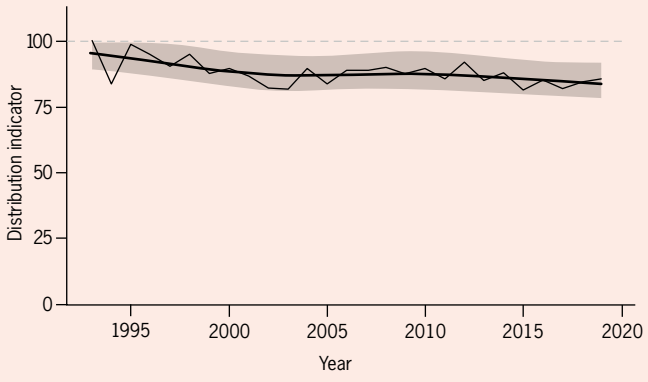
The declining distribution of Wall in Northern Ireland. The most recent date period in which Wall was recorded in each 10km grid square is shown.



Northern Ireland butterfly abundance indicator (14 species). Thick line shows the smoothed indicator with confidence intervals (shaded area), thin line shows the raw (unsmoothed) value.



Northern Ireland butterfly distribution indicator (15 species). Thick line shows the smoothed indicator with confidence intervals (shaded area), thin line shows the raw (unsmoothed) value.



WALL: MARK SEARLE

[50] There are insufficient data to produce separate habitat specialist species indicators for Northern Ireland, so all species with long-term trends have been combined into single indicators for abundance and distribution.

[51] Climate change and nitrogen pollution have been proposed as drivers of the Wall's decline (Van Dyck *et al.* 2015, Klop *et al.* 2015).

[52] Kurze *et al.* 2018

[53] Staats & Regan 2014, Fox *et al.* 2015

[54] O'Neill & Montgomery 2018

Species	Abundance trends (UKBMS)			Distribution trends (BNM)		
	Period	Total % abundance change over trend period	Average 10-year % abundance change	Period	Total % distribution change over trend period	Average 10-year % distribution change
Cryptic Wood White *(Leptidea juvernica)*	2009-2019	53	47	1993-2019	6	2
Orange-tip *(Anthocharis cardamines)*	2007-2019	-8	-6	1993-2019	2	1
Large White *(Pieris brassicae)*	2006-2019	-42	-31	1992-2019	**38****	**11****
Small White *(Pieris rapae)*	2006-2019	**-60***	**-47***	1992-2019	**-16***	**-6***
Green-veined White *(Pieris napi)*	2005-2019	53	31	1993-2019	**-10*****	**-4*****
Speckled Wood *(Pararge aegeria)*	2007-2019	38	27	1993-2019	**-14****	**-5****
Small Heath *(Coenonympha pamphilus)*	2004-2019	-48	-32	1995-2019	**-40****	**-18****
Ringlet *(Aphantopus hyperantus)*	2006-2019	81	51	1993-2019	-2	-1
Meadow Brown *(Maniola jurtina)*	2009-2019	**-44***	**-40***	1992-2019	**-8*****	**-3*****
Dark Green Fritillary *(Speyeria aglaja)*	-	-	-	2006-2019	12	8
Red Admiral *(Vanessa atalanta)*	-	-	-	1994-2019	**-25*****	**-10*****
Peacock *(Aglais io)*	2006-2019	-13	-9	1995-2019	**15*****	**5*****
Small Tortoiseshell *(Aglais urticae)*	2010-2019	-45	-45	1992-2019	-1	-0.2
Marsh Fritillary *(Euphydryas aurinia)*	2004-2019	79	42	-	-	-
Small Copper *(Lycaena phlaeas)*	2005-2019	-37	-26	1992-2019	-13	-5
Common Blue *(Polyommatus icarus)*	2005-2019	-16	-11	1993-2019	**-43****	**-18****

Species trends that are statistically significant are shown in bold. * p<0.05, ** p<0.01, *** p<0.001.

CRYPTIC WOOD WHITE: JAMES O'NEILL

Cryptic Wood White

Small Heath is another species, like Wall, which is associated with short, sparse turf, and which has undergone a rapid distribution decline (40% decrease 1995-2019) in Northern Ireland. Indeed, Small Heath has decreased significantly in all four UK countries. Loss and deterioration of habitat seem the most likely drivers of this decline, with factors such as climate change and nutrient pollution stimulating greater vegetation growth resulting in longer, denser swards even on sites managed for biodiversity. Small Heath caterpillars fail to survive on grasses when fertilizers are applied at the levels typically used in intensive agriculture[52], which suggests that the species may also be harmed away from farmland by smaller amounts of atmospheric nitrogen pollution.

In the UK, Cryptic Wood White only occurs in Northern Ireland so the fortunes of the species here are particularly important. Previous short-term assessments suggested that this Butterfly Conservation Priority Species might be declining, both in Northern Ireland and in the Republic of Ireland[53], but our new analyses provide a more optimistic picture with non-significant trends suggesting an increase in abundance over the past decade and a stable distribution trend from 1993-2019. Unlike Wood White, which is mainly a woodland species in the UK, Cryptic Wood White uses more open habitats such as grasslands[54], and colonies are at risk from urban development and agricultural intensification.

Other species that appear to be experiencing recent upturns in their fortunes, even if data are currently insufficient to demonstrate it quantitatively, include Dark Green Fritillary, Silver-washed Fritillary and Holly Blue. All three appear to be continuing to expand across Northern Ireland, where suitable habitats exist.

Scotland butterfly species trends

White-letter Hairstreak near Eyemouth, Scottish Borders in 2022

Scotland is the only UK country for which the all-species butterfly indicators show long-term increases in abundance and distribution, a 37% increase in abundance (1979-2019) and a non-significant 3% increase in distribution (1992-2019). However, habitat specialists and wider countryside species show contrasting trends. While wider countryside species as a group have increased in abundance (26% increase 1979-2019) and distribution (31% increase 1992-2019), habitat specialists have declined by -27% in abundance (1990-2019) and -26% in distribution (1995-2019)[55].

At the species level, of 25 species with long-term abundance trends in Scotland, 18 species (72%) increased and seven species (28%) decreased. Within these, just two species (8%) have strong evidence of decreased abundance and nine (36%) strong evidence of increases, while the remaining 14 species (56%) have non-significant trends. Twenty-six species have long-term distribution trends, 15 (58%) of which were negative and 11 (42%) positive. Considering those trends in which we have greatest confidence 10 species (38%) showed significant distribution decreases and six species (23%) significant increases, while the remaining 10 species (38%) did not have strong evidence of change.

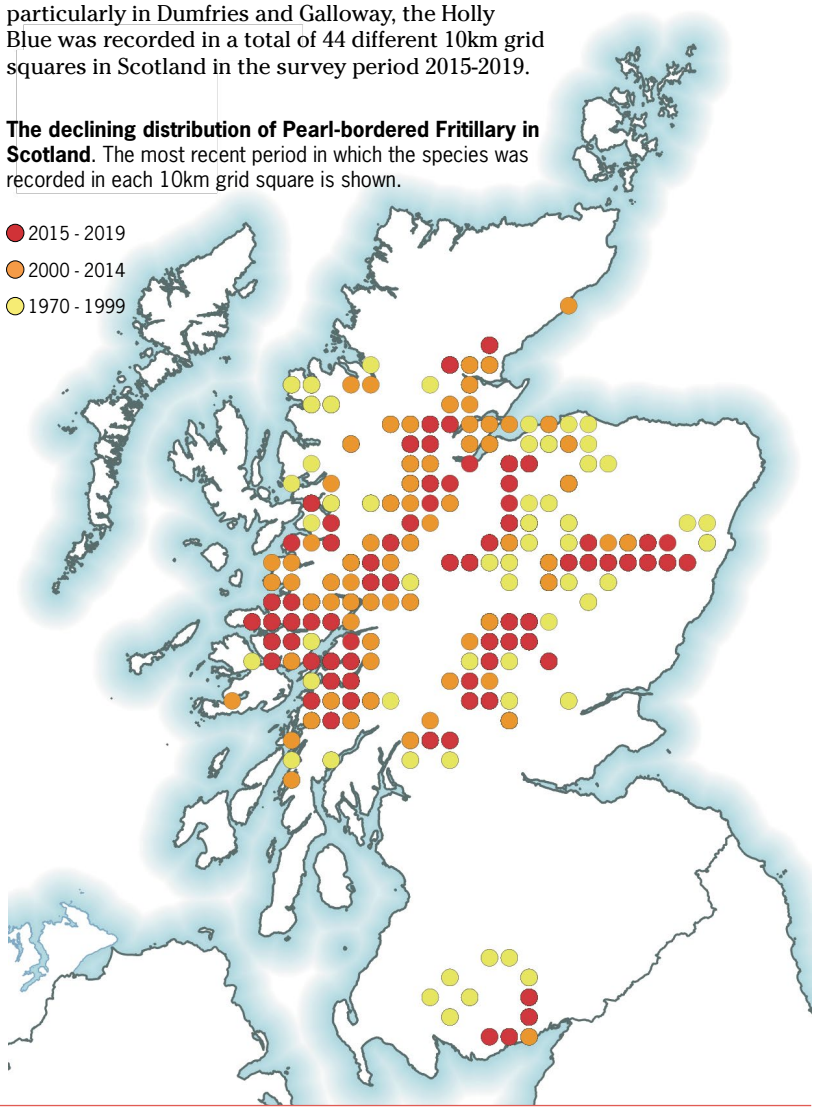
The trends highlight concerns in Scotland for Butterfly Conservation Priority Species such as Northern Brown Argus (see p.10) and Pearl-bordered Fritillary, as well as for Grayling (see p.10). Pearl-bordered Fritillary has been doing well at monitored sites (217% increase in abundance 2002-2019), with 2019 having the highest population levels since the series began. Many monitored sites are managed to enhance their biodiversity, such as at Mabie Forest in Dumfries and Galloway, where targeted management and partnership working between owners Forestry and Land Scotland and Butterfly Conservation has increased Pearl-bordered Fritillary numbers dramatically. However, despite the rediscovery of this species around Loch Katrine in the Trossachs, its distribution trend in Scotland (61% decrease 2001-2019) suggests that Pearl-bordered Fritillary colonies are disappearing elsewhere in the landscape.

Chequered Skipper, in contrast, is a Priority Species faring well in Scotland, with an 87% increase in distribution (2001-2019) and a stable abundance trend at monitored sites (see p.11). Wall, which is listed as Endangered on the GB Red List because of its severe decline, is also doing well in Scotland. Its abundance has increased by 457% (1999-2019) and it has also increased in distribution (143% increase 2004-2019), spreading in south-west Scotland and along the east coast through the Scottish Borders and the Lothians and across into Fife. There have even been confirmed recent sightings much further north near Arbroath, Angus and south of Stonehaven, Aberdeenshire. Ringlet, Peacock and Comma have also continued to extend their distributions in Scotland in response to climate change.

Other species faring well in Scotland, but for which data are currently insufficient to estimate robust trends, include Small Skipper, White-letter Hairstreak and Holly Blue. Until recently, there had been only two Scottish records of White-letter Hairstreak, in 1859 and 1884, but in August 2017 an adult was spotted nectaring in a field margin just 200m from the border with England. This prompted a search by volunteers in the following year, which confirmed that the species was established in Scotland by finding eggs in five different 10km grid squares spread along the Rivers Tweed and Teviot. By the end of 2019, eggs, caterpillars or adult White-letter Hairstreaks had been found in 16 1km grid squares in Scotland in 10 different 10km squares from Dryburgh near Melrose in the west to Paxton, close to Berwick-upon-Tweed in the east.

Prior to this century, Holly Blue had only been recorded occasionally in Scotland, but from 2006 it became firmly established in Edinburgh and from 2008 in Ayr. From these centres, the species has subsequently spread, into the Central Belt and through the Lothians on the east coast and Ayrshire in the west. With further sightings in the south of Scotland, particularly in Dumfries and Galloway, the Holly Blue was recorded in a total of 44 different 10km grid squares in Scotland in the survey period 2015-2019.

The declining distribution of Pearl-bordered Fritillary in Scotland. The most recent period in which the species was recorded in each 10km grid square is shown.



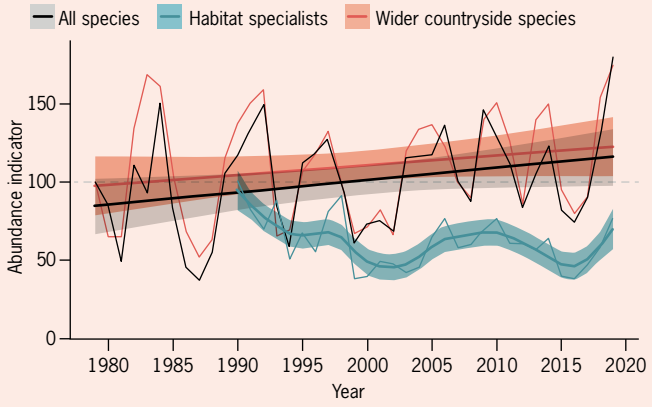
WHITE-LETTER HAIRSTREAK: IAIN COWE

[55] Note that the Scotland butterfly abundance indicators shown here differ from those published by NatureScot, both in the species composition of each indicator and the duration of the habitat specialists indicator. The overall findings, however, are similar.

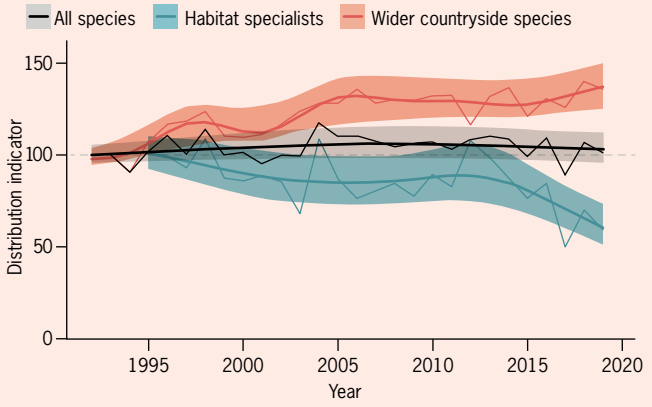
Species	Abundance trends (UKBMS)			Distribution trends (BNM)		
	Period	Total % abundance change over trend period	Average 10-year % abundance change	Period	Total % distribution change over trend period	Average 10-year % distribution change
Chequered Skipper (*Carterocephalus palaemon*)	2003-2019	1	0.4	2001-2019	**87*****	**37*****
Orange-tip (*Anthocharis cardamines*)	1999-2019	**400*****	**106*****	1992-2019	**66*****	**18*****
Large White (*Pieris brassicae*)	1979-2019	101	17	1992-2019	-7	-2
Small White (*Pieris rapae*)	1979-2019	65	12	1989-2019	20	6
Green-veined White (*Pieris napi*)	1979-2019	7	2	1977-2019	**-12*****	**-3*****
Wall (*Lasiommata megera*)	1999-2019	**457****	**117****	2004-2019	**143*****	**70*****
Speckled Wood (*Pararge aegeria*)	2001-2019	**91***	**38***	1998-2019	**-37*****	**-18*****
Large Heath (*Coenonympha tullia*)	-	-	-	1997-2019	-32	-15
Small Heath (*Coenonympha pamphilus*)	1979-2019	**122****	**20****	1976-2019	**-44*****	**-11*****
Scotch Argus (*Erebia aethiops*)	1990-2019	-1	-0.4	1995-2018	-10	-4
Ringlet (*Aphantopus hyperantus*)	1996-2019	**163*****	**46*****	1989-2019	**160*****	**33*****
Meadow Brown (*Maniola jurtina*)	1979-2019	-13	-3	1976-2019	**-27*****	**-6*****
Grayling (*Hipparchia semele*)	1990-2019	**-91*****	**-52*****	1995-2019	**-72*****	**-38*****
Pearl-bordered Fritillary (*Boloria euphrosyne*)	2002-2019	**217*****	**84*****	2001-2019	**-61****	**-38****
Small Pearl-bordered Fritillary (*Boloria selene*)	1979-2019	**62***	**11***	1989-2019	**-48*****	**-18*****
Dark Green Fritillary (*Speyeria aglaja*)	1979-2019	6	1	1978-2019	-7	-1
Red Admiral (*Vanessa atalanta*)	1980-2019	**723*****	**63*****	1991-2019	4	1
Painted Lady (*Vanessa cardui*)	1980-2019	254	34	1994-2019	12	4
Peacock (*Aglais io*)	1995-2019	**261*****	**62*****	1994-2019	**141*****	**37*****
Small Tortoiseshell (*Aglais urticae*)	1979-2019	**-61****	**-19****	1981-2019	1	0.3
Comma (*Polygonia c-album*)	2006-2019	139	83	2006-2018	**86***	**59***
Small Copper (*Lycaena phlaeas*)	1979-2019	-36	-9	1979-2019	**-44*****	**-12*****
Green Hairstreak (*Callophrys rubi*)	1990-2019	-22	-8	1995-2019	-17	-7
Small Blue (*Cupido minimus*)	2005-2019	-20	-13	2008-2019	6	5
Northern Brown Argus (*Aricia artaxerxes*)	1981-2019	28	6	1995-2019	**-46***	**-21***
Common Blue (*Polyommatus icarus*)	1979-2019	41	8	1982-2019	**-38*****	**-11*****

Species trends that are statistically significant are shown in bold. * p<0.05, ** p<0.01, *** p<0.001.

Scotland butterfly abundance indicators for all species (black, 25 species), habitat specialists (blue, eight species) and wider countryside species (red, 15 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



Scotland butterfly distribution indicators for all species (black, 26 species), habitat specialists (blue, nine species) and wider countryside species (red, 15 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



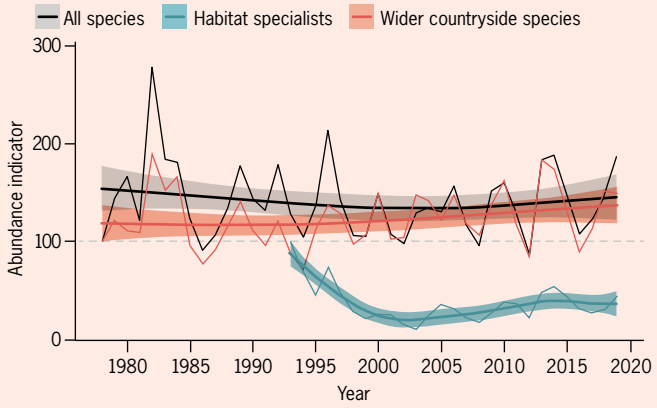
Wales
butterfly species trends

The all-species abundance indicator for Wales shows little overall change in butterfly numbers (8% decrease 1978-2019), but this is as a result of a substantial decline (45% decrease 1993-2019) among habitat specialists being largely counterbalanced by an 18% increase (1978-2019) in wider countryside species. Of the 33 species that have long-term abundance trends in Wales, 16 species (48%) decreased and 17 (52%) increased. There was strong evidence that six species (18%) have decreased and eight (24%) increased in abundance, while the remaining 19 species (58%) have non-significant trends.

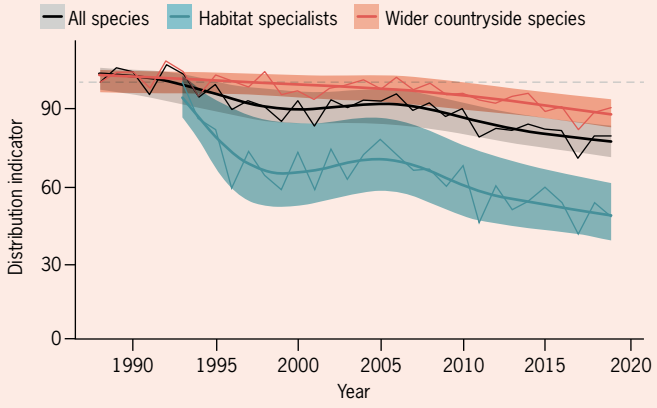
Distribution trends show a different pattern for Wales' butterflies. The all-species indicator shows a long-term decrease in species' distributions of almost one-quarter (24% decrease 1988-2019). Both habitat specialists and wider countryside species are decreasing in distribution, by -39% (1993-2019) and -14% (1988-2019), respectively. Long-term distribution change was estimated for 31 species in Wales, with 19 species (61%) having negative and 12 species (39%) positive trends. Considering the Welsh distribution trends in which we have most confidence, 17 species (55%) have decreased significantly and just two species (6%) have increased significantly, with the remaining 12 species (39%) having non-significant trends.

One species faring markedly worse in Wales is Brown Hairstreak. Although the trend is non-significant, its numbers appear to have fallen in Wales (39% decrease 2004-2019), while they show no change in England. Once found across large areas of Carmarthenshire, Ceredigion and Pembrokeshire, the distribution of Brown Hairstreak also appears to be contracting rapidly; it was recorded as breeding in 22 10km grid squares in the period 2005-2009 but only in 13 during 2015-2019. This is unlikely to be due to under-recording, as every year at least 25 days of systematic surveys are carried out by volunteer teams in South Wales. In contrast, the butterfly is expanding its local distribution in some parts of England, notably around Oxford and in Surrey and west London. The most likely driver of Brown Hairstreak decline in west Wales is

Wales butterfly abundance indicators for all species (black, 33 species), habitat specialists (blue, 10 species) and wider countryside species (red, 21 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.



Wales butterfly distribution indicators for all species (black, 31 species), habitat specialists (blue, eight species) and wider countryside species (red, 21 species). Thick lines show the smoothed indicators with confidence intervals (shaded areas), thin lines show the raw (unsmoothed) values.

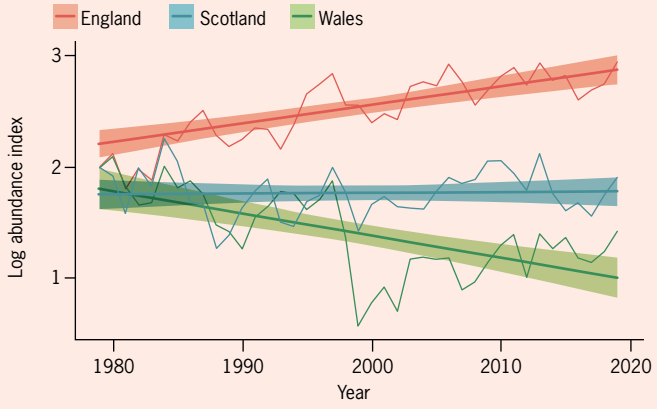


Dark Green Fritillary

Among declining species, Dark Green Fritillary is of concern as it shows an 84% decrease in abundance in Wales (1979-2019), which contrasts sharply with a 416% increase in England (1976-2019) and no change in Scotland (non-significant 6% increase 1979-2019). The reasons for these differing fortunes are not understood, but one threat to Dark Green Fritillary (and also Small Pearl-bordered Fritillary) in Wales is tree planting on its Bracken-dominated habitat. Butterfly Conservation Wales is working with the Welsh Government, using BNM data to flag up areas where proposed planting schemes may have detrimental impacts on fritillary butterflies. It should also be noted, as can be seen from the chart, that the fortunes of the species have improved in Wales more recently.


Dark Green Fritillary

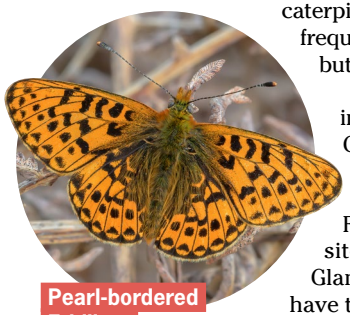
Abundance of Dark Green Fritillary in Wales compared to England and Scotland. Country abundance indices (thin lines) are shown with trends (thick lines) and shaded confidence intervals.



DARK GREEN FRITILLARY: MARK SEARLE

	Abundance trends (UKBMS)			Distribution trends (BNM)		
Species	Period	Total % abundance change over trend period	Average 10-year % abundance change	Period	Total % distribution change over trend period	Average 10-year % distribution change
Dingy Skipper (*Erynnis tages*)	2004-2019	42	24	1992-2019	6	2
Small Skipper (*Thymelicus sylvestris*)	1984-2019	31	7	1991-2019	**-30*****	**-11*****
Large Skipper (*Ochlodes sylvanus*)	1977-2019	**-60*****	**-18*****	1988-2019	**-29*****	**-10*****
Orange-tip (*Anthocharis cardamines*)	1978-2019	**365*****	**40*****	1984-2019	6	2
Large White (*Pieris brassicae*)	1976-2019	-11	-2	1976-2019	**-8****	**-2****
Small White (*Pieris rapae*)	1976-2019	**-51****	**-14****	1978-2019	**-8***	**-2***
Green-veined White (*Pieris napi*)	1976-2019	**155****	**22****	1977-2019	**-14*****	**-3*****
Brimstone (*Gonepteryx rhamni*)	1998-2019	62	23	1995-2019	1	0.3
Wall (*Lasiommata megera*)	1976-2019	**-52****	**-14****	1980-2019	**-65*****	**-22*****
Speckled Wood (*Pararge aegeria*)	1978-2019	**251*****	**32*****	1981-2019	**-24*****	**-6*****
Small Heath (*Coenonympha pamphilus*)	1976-2019	1	0.3	1976-2019	**-63*****	**-19*****
Ringlet (*Aphantopus hyperantus*)	1983-2019	**291*****	**41*****	1993-2019	0.04	0.01
Meadow Brown (*Maniola jurtina*)	1976-2019	13	3	1976-2019	**-10*****	**-2*****
Gatekeeper (*Pyronia tithonus*)	1978-2019	45	8	1980-2019	2	0.5
Marbled White (*Melanargia galathea*)	-	-	-	2002-2019	15	8
Grayling (*Hipparchia semele*)	1976-2019	**-94*****	**-44*****	1990-2019	**-74*****	**-35*****
Pearl-bordered Fritillary (*Boloria euphrosyne*)	1997-2019	**334*****	**82*****	-	-	-
Small Pearl-bordered Fritillary (*Boloria selene*)	1992-2019	**-76****	**-38****	1987-2019	**-69*****	**-28*****
Silver-washed Fritillary (*Argynnis paphia*)	1995-2019	-63	-31	1995-2019	**-48***	**-22***
Dark Green Fritillary (*Speyeria aglaja*)	1979-2019	**-84*****	**-34*****	1991-2019	**-37***	**-14***
High Brown Fritillary (*Fabriciana adippe*)	1995-2019	-1	-0.3	-	-	-
Red Admiral (*Vanessa atalanta*)	1976-2019	**153***	**21***	1983-2019	**21*****	**5*****
Painted Lady (*Vanessa cardui*)	1977-2019	77	13	1994-2019	**-10*****	**-4*****
Peacock (*Aglais io*)	1976-2019	-31	-8	1976-2019	0.1	0.02
Small Tortoiseshell (*Aglais urticae*)	1976-2019	-37	-9	1976-2019	3	1
Comma (*Polygonia c-album*)	1992-2019	**274*****	**55*****	1995-2019	**68*****	**21*****
Marsh Fritillary (*Euphydryas aurinia*)	1990-2019	-61	-26	1994-2019	8	3
Small Copper (*Lycaena phlaeas*)	1976-2019	-45	-12	1976-2019	**-16*****	**-4*****
Brown Hairstreak (*Thecla betulae*)	2004-2019	-39	-26	-	-	-
Purple Hairstreak (*Favonius quercus*)	2002-2019	-37	-22	-	-	-
Green Hairstreak (*Callophrys rubi*)	1993-2019	**359*****	**69*****	1993-2019	12	4
Holly Blue (*Celastrina argiolus*)	1999-2019	4	2	1996-2019	-14	-6
Silver-studded Blue (*Plebejus argus*)	-	-	-	1995-2019	**-49***	**-22***
Brown Argus (*Aricia agestis*)	1997-2019	87	29	2011-2019	-44	-48
Common Blue (*Polyommatus icarus*)	1976-2019	-19	-4	1988-2019	**-30*****	**-10*****

Species trends that are statistically significant are shown in bold. * p<0.05, ** p<0.01, *** p<0.001.



Pearl-bordered Fritillary

PEARL-BORDERED FRITILLARY: BARRY MILLS

widespread, annual trimming of farm hedgerows, which removes both the over-wintering eggs and food for any caterpillars that survive. Reducing the severity and frequency of hedge cutting would be beneficial for this butterfly and many other species[56].

Other species with large, long-term declines in abundance and distribution in Wales, such as Grayling and Small Pearl-bordered Fritillary (see p.10), are also faring badly in other UK countries.

Following long-term decline, High Brown Fritillary is restricted to just a single (large) site in Wales in the Alun Valley in the Vale of Glamorgan. A succession of conservation projects have taken place in this landscape since 2003[57], ensuring the survival of the butterfly, a Butterfly Conservation Priority Species. Through management of Bracken, scrub removal and coppicing, the area of suitable breeding habitat has been increased by two-thirds over the past 20 years. High Brown Fritillary numbers have increased in parallel, from a low of 1.5 butterflies per hour of searching in 1999 to 17.4 per hour in 2019.

Pearl-bordered Fritillary is another Priority Species that has benefitted from targeted conservation work at its few remaining Welsh sites, including Butterfly Conservation's reserve at Eyarth Rocks, Denbighshire. Its abundance in Wales has increased by 334% (1997-2019), helped by very good years in 2013, 2014 and 2019. However, this optimism is tempered by losses of colonies in Ceredigion and Montgomeryshire, reducing the species to only eight sites in the whole country, three of which are completely isolated from all the others. Maintenance of these remaining sites is unlikely to secure a long-term future for the butterfly in Wales and creating suitable habitat elsewhere in these landscapes is a priority.

[56] Staley *et al.* 2016, 2018
[57] Ellis *et al.* 2012

Using records to conserve butterflies

▶ **Butterflies are iconic insects** that are important as umbrella species for biodiversity conservation[58], flagship species for public engagement[59], sentinels for environmental change[60] and, with care, as indicators of wider invertebrate declines[61]. For these reasons, and because of ongoing human impacts on the environment, it is vital to maintain up-to-date assessments of butterfly trends.

▶ **Such assessments are possible thanks to the skill and dedication of many thousands of volunteer recorders**, channelled through the UK's long-running butterfly recording schemes (see p.4). These citizen science projects must be maintained and adequately resourced so that they can continue to provide globally important data on insect trends.

▶ **The overall results of the latest assessment, presented in this report, back up those of previous analyses.** There is strong evidence of decline in UK butterflies since the 1970s. Almost twice as many species have decreased significantly in either abundance or distribution (or both) than have increased and, on average, UK butterflies have lost 6% of their abundance and 42% of their distribution over the period 1976-2019. There are winners as well as losers, but Britain's butterflies are among the most threatened in Europe[62].

▶ **Butterfly records also play an important role in understanding the causes of biodiversity change.** For example, the overall pattern of butterfly responses to climate change has been clear for decades, with mobile, generalist butterflies expanding their ranges northwards, cold-adapted species retreating, and shifts in flight periods as the climate warms[63]. Recent research has looked at finer scales to reveal the negative effects of extreme weather, such as summer droughts and very mild spells in winter, on butterfly populations[64], the role of micro-climates[65] and the importance of habitat availability and land-use in determining species' responses to climate change[66]. Flight period shifts also have implications for butterfly populations, with earlier emergence appearing to benefit species that have more than one generation per year but not those that have a single brood[67].

▶ **Another important use of butterfly records and monitoring data is in assessing the effectiveness of measures designed to improve biodiversity.** This could be at the proof-of-concept stage, for example showing how rapidly butterflies colonise habitat created on the verges of a new road[68], or for monitoring long-term national policies such as agri-environment schemes[69]. Comparing butterfly counts in an arable farm landscape in Buckinghamshire with Wider Countryside Butterfly Survey data, for example, provided good evidence that well managed agri-environment schemes benefitted widespread butterflies[70]. Similarly, data gathered by butterfly recording schemes have provided rare insights into the effectiveness of protected areas for insects[71]. In Britain, Sites of Special Scientific Interest support larger populations of butterflies than unprotected sites, provide colonisation opportunities for species expanding their ranges and afford some protection for butterfly species retreating in the face of climate change[72]. However, several studies that include butterfly data found that protected areas were insufficient to stem overall biodiversity declines[73] and that even if expanded to 30% of UK land, protected landscapes would achieve little for priority species without substantial investment in habitat creation and restoration[74].

▶ **Continued and improved recording and monitoring of UK butterflies is essential.** By engaging citizen scientists, driving conservation, evaluating policy, catalysing scientific research and raising public awareness, the data gathered by many thousands of volunteers make a vital contribution to the huge challenge of halting and reversing long-term butterfly declines.

Volunteers are vital for recording and monitoring but also in conserving threatened species. Here volunteers are creating open habitat in a Cumbrian wood that will hopefully be colonised by High Brown Fritillary and Small Pearl-bordered Fritillary.

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[58] Spitzer *et al.* 2009
[59] Preston *et al.* 2021
[60] Hill *et al.* 2021
[61] Van Klink *et al.* 2022
[62] Britain ranks seventh worst out of 33 European countries in terms of mean Red List value for butterflies, a measure of the average level of threat faced by the butterfly fauna of each nation (Maes *et al.* 2019b).
[63] Roy & Sparks 2000, Warren *et al.* 2001, Franco *et al.* 2006
[64] Oliver *et al.* 2015, De Palma *et al.* 2017, McDermott Long *et al.* 2017, Palmer *et al.* 2017
[65] Suggitt *et al.* 2015
[66] Oliver *et al.* 2017, Platts *et al.* 2019, Hellegers *et al.* 2022
[67] Macgregor *et al.* 2019
[68] Hetherington *et al.* 2021
[69] Stewart *et al.* 2022
[70] Redhead *et al.* 2022
[71] Chowdhury *et al.* 2022
[72] Gillingham *et al.* 2015a,b
[73] Rada *et al.* 2019, Cunningham *et al.* 2021a
[74] Cunningham *et al.* 2021b

References

Red Admiral

RED ADMIRAL: BOB EADE

Bourn NA & Thomas JA (2002) The challenge of conserving grassland insects at the margins of their range in Europe. *Biological Conservation* **104**, 285–292.

Bourn N, *et al.* (2013) Conserving the Marsh Fritillary across the UK – lessons for landscape-scale conservation. *British Wildlife* **24**, 408–417.

Brereton T, *et al.* (2011) The development of butterfly indicators in the United Kingdom and assessments in 2010. *Journal of Insect Conservation* **15**, 139–151.

Burns F, *et al.* (2018) An assessment of the state of nature in the United Kingdom: a review of findings, methods and impact. *Ecological Indicators* **94**, 226–236.

Chowdhury S, *et al.* (2022) Protected areas and the future of insect conservation. *Trends in Ecology & Evolution* DOI: 10.1016/j.tree.2022.09.004

Connors BM, *et al.* (2014) The false classification of extinction risk in noisy environments. *Proceedings of the Royal Society B* **281**, 20132935.

Cook P, *et al.* (2021) *The status of the Wood White* Leptidea sinapis *in the UK. Butterfly Conservation report number S21-1*6. Butterfly Conservation, Wareham, UK.

Cunningham CA, *et al.* (2021a) The effectiveness of the protected area network of Great Britain. *Biological Conservation* **257**, 109146.

Cunningham CA, *et al.* (2021b) Translating area-based conservation pledges into efficient biodiversity protection outcomes. *Communications Biology* **4**, 1043.

Cusser S, *et al.* (2021) How long do population level field experiments need to be? Utilising data from the 40-year-old LTER network. *Ecology Letters* **24**, 1103–1111.

Dempster JP (1983) The natural control of populations of butterflies and moths. *Biological Reviews* **58**, 461–481.

Dennis EB, *et al.* (2016) A generalized abundance index for seasonal invertebrates. *Biometrics* **72**, 1305–1314.

Dennis EB, *et al.* (2017) Efficient occupancy model-fitting for extensive citizen-science data. *PLoS One* **12**, e0174433.

Dennis EB, *et al.* (2019) Trends and indicators for quantifying moth abundance and occupancy in Scotland. *Journal of Insect Conservation* **23**, 369–380.

De Palma A, *et al.* (2017) Large reorganizations in butterfly communities during an extreme weather event. *Ecography* **40**, 577–585.

De Ro A, *et al.* (2021) Occasional long-distance dispersal may not prevent inbreeding in a threatened butterfly. *BMC Ecology and Evolution* **21**, 224.

Didham RK, *et al.* (2020) Interpreting insect declines: seven challenges and a way forward. *Insect Conservation and Diversity* **13**, 103–114.

Dirzo R, *et al.* (2014) Defaunation in the Anthropocene. *Science* **345**, 401–406.

Ellis S, *et al.* (2011) Landscape-scale conservation in practice: lessons from northern England, UK. *Journal of Insect Conservation* **15**, 69–81.

Ellis S, *et al.* (2012) *Landscape-scale conservation for butterflies and moths: lessons from the UK.* Butterfly Conservation, Wareham, UK.

Forister ML, *et al.* (2021) Fewer butterflies seen by community scientists across the warming and drying landscapes of the American West. *Science* **371**, 1042–1045.

Fox R, *et al.* (2015) *The State of the UK's Butterflies 2015.* Butterfly Conservation and the Centre for Ecology & Hydrology, Wareham, UK.

Fox R, *et al.* (2019) Insect population trends and the IUCN Red List process. *Journal of Insect Conservation* **23**, 269–278.

Fox R, *et al.* (2022) A revised Red List of British butterflies. *Insect Conservation and Diversity* **15**, 485–495.

Franco AM, *et al.* (2006) Impacts of climate warming and habitat loss on extinctions at species' low-latitude range boundaries. *Global Change Biology* **12**, 1545–1553.

Gillingham PK, *et al.* (2015a) High abundances of species in protected areas in parts of their geographic distributions colonised during a recent period of climatic change. *Conservation Letters* **8**, 97–106.

Gillingham PK, *et al.* (2015b) The effectiveness of protected areas to conserve species undertaking geographic range shifts. *Biological Journal of the Linnean Society* **115**, 707–717.

Habel JC, *et al.* (2019) Long-term large-scale decline in relative abundances of butterfly and burnet moth species across south-western Germany. *Scientific Reports* **9**, 1–9.

Harris JE, *et al.* (2019) Decline in beetle abundance and diversity in an intact temperate forest linked to climate warming. *Biological Conservation* **240**, 108219.

Harvey JA, *et al.* (2020) International scientists formulate a roadmap for insect conservation and recovery. *Nature Ecology & Evolution* **4**, 174–176.

Hellegers M, *et al.* (2022) Modulating effects of landscape characteristics on responses to warming differ among butterfly species. *Frontiers in Ecology and Evolution* **10**, 873366.

Hetherington M, *et al.* (2021) Butterfly colonisation of a new chalkland road cutting. *Insect Conservation and Diversity* **15**, 191–199.

Hill GM, *et al.* (2021) Climate change effects on animal ecology: butterflies and moths as a case study. *Biological Reviews* **96**, 2113–2126.

Hodgson JA, *et al.* (2022) Where and why are species' range shifts hampered by unsuitable landscapes? *Global Change Biology* **28**, 4765–4774.

Isaac NJB & Pocock MJO (2015) Bias and information in biological records. *Biological Journal of the Linnean Society* **115**, 522–531.

Jones R, *et al.* (2019) *The changing status of Marsh Fritillary in England (2000-2017). Butterfly Conservation Confidential Report S19-02.* Butterfly Conservation, Wareham, UK.

Klop E, *et al.* (2015) Impact of nitrogen deposition on larval habitats: the case of the Wall Brown butterfly *Lasiommata megera. Journal of Insect Conservation* **19**, 393–402.

Kurze S, *et al.* (2018) Nitrogen enrichment in host plants increases the mortality of common Lepidoptera species. *Oecologia* **188**, 1227–1237.

Loram A, *et al.* (2003) The habitat requirements of the Grayling, *Hipparchia semele* (Linnaeus, 1758) (Lepidoptera: Nymphalidae, Satyrinae) in a semi-natural inland landscape in Shropshire, England. *Entomologist's Gazette* **54**, 153–165.

Macgregor CJ, *et al.* (2019) Climate-induced phenology shifts linked to range expansions in species with multiple reproductive cycles per year. *Nature Communications* **10**, 4455.

Maes D, *et al.* (2019a) The potential of species distribution modelling for reintroduction projects: the case study of the Chequered Skipper in England. *Journal of Insect Conservation* **23**, 419–431.

Maes D, *et al.* (2019b) Integrating national Red Lists for prioritising conservation actions for European butterflies. *Journal of Insect Conservation* **23**, 301–330.

Mallet J, *et al.* (2011) Hybridisation and climate change: brown argus butterflies in Britain (*Polyommatus* subgenus *Aricia*). *Insect Conservation and Diversity* **4**, 192–199.

Mason SC, *et al.* (2015) Geographical range margins of a wide range of taxonomic groups continue to shift polewards. *Biological Journal of the Linnean Society* **115**, 586–597.

McDermott Long O, *et al.* (2017) Sensitivity of UK butterflies to local climatic extremes: which life stages are most at risk? *Journal of Animal Ecology* **86**, 108–116.

Montgomery GA, *et al.* (2020) Is the insect apocalypse upon us? How to find out. *Biological Conservation* **241**, 108327.

Oliver TH, *et al.* (2015) Interacting effects of climate change and habitat fragmentation on drought-sensitive butterflies. *Nature Climate Change* **5**, 941–945.

Oliver TH, *et al.* (2017) Large extents of intensive land use limit community reorganization during climate warming. *Global Change Biology* **23**, 2272–2283.

O'Neill J & Montgomery I (2018) Demographics and spatial ecology in a population of cryptic wood white butterfly *Leptidea juvernica* in Northern Ireland. *Journal of Insect Conservation* **22**, 499–510.

Palmer G, *et al.* (2017) Climate change, climatic variation and extreme biological responses. Philosophical Transactions of the *Royal Society B* **372**, 20160144.

Pateman RM, *et al.* (2012) Temperature-dependent alterations in host use drive rapid range expansion in a butterfly. *Science* **336**, 1028–1030.

Pilotto F, *et al.* (2020) Meta-analysis of multidecadal biodiversity trends in Europe. *Nature Communications* **11**, 1–11.

Platts PJ, *et al.* (2019) Habitat availability explains variation in climate-driven range shifts across multiple taxonomic groups. *Scientific Reports* **9**, 15039.

Pollard E (1977) A method for assessing changes in the abundance of butterflies. *Biological Conservation* **12**, 115–134.

Pollard E, *et al.* (1975) A method of assessing the abundance of butterflies in Monks Wood National Nature Reserve in 1973. *Entomologist's Gazette* **26**, 79–88.

Porter K & Ellis S (2011) Securing viable metapopulations of the Marsh Fritillary butterfly, *Euphydryas aurinia*, (Lepidoptera: Nymphalidae) in Northern England. *Journal of Insect Conservation* **15**, 111–119.

Preston SD, *et al.* (2021) A case study of a conservation flagship species: the monarch butterfly. *Biodiversity and Conservation* **30**, 2057–2077.

Rada S, *et al.* (2019) Protected areas do not mitigate biodiversity declines: A case study on butterflies. *Diversity and Distributions* **25**, 217–224.

Redhead JW, *et al.* (2022) The effects of a decade of agri-environment intervention in a lowland farm landscape on population trends of birds and butterflies. *Journal of Applied Ecology* **59**, 2486–2496.

Robinson AE (2008) *Habitat requirements of the Grayling butterfly*, Hipparchia semele. MSc dissertation, University of East Anglia, Norwich, UK.

Roy DB & Sparks TH (2000) Phenology of British butterflies and climate change. *Global Change Biology* **6**, 407–416.

Saunders ME, *et al.* (2020) Moving on from the insect apocalypse narrative: engaging with evidence-based insect conservation. *BioScience* **70**, 80–89.

Schirmel J & Fartmann T (2014) Coastal heathland succession influences butterfly community composition and threatens endangered butterfly species. *Journal of Insect Conservation* **18**, 111–120.

Schowalter TD, *et al.* (2021) Arthropods are not declining but are responsive to disturbance in the Luquillo Experimental Forest, Puerto Rico. *Proceedings of the National Academy of Sciences of the USA* **118**, e2002556117.

Spitzer L, *et al.* (2009) The large blue butterfly, *Phengaris* [*Maculinea*] *arion*, as a conservation umbrella on a landscape scale: the case of the Czech Carpathians. *Ecological Indicators* **9**, 1056–1063.

Staats WT & Regan EC (2014) Initial population trends from a 5-year butterfly monitoring scheme. *Journal of Insect Conservation* **18**, 365–371.

Staley JT, *et al.* (2016) Little and late: How reduced hedgerow cutting can benefit Lepidoptera. *Agriculture, Ecosystems & Environment* **224**, 22–28.

Staley JT, *et al.* (2018) Experimental evidence for optimal hedgerow cutting regimes for Brown hairstreak butterflies. *Insect Conservation and Diversity* **11**, 213–218.

Stefanescu C, *et al.* (2022) Larval parasitism in a specialist herbivore is explained by phenological synchrony and host plant availability. *Journal of Animal Ecology* **91**, 1010–1023.

Stewart LB, *et al.* (2022) Navigating a shifting agri-environment policy landscape to conserve butterflies. *Conservation Science and Practice* e12795.

Suggitt AJ, *et al.* (2015) Microclimate affects landscape level persistence in the British Lepidoptera. *Journal of Insect Conservation* **19**, 237–253.

Taylor LR & Taylor RA (1977) Aggregation, migration and population mechanics. *Nature* **265**, 415–421.

Thomas CD, *et al.* (2019) "Insectageddon": A call for more robust data and rigorous analyses. *Global Change Biology* **25**, 1891–1892.

Thomas JA, *et al.* (2004) Comparative losses of British butterflies, birds, and plants and the global extinction crisis. *Science* **303**, 1879–1881.

Thomas JA, *et al.* (2009) Successful conservation of a threatened *Maculinea* butterfly. *Science* **325**, 80–83.

van Bergen E, *et al.* (2020) The effect of summer drought on the predictability of local extinctions in a butterfly metapopulation. *Conservation Biology* **34**, 1503–1511.

Van Dyck H, *et al.* (2015) The lost generation hypothesis: could climate change drive ectotherms into a developmental trap? *Oikos* **124**, 54–61.

Van Klink R, *et al.* (2020) Meta-analysis reveals declines in terrestrial but increases in freshwater insect abundances. *Science* **368**, 417–420.

Van Klink R, *et al.* (2022) Long-term abundance trends of insect taxa are only weakly correlated. *Biology Letters* **18**, 20210554.

Visser H (2004) Estimation and detection of flexible trends. *Atmospheric Environment* **38**, 4135–4145.

Wagner DL (2020) Insect declines in the Anthropocene. *Annual Review of Entomology* **65**, 457–480.

Wagner DL, *et al.* (2021) Insect decline in the Anthropocene: Death by a thousand cuts. *Proceedings of the National Academy of Sciences of the USA* **118**, e2023989118.

WallisDeVries MF & van Swaay CA (2017) A nitrogen index to track changes in butterfly species assemblages under nitrogen deposition. *Biological Conservation* **212**, 448–453.

Warren MS, *et al.* (2001) Rapid responses of British butterflies to opposing forces of climate and habitat change. *Nature* **414**, 65–69.

Warren MS, *et al.* (2021) The decline of butterflies in Europe: problems, significance, and possible solutions. *Proceedings of the National Academy of Sciences of the USA* **118**, e2002551117.

Welti EA, *et al.* (2020) Nutrient dilution and climate cycles underlie declines in a dominant insect herbivore. *Proceedings of the National Academy of Sciences of the USA* **117**, 7271–7275.

Wepprich T, *et al.* (2019) Butterfly abundance declines over 20 years of systematic monitoring in Ohio, USA. *PLoS One* **14**, e0216270.

Wilson EO (1987) The little things that run the world (the importance and conservation of invertebrates). *Conservation Biology* **1**, 344–346.

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Peacock

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