UK Biodiversity Indicators
2021

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

Technical background document

For further information on C4b. Status of priority species – distribution visit
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Indicator C4b. Status of UK priority species: distribution Technical background report, 2021

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Note well, this paper should be read together with Indicator C4a Status of UK priority species: relative abundance which presents a companion statistic based on time series of the relative abundance of priority species.

1. Introduction

Aichi Target 12 states:

> 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.

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 species list was derived from the biodiversity lists of the 4 UK countries. A link to the list for each country is provided below:

England – Section 41 Species
Northern Ireland – Northern Ireland Priority Species List Scotland – Scottish Biodiversity List
Wales - Section 7 Priority species

The species lists are unchanged from those used in the 2020 indicator analysis. The criteria for inclusion in each of the 4 biodiversity lists are derived from those used to identify the UK Biodiversity Action Plan (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.

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 (that is, sub-species) on their biodiversity lists. Such infra-specific taxa were only retained on the combined 4 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 4 countries of the UK

Country	Number of Taxa on country list	Criteria for inclusion of species on list
England (Section 41 Species)	943 taxa	On the 2007 UK BAP list
		Hen Harrier
Northern Ireland (NI) Priority Species List	481 taxa	1: On the 2007 UK BAP list
		2: Rapid decline of greater than or equal to 2% per year
		3: Decline of greater than or equal to 1 % per year and NI holds greater than or equal to 50% of Irish, or greater than or equal to 20 % of UK population or Irish/UK population restricted to NI
		4: Rare in NI (1 to 2 sites) and NI holds greater than or equal to 50% of Irish, or greater than or equal to 20% of UK population or Irish/UK population restricted to NI
		5: Greater than or equal to 20% of a well recognised sub-species in NI
		6: Irish Red data book species
		7: Red list Birds of Conservation concern Ireland or

Country	Number of Taxa on country list	Criteria for inclusion of species on list
		UK
Scottish Biodiversity List	2,090 taxa	S1: On the 2007 UK BAP list
		S2: International obligation
		S3: Species defined as 'nationally rare' in GB/UK (less than 15 10 square kilometres), which are present in Scotland
		S4: Species present in less than or equal to 5 kilometres square or sites in Scotland
		S5: Decline of greater than or equal to 25% in 25 years in Scotland
		S6a: Endemic
		S6b: Endemic subspecies if also meets another criterion
Wales (Section 7 Priority species)	567 taxa	International importance, IUCN Global Red List or Red listed in greater than or equal to 50% of EU countries where data is available or other source indicating international threat or decline
		International responsibility greater than or equal to 25% of EU/Global population in Wales and decline greater than or equal to 25% in 25 years in Wales
Country	**Number of Taxa on country list**	**Criteria for inclusion of species on list**
		Decline in Wales greater than or equal to 50% in 25 years
		Other for example decline and very restricted range
UK total (combined 4 country list)	*2,890*	

Table 2: Taxonomic breakdown of combined 4 country biodiversity list

Taxonomic group	Number of species in group
Invertebrates	
insect – beetle (*Coleoptera*)	191
insect – butterfly	25
insect – dragonfly (*Odonata*)	4
insect – hymenopteran	103
insect – moth	174

Taxonomic group	Number of species in group
insect – orthopteran	6
insect – other	4
insect – riverfly	8
insect – true bug (*Hemiptera*)	15
insect – true fly (*Diptera*)	94
other Invertebrate	233
Vertebrates	
amphibian	4
bird	127
fish	57
marine mammal	22
terrestrial mammal	26
reptile	10
Plants and fungi	
vascular plants	409
alga	254
stonewort	15
lichen	546
bryophytes	301
fungi	262
Total number of species	***2,890***

3. Data Sources and species-specific time series

Biological records data are used to produce an indicator of change based on annual estimates of the proportion of occupied sites ("occupancy") for a set of priority species in the UK. Biological records are observations of species in a known place in space and time. These data are curated by the Biological Records Centre. They include data from the following recording schemes: Aquatic Heteroptera Recording Scheme, Bees, Wasps and Ants Recording Society, British Arachnological Society Spider Recording Scheme, British Bryological Society, British Isles Neuropterida Recording Scheme, British Lichen Society, Centipede Recording Scheme, British Myriapod and Isopod Group, Millipede Recording Scheme, Bruchidae & Chrysomelidae Recording Scheme, Conchological Society of Great Britain and Ireland, Cranefly Recording Scheme, British Dragonfly Society, Empididae & Dolichopodidae Recording Scheme, Fungus Gnat Recording Scheme, Gelechiid Recording Scheme, Ground Beetle Recording Scheme, Hoverfly Recording Scheme, National Moth Recording Scheme, Orthoptera Recording Scheme, Riverfly Recording Schemes: Ephemeroptera, Plecoptera and Trichoptera, Soldierflies and Allies Recording Scheme, Staphylinidae Recording Scheme, Terrestrial Heteroptera Recording Scheme - Shield bugs and allied species and the Weevil and Bark Beetle Recording Scheme + Scolytidae.

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).

By using occupancy models to analyse occurrence records, greater taxonomic coverage was achieved for the 2015 C4b indicator (Eaton *et al.* 2015). Further improvements to the occupancy modelling framework (Outhwaite *et al.* 2018) enabled the inclusion of more taxonomic groups (for example, lichens, craneflies and weevils) in the 2020 indicator and more species from groups included in previous indicators. In 2021, new rules-of-thumb for assessing the data available for each species (Pocock *et al.* 2019) have been applied for 2021, giving greater confidence in the trend lines produced.

Annual occupancy estimates are available for 5,293 UK bryophytes, lichens, and invertebrates in 31 taxonomic groups with sufficient data (Outhwaite *et al.* 2019). For each 1 by 1 kilometre 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. The models are analysed in a Bayesian framework, meaning that, in addition to point estimates of occupancy, credible intervals (a measure of uncertainty) can be generated for each species' time-series. A detailed description of the occupancy model can be found in Outhwaite *et al.* (2019). These occupancy models are updated as and when new, (validated) data are received from recording schemes. Although continued improvements to the modelling process mean that more species can now be included, estimates cannot currently be established for all priority

species. Only recording schemes with sufficient data and for which the scheme has validated the assumptions of occupancy models.

Annual estimates of occupancy from between 1970 and 2018 were used for the multi-species indicator as this represents a core period of recording for many of the taxonomic groups. However, some datasets finished at different years within this time period. Since the 2020 C4b indicator the Biological Records Centre has received substantial data updates for Aquatic bugs, Empid & Dolichopodid Flies, Ephemeroptera, Plecoptera and Trichoptera (Table 4). This has enabled the improvement of model estimates for recent years and the addition of new species to the indicator.

A change from the approach used to select species-specific trends for the 2020 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. These model quality tests were unavailable for the moth dataset, so moth species with fewer than 50 records across the UK (Outhwaite *et al*. 2019, Powney *et al*. 2019) were excluded. The change in threshold creates a turnover of just a few species for all groups except Bryophytes and Lichens, which would gain 75 and 50 species, respectively. It is felt that further investigation and consultation with the scheme is required to assess whether the addition of 125 species to the indicator would be justified, therefore the new rules of thumb were not applied to Bryophytes and Lichens this year. They were instead excluded if there were fewer than 50 records across the UK.

Changing the criteria for species inclusion has led to the addition of 60 species and the loss of 12 species, compared with the 2020 publication. In addition, 13 new species have been added following a re-evaluation of mismatches between species names in the priority lists and those in the UK Species Inventory. In total, the 2021 indicator comprises 476 species that met these criteria for inclusion. This represents a net increase of 61 species compared with the 2020 indicator.

4. Thresholds for species-specific trends

Species were grouped into one of 5 categories based on both their short-term (over the most recent 5 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	An increase of more than 2.81% per annum	Increase of more than 100% over 25 years
Weak increase	An increase of between 1.16% and 2.81% per annum	Increase of between 33% and 100% over 25 years
Little change	Change is between +1.16% and -1.14% per annum	Change of between +33% and -25% over 25 years
Weak decrease	A decrease of between 1.14% and 2.73% per annum	Decrease of between 25% to 50% over 25 years
Strong decrease	A decrease of more than 2.73% per annum	Decrease of more than 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 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 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 (PDF 1.6MB) status assessment for birds in the UK.

5. Multispecies Indicator

Table 4 shows the number of species on the combined 4 Countries List within the taxonomic groups for which data were collated, and the number of species in each group whose modelled trends met the inclusion criteria for the indicator.

The composite indicator was produced using a novel hierarchical modelling method for calculating multi-species indicators developed by 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.

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

Taxonomic group	Number of priority species on Four Country list	Number of species with sufficient data to include in MSI	Models updated since Outhwaite *et al*. 2019	New data received since UKBI2020
Ants	9	5	yes	no
AquaticBugs	6	4	yes	yes
Bees	60	58	yes	no
Bryophytes	302	52	no	no
Carabids	34	6	yes	no
Centipedes	1	0	no	no
Craneflies	29	12	yes	no
Dragonflies	4	4	yes	no
Empid & Dolichopodid Flies	8	3	yes	yes
Ephemeroptera	2	2	yes	yes
Fungus Gnats	8	0	no	no
Gelechiids	2	0	no	no
Hoverflies	21	10	no	no
Leaf & Seed Beetles	21	10	yes	no
Lichens	613	76	no	no
Millipedes	3	0	no	no
Non-marine Molluscs	56	33	no	no
Moths	143	122	no	no
Neuroptera	2	0	no	no
Orthoptera	6	4	no	no
PlantBugs	1	0	yes	no
Plecoptera	2	2	yes	yes
RoveBeetles	7	0	no	no
ShieldBugs	1	1	no	no
SoldierBeetles	1	0	NA	NA
Soldierflies	16	12	no	no
Spiders	40	16	yes	no
Trichoptera	4	3	yes	yes
Wasps	34	32	yes	no
Weevils	15	9	no	no
Totals	**1447**	**476**		

6. Headline C4b Indicator

The headline indicator was generated by combining time series of change in the proportion of occupied sites for 476 species (Figure 1).

Figure 1: Change in the occupancy (proportion of occupied sites) of priority species in the UK between 1970 and 2018
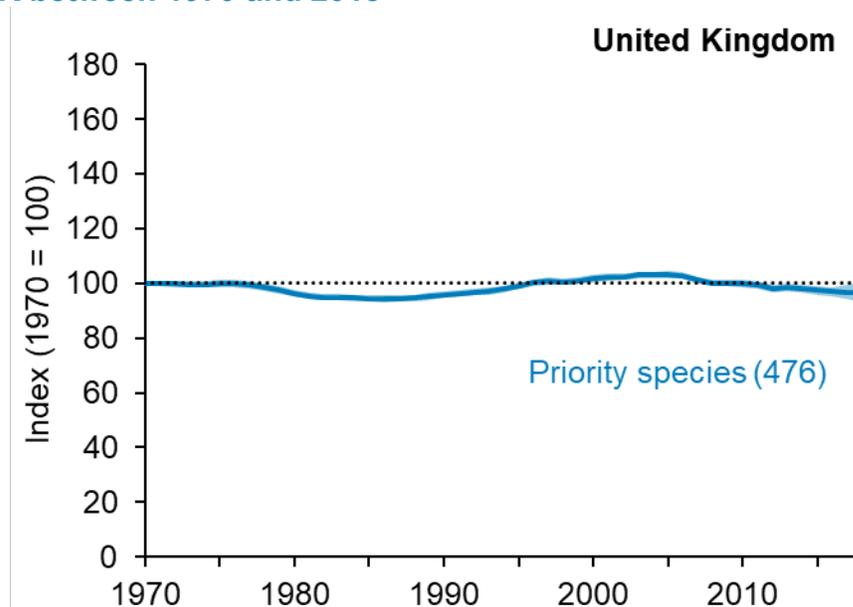

Notes:
1. The line graph shows the smoothed trend (solid line) with variation around the line (shaded area) within which users can be 95% confident that the true value lies (credible interval). The width of the credible interval is in part determined by the proportion of species in the indicator for which data are available.
2. The figure in brackets shows the number of species included in the composite index.
3. 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), Environment (Wales) Act 2016 section 7, Northern Ireland Priority Species list, Scottish Biodiversity List).
4. These charts are not directly comparable to previous versions of the indicator. Inclusion of new data has increased the number of species that can be included in the indicator from 422 in 2020, to 476 here. Additionally, novel methods to combine individual species trends into the multi-species indicator have been applied in 2021.

The index of distribution of priority species in the UK shows a decline of 6% between 1970 and 1986, after which it increases slightly to 103, then decreases again. Occupancy of priority species is assessed as stable between 1970 and 2018. The index is 4% lower in 2018 than in 1970; this is not considered a significant decrease, although the overlap of the 95% credible interval with the baseline index in 1970 is marginal. The indicator decreased by 2% between 2013 and 2018, it is assessed as little or no overall change when taking into account the 95% credible interval. The balance of increasing and decreasing species showed that in the long term, a smaller percentage of species are

decreasing (26%) compared with 36% of species in the short term, and a greater percentage of species are increasing in the long term (21%), compared with 18% in the short term (see Figure 2 below).

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 5 years)
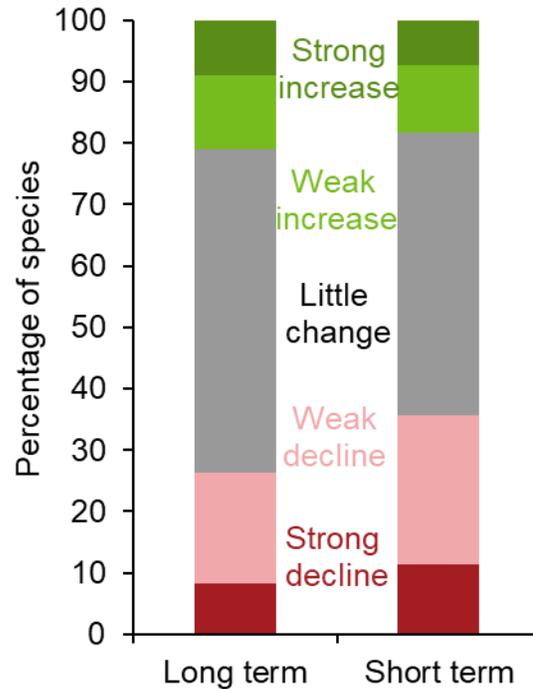

Note: The bar chart shows the percentage of species within the indicator that have increased, decreased or shown little change in distribution (measured as the proportion of occupied sites), based on set thresholds of change.

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[3] to 2018
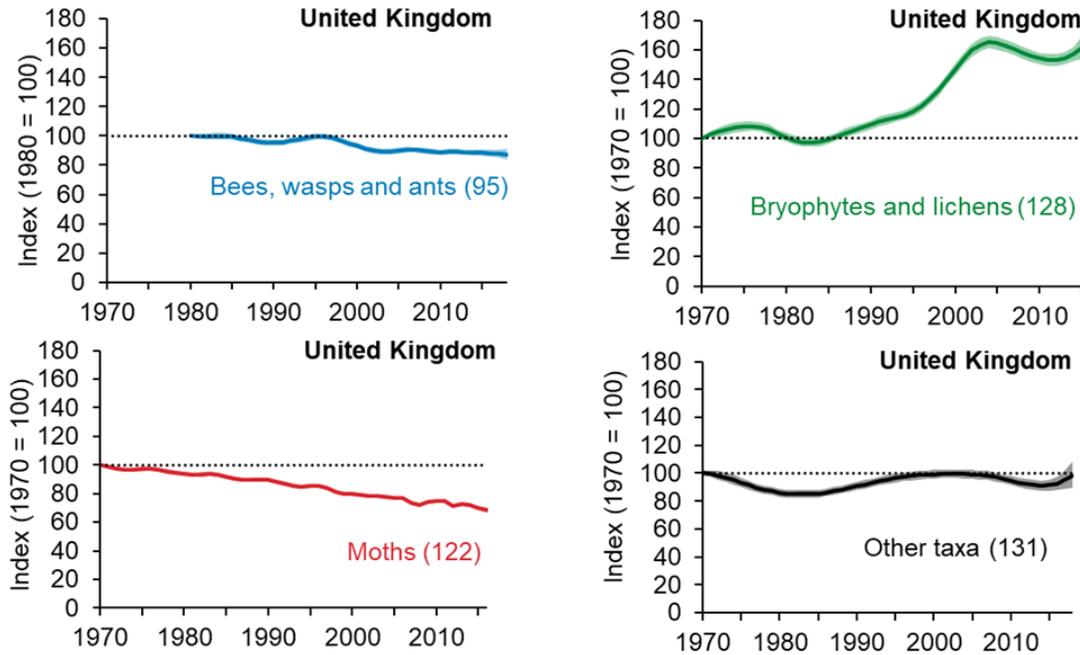
Notes:

1. The graphs show the smoothed trend (solid line) and variation around the line (shaded area) within which users can be 95% confident that the true value lies (credible interval) for each of the taxonomic groups included in the composite indicator.
2. The figures in brackets show the number of species included in each measure.
3. Other taxa includes a number of insect groups, molluscs and spiders.
4. 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), Environment (Wales) Act 2016 section 7, Northern Ireland Priority Species list, Scottish Biodiversity List).
5. The indicator for bees, wasps and ants starts in 1980.
6. These charts are not directly comparable to previous versions of the indicator. Inclusion of new data has increased the number of species that can be included in the indicator from 422 in 2020, to 476 this year. Additionally, novel methods to exclude species and to combine individual species trends into the multi-species indicator have been applied in 2021.

The trends of the taxonomic groups included within a multi-species indicator are often obscured by its composite nature, therefore trends for a number of sub-groups are presented here to provide clearer insight.

The bees, wasps and ants group experienced an overall decline, with an index value in

2018 of roughly 87% that in 1980. These are counterbalanced by increases in bryophytes and lichens, which had an index value of 161 in 2015. The moths have undergone the most dramatic decline with an index value in the final year 68% of the value in 1970. Similar strong declines in moths were noted in C4a. The underpinning causes of this decrease are not fully understood.

7. References

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