England Biodiversity Indicators 2023

This document supports

10. Status of pollinating Insects

Technical background document:

The Biological Records Centre

Biodiversity and Ecosystem Services – status of pollinating insects – technical background document

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Introduction

Pollination is a vital ecosystem service that benefits agricultural and horticultural production and is essential for maintaining wild flower biodiversity. By improving the yield, quality and resilience of crops, insect pollination has been valued at £400 million per year to the UK economy (POST, 2010). 35% of the world's agricultural output, by volume, consists of 87 crop types that benefit from pollination by animals (insects, birds and mammals), but because most of these crops are not entirely dependent on animal pollination, the amount of production directly attributable to animals is lower than this value (Klein et al., 2007). There is growing concern regarding the population status of insect pollinators, and in turn the pollination service they provide (Potts et al., 2010 and Garratt et al., 2014).

As with most other areas of biodiversity, the main threats to pollinators include habitat loss, environmental pollution, climate change and the spread of alien species (Klein et al., 2007, Potts et al., 2010, Vanbergen and the Insect Pollinators Initiative 2013). The widespread application of pesticides is also perceived as a major threat to pollinator diversity (Brittain et al., 2010).

In order for governments to act upon these threats they need robust metrics on the national-scale status of pollinators and pollination, though deriving such a metric has previously been limited by the availability of suitable data and analytical techniques and the species considered to be wild pollinators are subject to debate (Hutchinson et al. 2021).

With the increase in citizen science, the availability of large-scale biological record data has increased (Silvertown, 2009). Such data are collected without a standardised survey protocol and therefore extracting reliable trends from them can be difficult. However, with recent analytical advances it is now possible to estimate reliable trends from such data (van Strien et al., 2013, Isaac et al., 2014).

Methods

Data sources

Occurrence records of bee and hoverfly species within 1km grid cells in the UK originate from the Bees, Wasps and Ants Recording Society (BWARS) and the Hoverfly Recording Scheme biological records databases. The time-period used for the indicator was 1980 to 2019, as this represents a core period of recording for these taxa in the UK. Bee species were filtered (following expert guidance from BWARS) so that only species considered to be wild pollinators were included. Species that had undergone taxonomic changes or had taxonomic issues during the time frame of the indicator were excluded from the analysis.

The final composite indicator was based on 389 species of wild pollinator, see Appendix 1 for a list of species covered. Note that the species considered to be wild pollinators are subject to review, following feedback from the scientific community and the publication of a literature review of field survey data recording wild bee visits to crops in Great Britain and Europe (Hutchinson et al. 2021).

Generating species' trends and the composite indicator

The data used to produce the indicator were not collected using a standardised protocol, but instead are a collation of unstructured biological observations collected by a large network of volunteer recorders.

Such data tend to contain many forms of sampling bias and noise, making it hard to detect genuine signals of change (Tingley and Beissinger, 2009, Hassall and Thompson, 2010; Isaac et al., 2014). Recent studies have highlighted the value of Bayesian occupancy models for estimating species occurrence in the presence of imperfect detection (van Strien et al., 2013 , Isaac et al., 2014). This approach uses 2 hierarchically coupled sub-models: an occupancy sub-model (that is, presence verses absence), and a detection sub-model (that is, detection verses non-detection).

Together these sub-models estimate the conditional probability that a species is detected when present. Species-specific time series estimates are derived from a Bayesian occupancy model, described in Outhwaite et al. (2019) and following van Strien et al. (2013) and Isaac et al. (2014), with improvements based on Outhwaite et al. (2018). Annual estimates of occupancy, with estimates of uncertainty, are available for 5,293 UK invertebrate, bryophyte and lichen species for the period 1970 to 2015 (Outhwaite et al. 2019). These models are updated as and when new data become available from recording schemes.

For each site-year combination the model estimates presence or absence for the species in question given variation in detection probability: from this the proportion of occupied sites ('occupancy') was estimated for each year. To estimate the composite indicator trend with uncertainty, the posterior distribution of the annual occupancy estimates for each species was utilised.

A change from the approach used to select species-specific trends for the 2021 indicator is the adoption of new criteria (rules-of-thumb), based on the suitability of the underlying data for producing occupancy trends with acceptable precision. This data-driven approach is considered to be more objective than the previous threshold of 50 records (Pocock et al. 2019). Rarely recorded species (less than 1 record in every 100 visits) were excluded if there were fewer than 3.1 records across the 10% of the best recorded years. More frequently recorded species were excluded if there were fewer than 6.7 records across the 10% of the best recorded years (Pocock et al. 2019).

Exclusion criteria are based on classification trees, selected to balance the rates at which species are excluded when not meeting precision thresholds and included when meeting the precision thresholds. In total, the 2022 indicator comprises 389 species that met these criteria for inclusion. This represents a net increase of 12 species compared with the 2021 indicator.

The composite indicator was produced using a novel hierarchical modelling method for calculating multi-species indicators developed by the UK Centre for Ecology & Hydrology (UKCEH) (Freeman et al. 2020), which offers some advantages over the geometric mean method used to produce the 2020 indicator. It can be applied to multiple data types, improving the comparability between metrics derived from occupancy and abundance data and can account for the uncertainty associated with the underlying species-specific time series as well as uncertainty in the indicator arising from the subset of species that are included. Case studies with four taxonomic groups show it to be robust to missing values, especially when these are non-random, for example when declining species are more likely to be missing observations in recent years or if recent colonists are absent earlier in the time series. Imputing missing values is informed by between-year changes in species for which data is available, assuming shared environmental responses. Additionally, a smoothing process is used to reduce the impact of between-year fluctuations - such as those caused by variation in weather - making underlying trends easier to detect. The smoothing parameter (number of knots) was set to the number of years divided by three following Fewster et al. (2000).

The indicator represents annual change in the geometric mean estimated occupancy across the constituent species. The index is set to a value of 100 in the start year (the baseline), so that changes subsequent to this represent proportional change in occupancy; if on average species' trends doubled, the indicator would rise to 200, if they halved it would fall to a value of 50.

Species-specific trends

For each species, the long- and short-term trend in occupancy was estimated as the mean annual percent change (over the time-period in question) across 1,000 estimates from the posterior distribution. Species were grouped into one of 5 categories based on both their short-term and long-term occupancy trend (Table 1). The threshold values for each category were based on those of the wild bird indicator; whether an individual species is increasing or decreasing has been decided by its rate of annual change over the time period (long or short) of interest.

If the rate of annual change would lead to an occupancy increase or decrease of between 25% and 49% over 25 years, the species is said to have shown a 'weak increase' or a 'weak decline' respectively. If the rate of annual change would lead to a population increase or decrease of 50% or more over 25 years, the species is said to have shown a 'strong increase' or a 'strong decline' respectively. These thresholds are used in the Birds of Conservation Concern status assessment for birds in the UK.

Table 1: Thresholds used to define individual species trends

Category	Thresholds	Threshold – equivalent
Strong increase	Above +2.81% per annum (pa)	+100% over 25 years
Weak increase	Between +1.16% and +2.81% pa	+33% to +100% over 25 years
Stable	Between -1.14 % and +1.16% pa	-25% to +33% over 25 years
Weak decrease	Between -2.73% and -1.14% pa	-50% to -25% over 25 years

Category	Thresholds	Threshold – equivalent
Strong decrease	Below -2.73% pa	-50% over 25 years

Asymmetric percentage change thresholds are used to define these classes as they refer to proportional change, where a doubling of a species index (an increase of 100%) is counterbalanced by a halving (a decrease of 50%).

Results

The indicator for wild bees, hoverflies and all pollinators have been updated and the time series for hoverflies and all pollinators were extended by 2 additional years to 2019.

- the indicator (Figure 1) shows the average relative change in the area over which each of 389 species of pollinator was found, as measured by the number of 1km grid squares across the UK in which they were recorded – this is referred to as the ‘occupancy index’
- over the long term (1980 to 2019), the pollinator indicator showed 21% decline, and was therefore assessed as declining
- temporal patterns of change in the pollinator indicator showed a steady decline from 1987 onwards
- between 2014 and 2019 the indicator decreased by approximately 6%, therefore the short-term trend was assessed as declining
- over the long term, 16% of pollinator species became more widespread (8% showed a strong increase), and 42% became less widespread (20% showed a strong decrease).
- over the short term, a greater proportion of species were decreasing (48%, with 33% exhibiting a strong decline) than increasing (27%, with 17% exhibiting a strong decrease)
- as individual pollinator species become more or less widespread, the communities in any given area become more or less diverse, and this may have implications for pollination as more diverse communities are, in broad terms, more effective in pollinating a wide range of crops and wild flowers

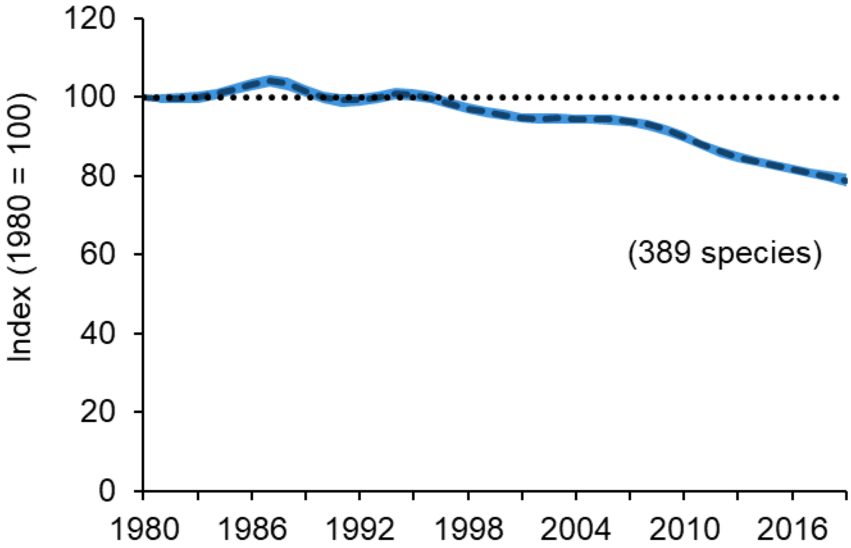
The indicator plot was also produced for the bee (Figure 3) and hoverfly (Figure 5) species separately.

The wild bee index fluctuates around its initial value over much of the time-series. Although the bee index in 2019 was estimated to be 2% higher than in 1980, it is assessed as stable. A larger proportion of bee species had decreased than increased over the long term (33% decreased and 22% increased), as well as over the short term (37% decreased and 28% increased).

With regard to hoverflies, the index was at a peak in 1987 (108% compared to its 1980 value), and then (apart from some minor increases), underwent a progressive decline. Thus, the indicator is approximately 34% lower in 2019 than in 1980. Over the short term (2014 to

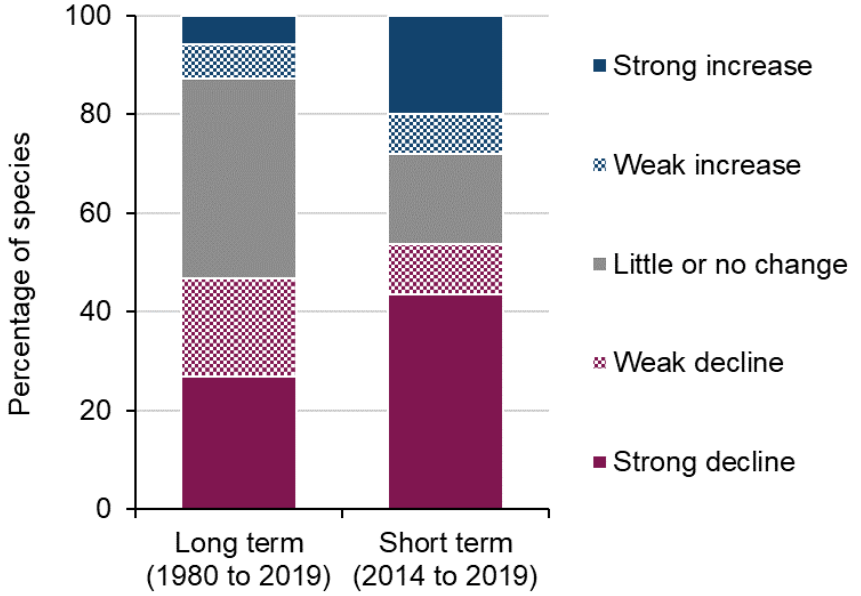
2019), the indicator decreases by just over 6%. A greater proportion of hoverflies have declined than increased in occupancy over both the long and short term (1980 to 2019: 47% decreased and 13% increased; 2014 to 2019: 54% decreased and 28% increased). It is not clear why hoverflies show a different trend to bees, although differences in the life cycle will mean they respond differently to weather events and habitat change.

Figure 1: Change in the distribution of wild pollinators (n = 389) in the UK between 1980 and 2019.



The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of pollinator species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2019) and b) the short term (2014 to 2019).

Figure 2: Long-term and short-term changes in individual species trends for pollinators in the UK, 1980 to 2019.



The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of pollinating wild bee species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2019) and b) the short term (2014 to 2019).

Figure 3: Change in the distribution of wild bee species in the UK, 1980 to 2019.

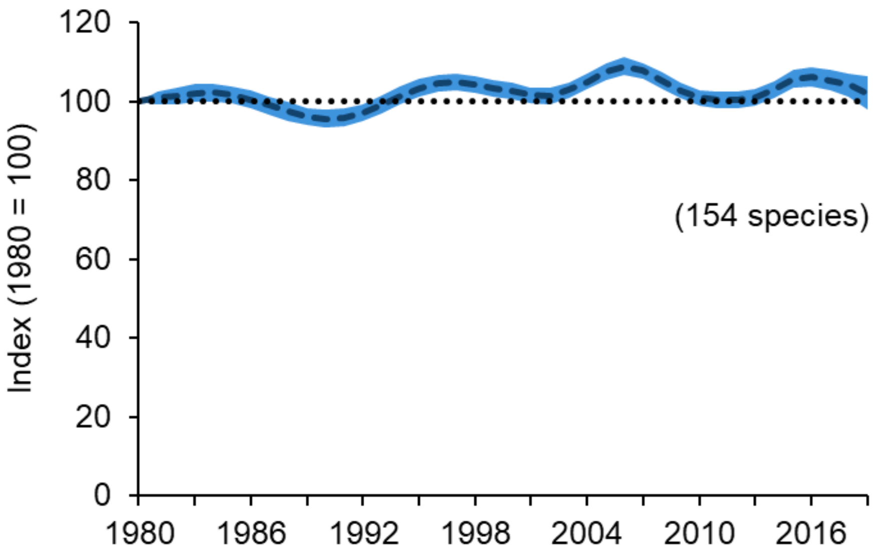


Figure 4: Long-term and short-term changes in individual species trends for wild bees in the UK, 1980 to 2019.

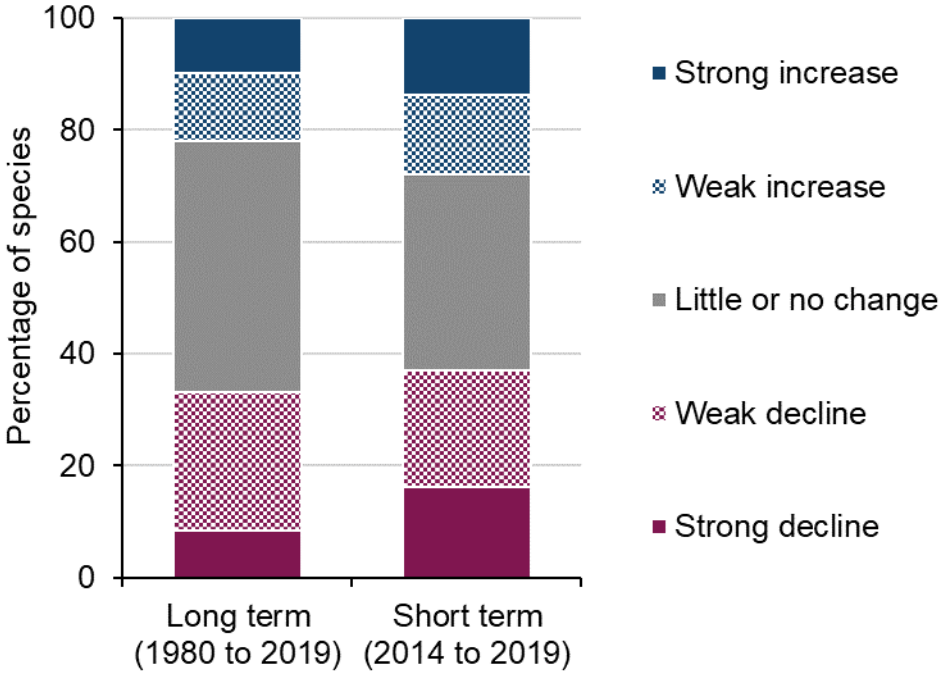
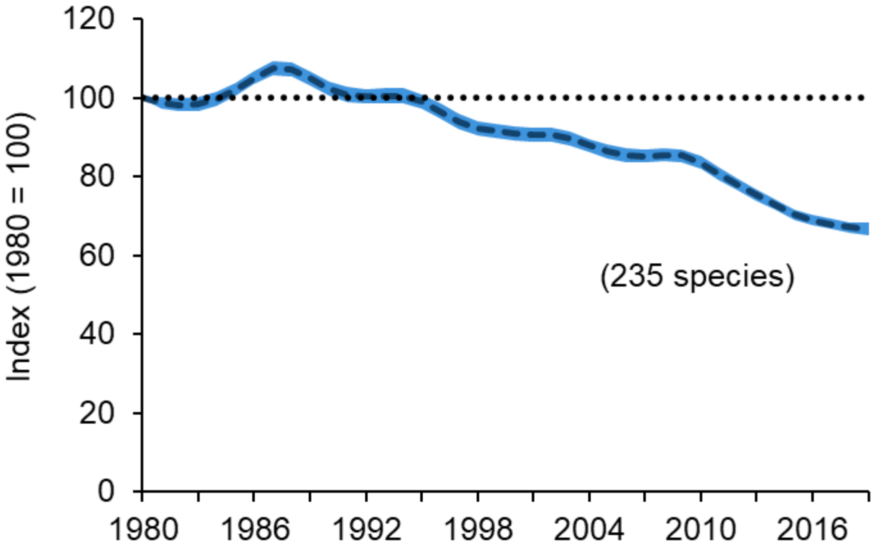
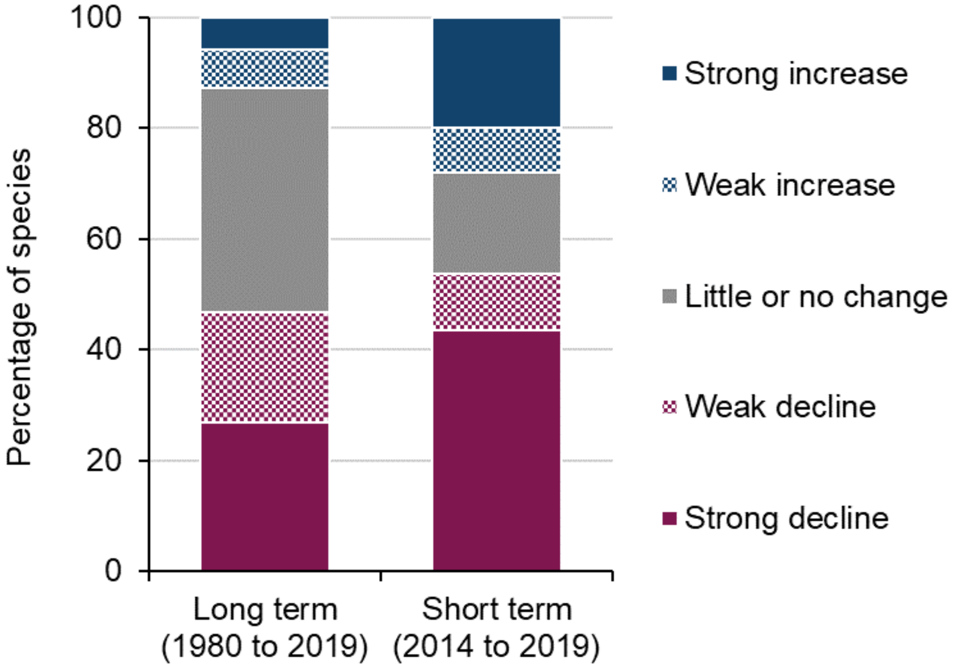


Figure 5: Change in the distribution of hoverfly species (n = 235) in the UK between 1980 and 2019.



The shaded region is the 90% credible intervals of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates the rescaled indicator value. The proportion of hoverfly species in each trend category is based on the mean annual change in occupancy over both a) the long term (1980 to 2019) and b) the short term (2014 to 2019).

Figure 6: Long-term and short-term changes in individual species trends for hoverflies in the UK, 1980 to 2019.

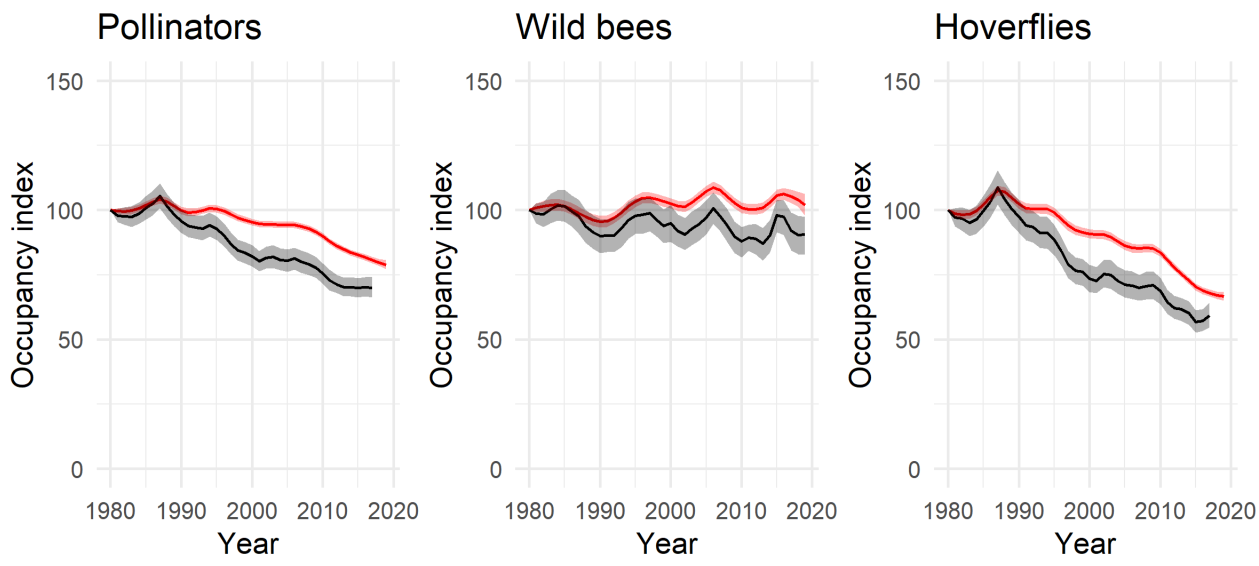


Changes from last year

The hoverfly indicator has been updated with new data, therefore extending the time series by 2 years to 2019. The occupancy models for the wild bee species have not been updated since last year as new data was not available. However, both indicators have been updated with new methods to select species-specific trends and to calculate the multispecies indicators.

The change to filtering by rules-of-thumb meant that 6 more bee species and 6 more hoverfly species were included in this year's indicator compared to last year. The change in methodology used to calculate the multispecies indicator from the species annual occupancies also resulted in some changes in this year's indicator compared to last year (Figure 7). The new hierarchical modelling method has produced a much smoother and more precise trend and smaller magnitude of decline since 1980. The difference is more pronounced for hoverflies than bees, but in both taxa, there is little difference in the index value at the start of the time series, with the indicator lines departing after 1990.

Figure 7. Comparison between the indicators last year (in black) and this year (in red) for wild bees, hoverflies and all pollinators.



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