

# Technical Annex for the Official Statistic in Development 'Pollinating insect trends'

June 2026

This technical annex accompanies the Official Statistic in Development 'Pollinating insect trends', available at:

<https://jncc.gov.uk/our-work/official-statistic-on-pollinating-insect-trends/>

**Note:** the contents of this Technical Annex are largely taken from a scientific journal manuscript currently in review. It is anticipated that this paper will be available towards the end of June 2026.

# 1 Overview

Metrics of change in pollinator abundance and species richness are derived from data collected through the UK Pollinator Monitoring Scheme (PoMS) using standardised survey protocols. The metrics of change are based on statistical models that estimate temporal trends in insect abundance and species richness while accounting for variation in survey conditions.

Estimates are derived from models that incorporate local-scale environmental variables recorded during sampling. These models are designed to reduce variability in insect numbers associated with environmental conditions, such as weather and habitat, improve the precision of trend estimates, and allow us to detect long-term trends beyond annual fluctuations.

## 2 Model structure

All metrics are derived using Generalised Linear Mixed-effects Models (GLMMs) fitted to count data. Models are fitted separately for each insect group. The response variable is the number of individuals (or species) of each insect group per sampling unit (pan trap sample or FIT count). We use a negative binomial error distribution to account for overdispersion in count data. Models for the FIT Count data include a random effect for the 1 km grid cell in which each FIT Count was conducted, while models for the pan trap data include a nested random effect of pan trap station within 1 km grid cell. This hierarchical structure reflects the repeated sampling of the same locations over time and allows separation of within-site temporal variation from between-site differences.

### 2.1 Covariates

Time is modelled using a cubic spline for year with three degrees of freedom. The use of a spline allows the estimation of smoothed annual trends, reducing sensitivity to short-term inter-annual fluctuations in insect abundance.

The models include explanatory variables describing conditions at the time and location of sampling, which influence observed insect activity and detectability. For the pan trap data the model includes:

- Month
- Total flower abundance (number of floral units) within 2m radius
- Flower species richness within 2m radius
- Habitat type
- Sun exposure during the survey
- Wind speed during the survey
- Country

For FIT Count data, the model includes:

- Month
- Flower structure
- Number of flowers in the quadrat
- Habitat type
- Floral context
- Sunshine
- Wind
- Country

Table 1 describes the variables in detail.

**Table 1. Environmental variables included in the PoMS models.**

<b>Variable (Type, model)</b>	<b>Description</b>	<b>Survey</b>
Month	Month in which the survey was conducted. One of: April, May, June, July, August, September.	Pan trap and FIT Counts
Flower count	For pan trap data this is the total number of floral units counted by the surveyor within a 2 m radius of the pan trap station.  The variable was logged, centred around the mean and divided by the standard deviation.  For FIT Count data this is the number of floral units of the target species counted in the 50x50 cm patch where the survey was conducted.  The variable was logged, centred around the mean and divided by the standard deviation. We modelled the effect of this variable as linear.	Pan trap and FIT Counts
Flower richness	The number of plant species in flower counted within a 2 m radius of the pan trap.  The variable was centred around the mean, divided by the standard deviation and modelled as a linear effect.	Pan trap
Flower structure	The structure of the target flower on which the FIT Count was conducted. One of: open or closed floral structure.	FIT Counts

<b>Variable (Type, model)</b>	<b>Description</b>	<b>Survey</b>
Flower context	The category of flower context in which the FIT Count was conducted. One of: growing in a larger patch of many different flowers, growing in a larger patch of the same flower, or more or less isolated.	FIT Counts
Habitat type	Broad categorisation of local habitat type. For pan trap data, one of: semi-natural or agricultural.  For FIT Count data, one of: semi-natural, agricultural, garden or urban (UK Pollinator Monitoring Scheme 2025a).	Pan trap and FIT Counts
Sunshine	An estimate of amount of sunlight falling on the 50 x 50 cm quadrat during the ten-minute count. One of: entirely in sunshine, partly in sun and partly shaded, or entirely shaded.	FIT Counts
Sun exposure	Estimated % of total trapping time per survey during which the sun was shining.  The variable was modelled as a linear effect.	Pan trap
Wind speed	Average wind speed on the Beaufort scale during the pan trap survey.  The variable was modelled as a linear effect.	Pan trap
Wind	Wind prevalence category during the ten-minute count. One of: leaves still/moving occasionally, leaves moving gently all the time, or leaves moving strongly.	FIT Counts
Country	Country in which the survey was undertaken. One of England, Wales or Scotland.	Pan trap and FIT Counts

## 2.2 Model specification

For a given insect group, the expected count at survey  $i$  in site  $j$  is modelled as:

$$\log(\mu_{ij}) = f(\text{Year}_i) + \beta X_{ij} + u_j$$

where  $f(\text{Year}_i)$  is the cubic spline,  $X_{ij}$  is the vector of environmental covariates described above,  $\beta$  are regression coefficients and  $u_j \sim N(0, \sigma^2)$  is the random site effect.

## 2.3 Model validation

All models reached convergence and model residuals were checked for violation of model assumptions using [DHARMA residuals](#) (Hartig 2026).

# 3 Generating the change metrics

From each fitted model, we derive annual predictions of abundance as [estimated marginal means](#) (Lenth and Piaskowski 2026), holding other covariates at their mean, for numerical variables, and averaging over all levels of categorical variable using a weighted mean. This produces a standardised annual index of abundance, representing expected counts under average survey conditions.

From these predictions three metrics are derived:

- **First-to-last year percentage change in abundance or species richness:** this is the difference between the predicted abundance or species richness in the first and last year of the time series, converted to percentage change.
- **Average annual percentage change in abundance or species richness:** this is the percentage change in abundance or species richness between all consecutive years (calculated using the equation above) and then averaged across the time series.
- **Last year vs all previous years percentage change in abundance or species richness:** this metric is the difference between the predicted abundance or species richness in the last year of the time series and the average abundance or species richness across all previous years; it reflects whether the last year was a “good” or “bad” year compared to all other years on average.

## 3.1 Deriving uncertainty

Uncertainty in predictions is quantified using bootstrap resampling. The dataset is resampled with replacement (1,000 iterations), the model is refitted to each

resampled dataset and predictions and metrics are generated for each iteration. This produces a distribution of change metrics from which 95% confidence intervals are derived.

## 4 References

Hartig, F. 2026. *DHARMA: Residual Diagnostics for Hierarchical (Multi-Level / Mixed) Regression Models*. R package version 0.5.0, <https://github.com/florianhartig/dharma>.

Lenth, R.V. & Piaskowski, J. 2026. *emmeans: Estimated marginal means, aka least-squares means* (R package version 2.0.3). <https://CRAN.R-project.org/package=emmeans>.