**Technical background document – Butterfly Population trends**

March 2023

1. **Data collection method overview**

The UK Butterfly Monitoring Scheme (UKBMS) has operated since 1976 and involves thousands of volunteers collecting data every week throughout the summer. Data are collected from over 3,000 sample locations across the UK. The scheme comprises three survey components: 1. Traditional butterfly transects (Pollard Walks); 2. Wider Countryside Butterfly Survey transects; 3. Targeted surveys in which non-transect methods are used to survey specific species. The protocols for these are summarised as follows:

1. *Traditional butterfly transects (Pollard walks)*: Butterfly counts are made along fixed-route walks (transects), typically 2-4km long and sub-divided into sections according to habitat and management units, established at a site and recorded on a regular (weekly) basis under set weather conditions suitable for butterfly activity from the beginning of April until the end of September. All butterflies seen within an imaginary box, 5m wide, 5m high and 5m ahead of the surveyor are recorded within each section. All butterfly species are recorded on the majority of transects with just a small number of transects where only targeted species are recorded.
2. *Wider Countryside Butterfly Survey transects (WCBS):* The WCBS is based on the BTO’s Breeding Bird Survey (BBS). Using the traditional transect methodology, butterflies are counted along two parallel 1-km long survey lines each subdivided into five 200m sections, located within randomly selected 1-km squares (stratified by recorder density). Counts are made at least twice a year in July and August with optional additional counts outside this core period.

1. *Targeted surveys:* Alternative, more rapid approaches targeted at specific species and sites where the standard transect methods are not appropriate include:
* ‘Timed counts’ - recording the abundance of adults of a particular species over a set period of time and within a set area under UKBMS weather criteria. These are carried out especially for scarce fritillary species such as Heath Fritillary and High Brown Fritillary, that vary in distribution over extensive habitats from year to year, for species that are not easily detected on transects, and for scarce species in habitats/locations where it is difficult to make repeated visits.
* Egg and larval web counts - recording the number of eggs or larval webs of a species from a given area of suitable habitat (carried out for Marsh Fritillary, Glanville Fritillary, Brown Hairstreak and Large Blue).
1. **Sample site selection**

The sampling locations of traditional butterfly transects and targeted single species surveys are chosen either by the recorder, a local transect co-ordinator or a project officer from a local conservation body, who also choose the exact route. The same sites are sampled on a yearly basis, though for timed counts the location of the route may change according to changes in the species distribution.

WCBS routes are located in random 1-km squares, originally stratified by recorder density in different regions (i.e. regions with more potential recorders had more random 1-km squares generated for sampling). Survey lines within squares are set up as far as possible to follow two north-to-south 1km lines, approximately 500m apart. The lines are divided into 200m sections. The same sites/routes are sampled on repeat visits.

1. **Data submission**

The primary method for capturing UK Butterfly Monitoring Scheme (UKBMS) data, including the Wider Countryside Butterfly Survey (WCBS) and a growing proportion of data from targeted surveys, is through the online capture system available at www.ukbms.org/mydata. This includes recorder details, site details (e.g. location and habitat information), the butterfly counts, and weather and other visit details from each survey. A proportion of data are also captured via the Transect Walker software package or via spreadsheets.

1. **Standardisation and harmonisation of the UKBMS dataset**

All UKBMS data are collated into a single dataset to enable analysis and reporting. Data are standardised to conform with the UKBMS database structure, including: standardised species nomenclature, data integrity checks to ensure that all mandatory information is captured, valid date and time information and accurate geographic location information.

1. **Data verification**

The UKBMS online data capture system is built using the Indicia software tools and links to the iRecord verification system (www.brc.ac.uk/irecord) to enable review of the data by experts approved by Butterfly Conservation. To support verification, iRecord applies automated data checks against known species distributions (e.g. derived from the Butterflies for the New Millennium recording scheme) and timing of adult flight periods. Experts can use these checks and other information to confirm observations.

The UKBMS online data capture system (www.ukbms.org/mydata) also provides data summaries to enable UKBMS Branch Co-ordinators to review all transect data for their area and make corrections.

Further review and correction is undertaken by staff at Butterfly Conservation and the UK Centre for Ecology and Hydrology at the end of each field season, including the following checks that are discussed with Branch Co-ordinators and/or transect recorders:

* Counts outside of known distribution;
* Counts outside of the standard flight period for a species;
* Species newly recorded on a transect site;
* All records of rare specialist species at sites monitored for the first time, and at any sites that seem unlikely habitat for a species
* Potential data input errors or misidentifications - all counts of specialist butterfly species

Transect visits which are undertaken outside the criteria for butterfly activity (e.g. based on weather conditions and time of day) are flagged and excluded from the main data analyses; data is retained within the database for use in other analysis.

1. **Data analysis**

Data analysis follows a series of steps outlined below, taking into account butterfly phenology, and variation in data patterns for species and sites. Statistical models are used to impute missing values. Data from all components of the UKBMS feed into the trend analyses.

**6a. Calculation of phenology metrics**

Algorithms are applied to butterfly counts throughout the season for each species at each site to estimate phenology metrics for each year. These are calculated separately where it is possible to separate distinct peak flight periods. This includes uni-voltine species such as Brimstone and Peacock where the over-wintering of the adults produces two distinct flight periods in a year, and for bi/multi-voltine species where the flight curve for the first generation can be readily split out from the flight curve for second (and subsequent) generations. Where the flight periods overlap enough to obscure such peaks, they are treated as one for analytical purposes.

The following metrics are calculated for each site, year and species (split into generations where possible with confidence):

* Number of generations
* Date of gap between generations
* Date of first positive count (for each generation)
* Date of last positive count (for each generation)
* Date of highest positive count (for each generation)
* Count at date of highest positive count (for each generation)
* Mean date of flight period (for each generation), as defined as the weighted date of counts (Brakefield, 1987)
* Length of flight period (for each generation), as defined as the standard deviation of counts (Brakefield, 1987)

Long-term and decadal phenology trends are calculated for each species (and generation) at each site, where sufficient data are available, using linear regression models on the timing and duration phenology metrics.

**6b. Calculation of abundance indices for each species, site, year**

The UKBMS relies on the creation of abundance indices, i.e. based on the number of individual butterflies recorded in transect sections and sites. These indices are a relative rather than an absolute measure of the size of a population. The site index reflects a more or less constant proportion of the number of butterflies present, although the proportion seen is likely to vary according to species; some butterfly species, such as Marbled White are conspicuous, whereas others such as Dingy Skipper are much less likely to be detected. Indices have been shown to relate closely to other, more intensive, measures of population size such as mark, release, recapture (MRR) methods (Pollard & Yates 1993)**1**.

**6c. Calculation of collated indices (regional index of abundance for each year) and trends**

The method for combining site indices to produce overall indices for each butterfly species (‘collated indices’) involves applying the Generalised Abundance Index (GAI) method developed by Dennis *et al* in 20162 with an additional modification that the data from each site in each year are weighted in the final stage relative to the proportion of the species flight period surveyed that year for that site. The method uses all butterfly counts in a season (from traditional transects, WCBS transects and targeted surveys) to estimate the seasonal pattern of butterfly counts for that year, and this is used to extrapolate from observed data to account for gaps in recording. The weighting ensures that the observed data have a stronger effect upon the final indices than the extrapolated data.

**References**

Brakefield, P.M., (1987) Geographical variability in, and temperature effects on, the phenology of *Maniola jurtina* and *Pyronia tithonus* (Lepidoptera, Satyrinae) in England and

Wales. *Ecological Entomology*, *12*, 139-148.

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

Dennis, E.B., Morgan, B.J., Freeman, S.N., Brereton, T.M. and Roy, D.B., (2016) A generalized abundance index for seasonal invertebrates. *Biometrics*, 72(4), pp.1305-1314.

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

Rothery, P. & Roy, D.B. (2001) Application of generalized additive models to butterfly transect count data. *Journal of Applied Statistics*, *28*, 897-909.

ter Braak, C.J.F., van Strien, A.J., Meijer, R., & Verstrael, T.J. (1994) Analysis of monitoring data with many missing values: which method? In *Bird Numbers 1992: Distribution, monitoring and ecological aspects*. (eds W. Hagemeijer & T. Verstrael), pp. 663-673. SOVON, Beek-Ubbergen, Netherlands.