

# UK Biodiversity Indicators 2015

This documents supports  
C4b. Status of UK priority species:  
distribution

**Technical background document**

For further information on C4b. Status of priority species – distribution  
visit <http://jncc.defra.gov.uk/page-6850>

For further information on the UK biodiversity indicators visit  
<http://www.jncc.gov.uk/page-1824>

## Indicator C4b. Status of UK priority species: distribution

### Technical background report – December 2015

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NB this paper should be read together with [Indicator C4a](#) which presents a companion statistic based on time series in the relative abundance of priority species.

#### 1. Introduction

The adjustments to the UK biodiversity indicators set as a result of the adoption of the [Strategic Plan for Biodiversity](#) (including the Aichi Targets) at the 10th Conference of Parties of the Convention on Biological Diversity mean there is a need to report progress against Aichi Target 12:

*Target 12: By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained.*

Previously, the UK biodiversity indicator for threatened species used lead partner status assessments on the status of priority species from three-yearly UK Biodiversity Action Plan (UK BAP) reporting rounds. As a result of the devolution of biodiversity strategies to the UK's four nations, there is no longer reporting at the UK level of the status of species previously listed by the BAP process.

This paper presents one of the two indicators which aim to provide a robust measure of the status of threatened species in the UK, with 'species identified as conservation priorities' being taken as a proxy for 'threatened species'. Although biodiversity monitoring in the UK is probably as good as anywhere else in the world, and a wide range of data and novel analytical approaches have been used, it should be recognised from the outset that any indicator on the status of priority species will be hampered by short comings in the availability of data.

#### 2. Species List

The UK BAP list has been superseded by the biodiversity lists of the four UK countries (Section 41 of the Natural Environmental and Rural Communities (NERC) Act 2006 in England, Section 42 of the NERC Act in Wales, Northern Ireland priority species list in Northern Ireland and the Scottish biodiversity list in Scotland). As a result, there is no single list of species that represents the UK's species of conservation priority. The criteria for inclusion in each of the four biodiversity lists are derived from those used to identify the UK BAP priority species list, most recently in 2007, but there has been some divergence in approaches, see Table 1. For example, the Scottish biodiversity list and the Northern Ireland priority species list both have criteria based on rarity alone, whereas the UK BAP criteria did not consider rarity; rare species were only listed if they were considered threatened or declining.

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<sup>1</sup> NB some text re-used from 2013 BIYP Indicator C4b prepared by the Species Indicator Initiative working group and we wish to acknowledge the input from the authors of that original document.

For the purposes of this indicator, an inclusive approach has been taken, whereby a species only has to be included in one of the country lists to be included on the combined list. The Scottish Biodiversity list has a final criterion based on the importance of species to people, however, species listed as a result of this criterion were not considered here. The taxonomic composition of the combined Four Country List (FCL) is shown in Table 2.

Some countries have included a small number of taxa below the species level (i.e. sub-species) on their biodiversity lists. Such infra-specific taxa were only retained on the combined four country biodiversity list if the associated species was not included. For example, a sub-species of the grass rivulet moth (*Perizoma albulata*) is included on the Scottish biodiversity list but it is a full species on the Northern Ireland priority species list, thus on the combined list only the full species was retained.

**Table 1.** The biodiversity lists of the four countries of the UK.

Country	Number of Taxa	Criteria for species inclusion
England (S41)	943	On the 2007 UK BAP list
		Hen Harrier
Northern Ireland (NI) priority species list	481	1: On the 2007 UK BAP list
		2: Rapid decline of $\geq 2\%$ per year
		3: Decline of $\geq 1\%$ per year and NI holds $\geq 50\%$ of Irish, or $\geq 20\%$ of UK population or Irish/UK population restricted to NI
		4: Rare in NI (1-2 sites) and NI holds $\geq 50\%$ of Irish, or $\geq 20\%$ of UK population or Irish/UK population restricted to NI
		5: $\geq 20\%$ of a well recognised sub-species in NI
		6: Irish Red data book species
		7: Red list Birds of Conservation concern Ireland or UK
Scottish Biodiversity List	2,090	S1: On the 2007 UK BAP list
		S2: International obligation
		S3: Species defined as 'nationally rare' in GB/UK ( $< 15 \times 10 \text{ km}^2$ ), which are present in Scotland
		S4: Species present in $\leq 5 \text{ km}^2$ or sites in Scotland
		S5: Decline of $\geq 25\%$ in 25 years in Scotland
		S6a: Endemic
		S6b: Endemic subspecies if also meets another criterion
Wales (S42)	567	International importance, IUCN Global Red List or Red listed in $\geq 50\%$ of EU countries where data is available or other source indicating international threat or decline
		International responsibility $\geq 25\%$ of EU/Global population in Wales and decline $\geq 25\%$ in 25 years in Wales
		Decline in Wales $\geq 50\%$ in 25 years
		Other for example decline and very restricted range
<b>UK (combined four country list)</b>	<b>2,890</b>	

**Table 2.** Taxonomic breakdown of combined four country biodiversity list.

<b>Group</b>	<b>Number of Species</b>
<i>Invertebrates</i>	
insect – beetle (Coleoptera)	191
insect – butterfly	25
insect – dragonfly (Odonata)	4
insect – hymenopteran	103
insect – moth	174
insect – orthopteran	6
insect – other	4
insect – riverfly	8
insect – true bug (Hemiptera)	15
insect – true fly (Diptera)	94
other Invertebrate	233
<i>Vertebrates</i>	
Amphibian	4
Bird	127
Fish	57
marine mammal	22
terrestrial mammal	26
reptile	10
<i>Plants and fungi</i>	
vascular plants	409
Alga	254
stonewort	15
Lichen	546
Bryophytes	301
Fungi	262
<b>Grand Total</b>	<b>2890</b>

### 3. Data Sources

Biological records data were collated to produce an indicator of change based on trends in occupancy of a set of priority species in the UK. Biological records are observations of species in a known place in space and time. Most records are made by volunteer recorders and whilst these data may be collected following a specific protocol, the majority of records in these datasets are opportunistic. The intensity of recording varies in both space and time (Isaac *et al.* 2014), which is a challenge for estimating robust quantitative trends. Fortunately, a range of methods now exist for producing such trends using unstructured biological records data (e.g. Szabo *et al.* 2010; Hill 2012, Isaac *et al.* 2014). Bayesian occupancy models have been shown to be more robust and more powerful than these other methods when analysing this kind of data (Isaac *et al.* 2014), specifically because the occupancy model explicitly models the data collection process

and produces annual estimates for each species of the proportion of occupied sites (van Strien *et al.* 2013).

An effort has been made to boost the taxonomic coverage of the 2015 indicator, with a number of groups being added including soldierflies, freshwater fish and bryophytes. The Bayesian occupancy approach, described in detail in the [Bayesian indicator development technical report](#) is relatively data hungry and as a result reliable trends could not be produced for all priority species using this approach.

For the occupancy models, occurrence records were extracted at the 1km grid square scale with day precision.

Data were collated through the Biological Records Centre and include data from the following recording schemes: British Arachnological Society Spider Recording Scheme, British Bryological Society, British Dragonfly Society, British Myriapod and Isopod Group Centipede Recording Scheme, British Myriapod and Isopod Group Millipede Recording Scheme, BWARS (Bees, Wasps and Ants Recording Society), Database & Atlas of Freshwater Fishes, Dipterists Forum Crane-fly Recording Scheme, Dipterists Forum Empididae & Dolichopodidae Recording Scheme, Ground Beetle Recording Scheme, Hoverfly Recording Scheme, National Moth Recording Scheme, Orthoptera Recording Scheme, Soldierflies and Allies Recording Scheme and the Riverfly Recording Schemes: Trichoptera, as well as a number of local record centres. Data from between 1970 and 2013 were extracted as this represents a core period of recording for many of the taxonomic groups.

#### 4. Generating species' trends

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 two hierarchically coupled sub-models, an occupancy sub-model (i.e. presence versus absence), and a detection sub-model (i.e. detection versus non-detection), together these sub-models estimate the conditional probability that a species is detected when present. A Bayesian occupancy model, following van Strien *et al.* (2013) and Isaac *et al.* (2014), was applied to all priority species from those taxonomic groups for which data were available (651 species). 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. These annual occupancy estimates were scaled so the value for 1970 was set to 100. The annual value of the composite indicator was calculated as the arithmetic mean of scaled species-specific occupancy estimates and uncertainty in the species-specific annual occupancy estimates was propagated through to the final indicator. A detailed description of the occupancy model, and the creation of the composite indicator, can be found in the [technical document](#) on the Bayesian indicator development. The final year (2013) was dropped from the indicator due to a lack of data for many taxonomic groups. This lack of data in the 2013 reflects the lag in data collation rather than a decline in recording activity.

#### 5. Thresholds for species-specific trends

Species were grouped into one of five categories based on both their short-term (over the most recent five years of data) and long-term (all years) mean annual change in occupancy (Table 3).

**Table 3.** Thresholds used to define individual species trends.

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

The threshold values for each category were based 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 per cent and 49 per cent 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 per cent 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. See the [technical document](#) on the Bayesian indicator development for further detail on the calculation of the species-specific trends.

## 6. Indicator Methods

Table 4 shows the number of species on the combined Four Countries List within the taxonomic groups for which data were collated, and the numbers modelled. Indicator methods were developed as the project progressed. As mentioned above, the Bayesian approach now incorporates species-specific uncertainty in the indicator, a detailed description of this method can be found in the Bayesian indicator development [technical report](#).

**Table 4.** Summary of species time-series included in the Priority Species Bayesian measure.

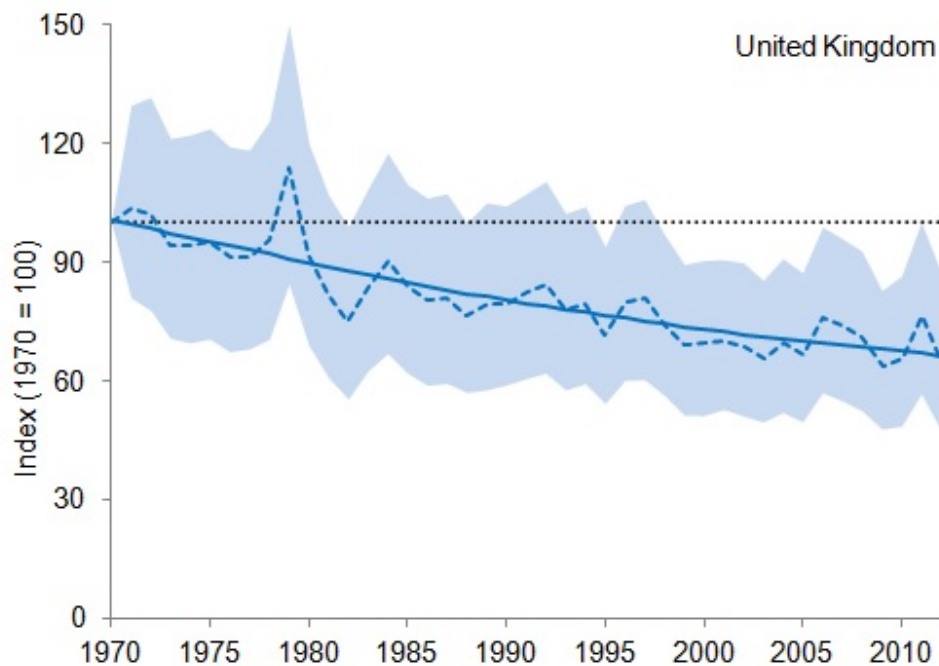
<b>Taxonomic group</b>	<b>Number on FCL</b>	<b>Number modelled</b>	<b>Number meeting criteria for inclusion in the Bayesian measure</b>
Ants	9	9	1
Bees	60	59	40
Bryophytes	301	294	7
Carabids*	34	33	1
Centipedes	1	1	0
Craneflies	30	26	0
Dragonflies	4	4	4
Empid & dolichopodid flies	8	6	0
Fish	40	14	3
Hoverflies	21	21	0
Millipedes	3	3	0
Molluscs	82	51	0
Macro Moths*	174	38	33
Orthoptera*	6	6	3
Soldierflies	16	16	4
Spiders	40	38	0
Tricoptera	4	3	0
Wasps	34	29	15
<b>Total</b>	<b>867</b>	<b>651</b>	<b>111</b>

Due to the methodological changes in the analysis (switching from the Well-sampled Sites method), a greater number of taxonomic groups have been able to be included compared to the 2014 C4b indicator. Models were run for all species on the FCL within the taxonomic groups for which data could be collated.

## 7. Headline C4b Indicator

The headline indicator was generated by combining time series of change in the proportion of occupied sites for 111 species (Figure 1).

**Figure 1.** Change in the occupancy (proportion of occupied sites) of priority species in the UK between 1970 and 2012 (dashed line). The shaded region is the 90 per cent credible interval of the annual occupancy estimates and represents the uncertainty surrounding the annual estimates. The solid line illustrates a smoothed trend estimated from a GAM fitted to the rescaled indicator values.

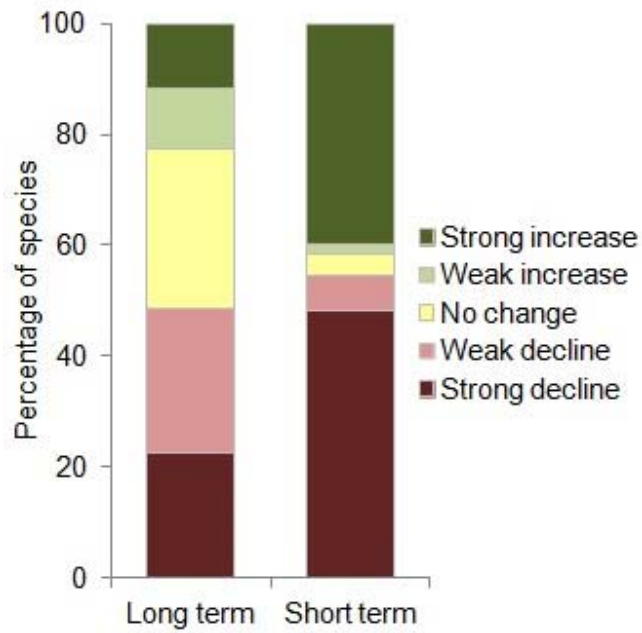


The headline indicator shows a steady decrease in priority species occupancy between 1970 and 2012. This steady decline is emphasised by the GAM smoothed indicator line. In 1979, there was a strong increase in priority species occupancy, however the following year (1980) was a strong decline which was the largest individual year to year change across the entire time period. The index value of the final year of the time series (2012) is 65 per cent of the value in 1970, this indicates a decline in priority species occupancy of 35 per cent. The upper 90 per cent credible interval of the indicator value in 2012 was 85 per cent of the value in 1970, therefore the models suggest we can be 90 per cent sure that priority species occupancy declined by at least 15 per cent between 1970 and 2012. A greater proportion of priority species were showing negative trends in occupancy over both the long- and short-term than were increasing (Figure 2).

The short-term trends tend to have a far greater number of species showing increasing or decreasing trends, and of them, a greater number falling into the “stronger” categories than the long-term trends. This is likely to be a result of the high level of short-term variation in priority species populations. The species-specific trends were calculated as the mean percentage change in occupancy per year, therefore over a 40+ year period the influence of short-term variation on the trend is reduced compared to its influence on a five year trend.



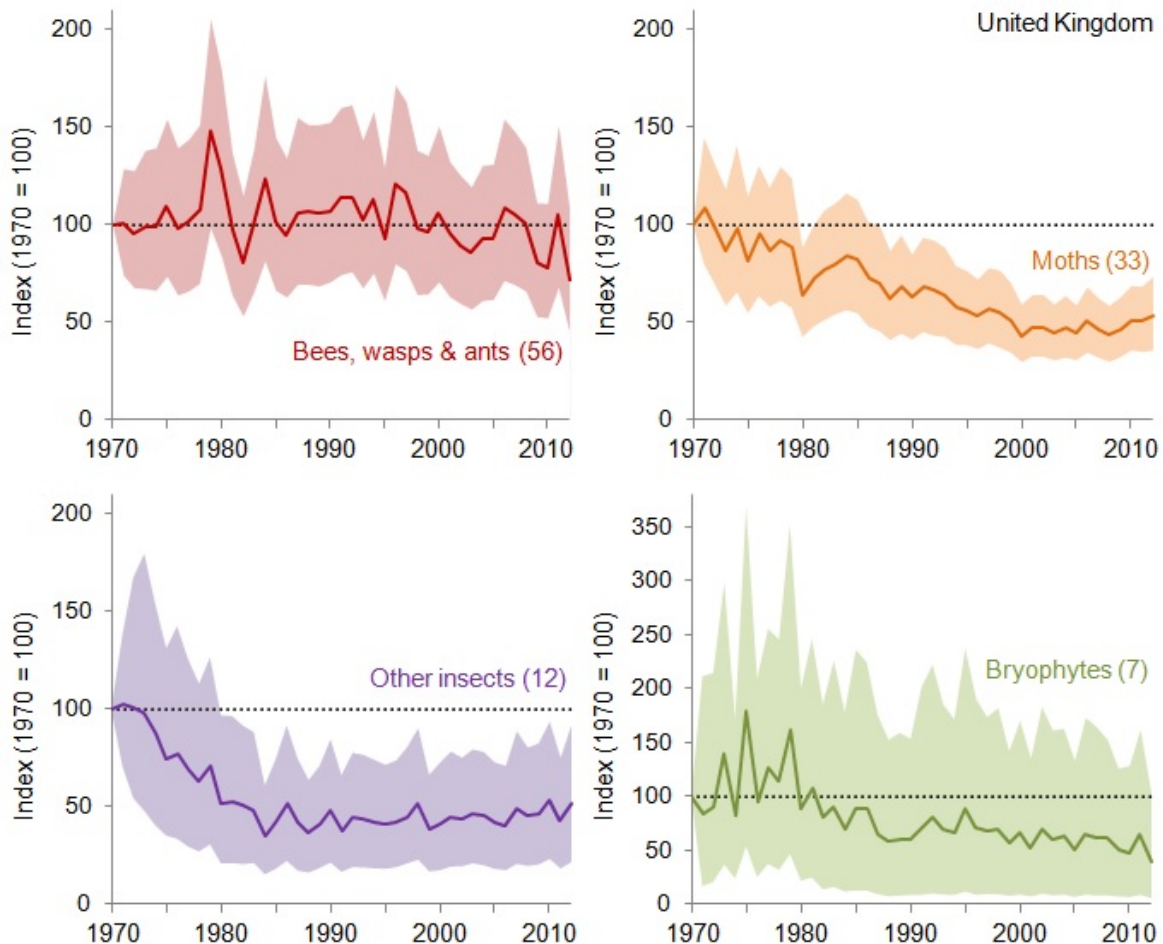
**Figure 2.** The proportion of priority species in each trend category based on mean change in occupancy over both a) the long term (all years) and b) the short term (the most recent five years).



## 8. Change in priority species by taxonomic group

The headline indicator (Figure 1) masks variation within and between taxonomic groups. Figure 3 shows indicators for each taxonomic group separately. These were generated using the same methods as the overall indicator.

**Figure 3.** Change in distribution of UK priority species, by taxonomic group, 1970 to 2012.



### Notes:

1. The number of species included in each line is shown in brackets. Freshwater fish are not shown as there are only three species.

The trends of the taxonomic groups included within a multi-species indicator are often obscured by its composite nature. Indicator lines have been generated for a number of sub groups using the same method so that the trends for these groups can be seen more clearly.

The moths and the “other insects” group (consisting of the orthoptera, dragonflies, carabids and soldierflies which were combined due to the small numbers of species included), have undergone the most dramatic decline. In the final year, the index values are 53 per cent of their values in 1970 for moths, and 51 per cent for “other insects”.

The bryophytes have also experienced a decline in the proportion of occupied sites since 1970, although over the course of the time series, this is much more variable and the indicator line has

a high level of uncertainty. In 2012, the final index value for bryophytes is 40 per cent of the value in 1970, indicating a decline of 60 per cent.

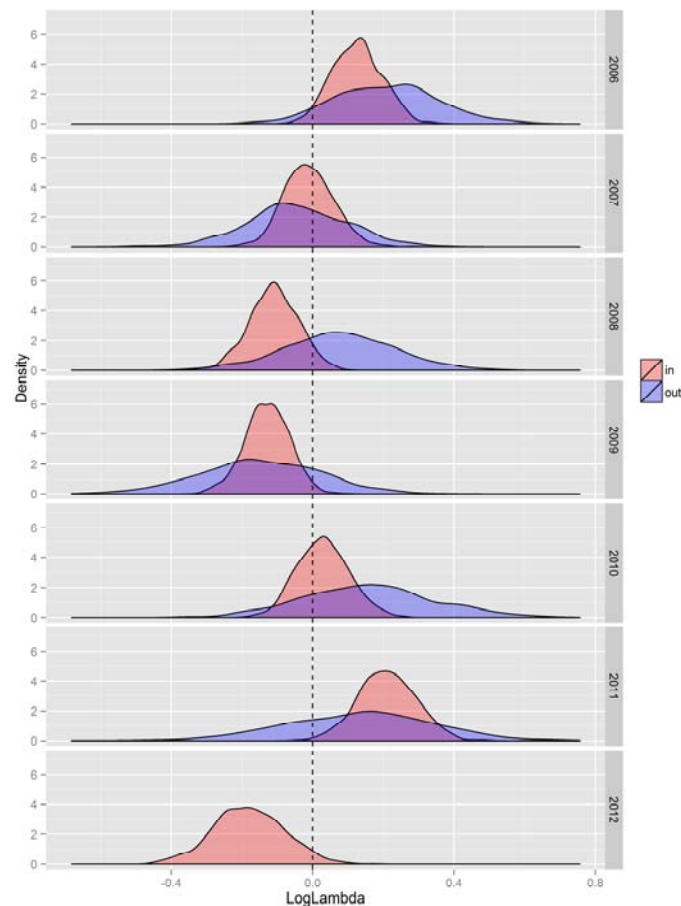
The bees, wasps and ants group, which contains the greatest number of species, has also experienced an overall decline. In the final year of the index, this group has a value of 72 which represents an overall decline of 28 per cent. However, looking at the indicator as a whole, for the majority of years the index values are just above the baseline of 100, with the decline only being seen in the most recent years.

## 9. Validation

### 9.1 Justification for inclusion of the 2012 data

The final year was chosen to be 2012 as it was the last year to include the majority of species (data1 of the C4b datasheet). In 2013 the number of species fell to only 34. To ensure that the decrease of species from 2011 to 2012 (101 to 75) did not bias the indicator value the distribution of log lambda values for species included in 2012 and those that were not were compared (Figure 4). Both sets of species have similar values in the years preceding 2012, suggesting the loss of these in 2012 is unlikely to bias the last year's value.

**Figure 4.** The distribution of log lambda values for species present ('in') or absent ('out') of the dataset for 2012, the last year of the indicator. Both sets of species have similar values for the preceding years suggesting the loss of 'out' species in 2012 is unlikely to bias the last year's data.



## 9.2 Sensitivity of the indicator to the first year of data

The first year of the indicator is used as the reference point against which all subsequent years values are compared. As a result the analysis may be sensitive to which year is chosen as the first year. The sensitivity was tested by recalculating the indicator using all years between 1970 and 1980 as start years. All start years generated an indicator with an overall decline, and in all cases the index value fell outside the 90 per cent credible interval of the final year. Therefore 1970 was retained as the start year for the indicator.

## 10. Using Frescalo to generate decadal trends for species which failed the criteria for the Bayesian models

Trends for species that did not meet a minimum data requirement for the occupancy models were instead estimated using Frescalo (Hill 2012). A key strength of Frescalo is that by aggregating data to a coarse spatial (10km grid square) and temporal (10 year blocks) resolution, it is able to produce reliable trends of the relative frequency of occurrence for species that fail the minimum data requirements of other approaches. Frescalo uses the proportion of benchmark species within a neighbourhood to assess recording intensity at a given location. The fraction of benchmark species observed in a focal square enables recording effort to be estimated, which in turn is used to adjust the observed frequencies of species occurrence. The measure is based on the relative frequency of recording within each time period that was extracted for each of the priority species covered by the Frescalo method. Frescalo was based on occurrence records at the 10km grid square scale with year precision.

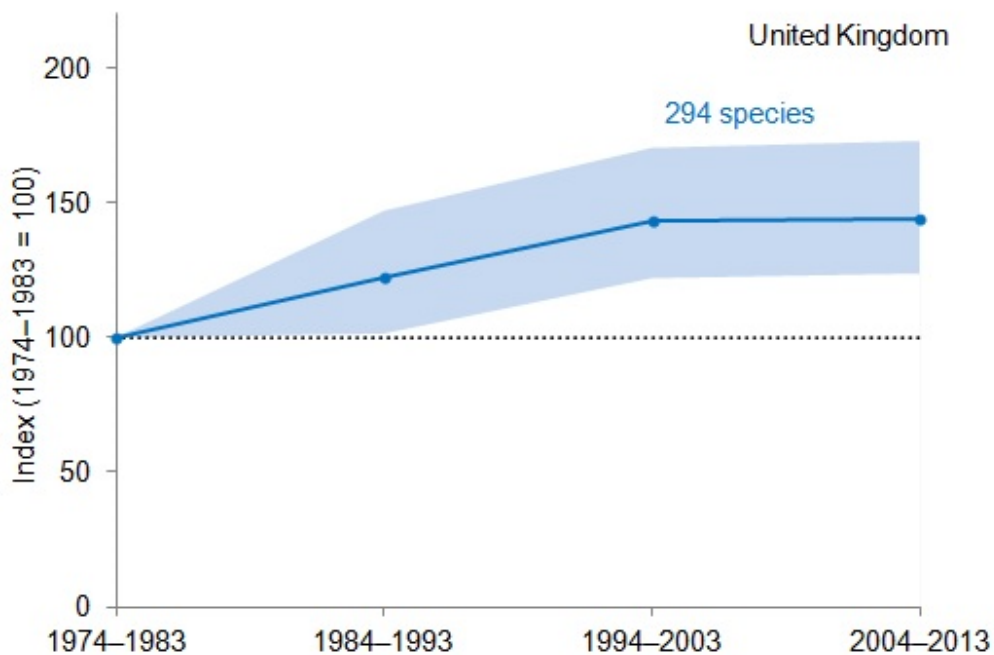
Frescalo was used to estimate the relative frequency of occurrence per species per time period (decade in this case). The data were split into the following time periods: 1974–1983, 1984–1993, 1994–2003, 2004–2013. To generate the composite indicator, each species-specific time-series of occurrence estimates was expressed as a proportion of the relative occurrence estimate in their first year. The annual index was then calculated as the geometric mean of the scaled occurrence estimates across all species. Each species time-series were scaled so the occurrence estimate in the first time period (1974–1983) was set to 100. Currently, species with no records in any of the time periods are dropped from the indicator. Each species was given equal weighting when calculating the geometric mean. Confidence intervals for the Frescalo based measure were created using bootstrapping (Buckland 2005; Freeman *et al.* 2001); in each iteration ( $n = 10,000$ ) a random sample of species were selected with replication and the geometric mean calculated. The uncertainty was then represented by the 95 per cent quantiles of the 10,000 replicated geometric mean values.

**Table 5.** Summary of species time-series included in the Priority Species Frescalo measure.

<b>Taxonomic group</b>	<b>Number on FCL</b>	<b>Number modelled</b>	<b>Number in the Frescalo Measure</b>
Ants	9	9	6
Bees	60	59	13
Bryophytes	301	294	186
Carabids*	34	33	0
Centipedes	1	1	0
Craneflies	30	26	17
Dragonflies	4	4	0
Empid & dolichopodid flies	8	6	1
Fish	40	14	6
Hoverflies	21	21	15
Millipedes	3	3	0
Molluscs	82	51	23
Macro Moths*	174	38	0
Orthoptera*	6	6	0
Soldierflies	16	16	0
Spiders	40	38	17
Tricoptera	4	3	1
Wasps	34	29	9
<b>Total</b>	<b>867</b>	<b>651</b>	<b>294</b>

\* Due to time limitations, Frescalo was not run for moths, carabids and orthopterans.

**Figure 5.** Decadal trend in relative frequency of occurrence of priority species, 1974 to 2013.



**Notes:**

1. Based on 294 species. The shaded region represents the 95 per cent confidence intervals of the geometric mean.
2. All species in the indicator are present on one or more of the country priority species lists (Natural Environmental and Rural Communities Act 2006 – Section 41 (England) and Section 42 (Wales), Northern Ireland Priority Species list, Scottish Biodiversity List).

The decadal index shows a steady increase in occurrence between 1974 and 2013, ending approximately 45 per cent higher than the value in 1974. Based on this result, if it were possible to add this subset of species into the main priority species indicator then the indicator line would be predicted to rise. It is worth noting that the confidence intervals are relatively large. However, it should be noted that species with no records in any time-period were dropped from the Frescalo measure. Therefore genuine species loss may be artificially excluded, which could explain the positive trends in this measure.

**Source:** Biological records data collated by a range of national schemes and local data centres.

## 11. Future developments

Data are available for a number of additional taxonomic groups which are represented on the combined Four Countries List. Due to time constraints these could not be added to this year's indicator, however there is the potential to add these groups in future years.

Whilst the Bayesian occupancy model is the preferred tool for future indicators, further research is required to assess whether the short-term trends should be evaluated over five years, or over

a longer period. While they may show evidence of change in relation to conservation policy, disentangling this from short-term effects of weather is a challenge. Currently, a smoothed line has been added to the headline indicator to make the overall trend clear to observe. An assessment based on the smoothed indicator should be investigated in future iterations of the indicator. Using a smoothed trend should reduce the influence of short-term weather variation on the indicator can be reduced.

The Frescalo indicator was used to model trends in species that did not meet the data requirement of the occupancy models. Development of a method to incorporate the uncertainty surrounding the species-specific annual occupancy estimates from Frescalo into the overall indicator and its associated confidence intervals is an important future challenge. At present, uncertainty was only captured for the geometric mean across all species, the species-specific uncertainty in the relative occurrence estimates was not considered. An additional issue with the Frescalo indicator is that species with no data in any time period are dropped. Further development of the Bayesian indicator, (such as, extending the closure period to multiple years) may remove the need to use Frescalo.

As the sample size increases it should become possible to investigate other ways to break down the indicator; possibilities include, by country, upland/lowland, ecosystems/habitats, traits/life history strategies and or by trophic level.

## 12. References

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