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Technical background document: The wild bird indicator for the UK and England

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Technical paper: the wild bird indicator for the UK and England

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1. Introduction

This report presents the UK and England wild bird indicator, giving details of its construction, presentation and underlying data. This indicator has been generated by the BTO and RSPB, under contract to (and in collaboration with) Defra and JNCC, using robust long-term bird monitoring data from a range of sources, analysed with well-established methods. We present the indicator and its five components and describe the methods used to collect and analyse data for the indicators along with the processes used to maintain quality assurance.

The wild bird indicator includes individual multi-species indicators on the breeding birds of four habitats: farmlands, woodlands, water & wetlands and seabirds, plus another for wintering (non-breeding) waterbirds. Each of these indicators (described in more detail below) combines population trend data, in the form of annually-updated indices, for between 19 and 46 species, races or populations representative of that habitat. Each indicator is produced and published for both England and the UK; indicators for other UK nations are produced using different approaches and are not presented here.

2. Generic data sources, methods & analyses

2.1 Species selection

For the most part, species are included in habitat indicators on the basis of the classifications in Gibbons *et al*. (1994). Farmland species are those defined as "feeding in open farmland during the breeding season, even though they may nest in woodlands and hedges", woodland species as those "that feed and breed mainly in woodland… this also includes species that breed in scrub, or woodland with a more open canopy…species that nest in woodland but feed mainly in surrounding open habitats… were excluded". Species included in the wetland indicator are those defined as having a positive association with waterways or wetlands, based on a literature review and analyses of BTO/JNCC/RSPB Breeding Bird Survey (BBS) data (Everard and Noble 2008). In practice, these overlap markedly with those classified as 'lowland wetland' species in Gibbons *et al*. (1994) but also include some upland birds and those also associated with farmland. Although no clear definition of "seabird" exists, in the UK they are commonly accepted to include auks, tubenoses, gulls, terns, gannet and cormorants, a group which does include species which may spend a considerable proportion of their time in terrestrial or freshwater environments. The wintering waterbird indicator includes all species of wildfowl, waders and miscellaneous other waterbirds (e.g. coot) with substantial non-breeding populations in England and/or the UK.

Species composition of the indicators is the same at the England and UK scale, with a few exceptions. These exceptions arise either because species are present in the UK but not within England (e.g. capercaillie, which breeds solely in Scotland, and Nearctic light-bellied brent goose, which winter principally in Northern Ireland) or because data are insufficient to enable the production of robust trends at the English scale (e.g. pied flycatcher and common crossbill, which are recorded in too few BBS squares within England to enable trend production).

The species-habitat definitions provided by Gibbons *et al.* (1994) are mutually exclusive (i.e. species are assigned to one habitat only). However, the different approach used to define wetland species means that there is potential for species to occur in more than one indicator, and thus three species in the wetland bird indicator (lapwing, reed bunting and yellow wagtail) also appear in the farmland bird indicator. In addition, there is overlap between the species occurring in the wintering waterbird indicator and the farmland (lapwing) and water & wetland indicators (11 species e.g. teal, goosander and lapwing). In the latter case, the trends used are different and in some cases the populations being monitored are completely different owing to the movements of bird populations in and out of the UK between seasons.

In all cases the population trends used reflect changes in the entire populations of species, not just the proportion of the population using the habitat in question. The use of habitat-specific trends, using data from the relevant habitat only, has been investigated (e.g. Renwick *et al*. (2012)); this different approach had relatively little influence on indicator outcome.

The approach used to attribute species to habitat indicators has been questioned in the past, and alternative approaches (e.g. more intensively data-based) could be used to assign species. However, Renwick *et al.* (2012) looked at three different approaches for assigning species to the farmland and woodland bird indicators and found that none of the approaches they tested resulted in significantly different indicators, although species composition varied.

Non-native species are excluded from the indicators (e.g. red-legged partridge, little owl, pheasant, greylag goose and canada goose), as are rare and scarce breeding species (defined as having a UK breeding population of less than 500 pairs or an English breeding population of less than 300 pairs). A limited number of species are excluded due to the lack of sufficiently robust population trends – see below for further discussion. In some cases (e.g. barn owl) it may be possible to include such species in the indicators at a later date, when suitable indices become available.

2.2 Data sources

Data on bird populations in the UK and England comes from a variety of UK-wide monitoring schemes run by NGOs, principally the BTO and RSPB but with other partners, in collaboration with the UK Government (the JNCC and the four statutory nature conservation agencies). The most important sources of data for the wild bird indicator are the BTO/JNCC Common Bird Census (CBC) (1966–2000) and its replacement survey, the BBS (1994 to date). The latter involves volunteer surveys of over 3500 1-km squares throughout the UK and provides robust measures of abundance, on an annual basis, for over 100 breeding bird species. Volunteers survey randomly-selected 1-km squares on two occasions between April and June every year. Surveys involve walking two parallel 1-km transects through the square, recording all birds seen or heard along the transect: see the latest BBS report (e.g. Harris *et al*. 2018) or http://www.bto.org/volunteer-surveys/bbs for further details. In most cases these two principal data sources can be used in combination to generate long-term population indices (see below).

A number of species of relevance to the indicators (native, assigned to one of the three relevant habitats and with a population of over 500 (UK) or 300 (England) pairs) are either too scarce, or have too specialised habitat requirements, to be monitored well by the BBS, or the CBC before it. Data for seabirds come from three complete censuses of the UK's breeding seabirds, and from the annual Seabird Monitoring

Programme. For other breeding species a variety of alternative data sources are used to generate annual trends, including:

- BTO/JNCC Waterways Bird Survey (WBS) and Waterways Breeding Bird Survey (WBBS) (http://www.bto.org/volunteer-surveys/wbbs)
- Rare Breeding Bird Panel (RBBP)
- periodic single-species surveys conducted as part of the Statutory Conservation Agency and RSPB Annual Breeding Bird Scheme (SCARABBS)
- periodic Rook censuses,
- Heronries Census (www.bto.org/our-science/projects/heronries-census)
- Constant Effort Site scheme (www.bto.org/volunteer-surveys/ringing/surveys/ces)

Data for the wintering waterbird indicator come from the BTO/JNCC/RSPB Wetland Bird Survey (WeBS), with additional data from the WWT/JNCC Goose & Swan Monitoring Programme (GSMP).

2.3 Calculation of indicators

The creation of the wild bird indicators involves two analytical steps: the production of annual population indices for each individual species and then the combining of these indices in habitat groups to produce the habitat indicators. The farmland bird indicator is the same as that produced previously to assess progress towards targets for PSA indicator CSR04. This has both unsmoothed and smoothed versions, with 95% confidence limits to allow the assessment of the statistical significance of change since the beginning of the indicator and also other any other time periods of interest e.g. between years, or since 2000. All the indicators follow the same basic analytical approach (e.g. Noble *et al*. 2003b).

For those species covered by the CBC and BBS, all data from survey sites are used in the generation of trends, regardless of the habitat at these sites (e.g. survey data from woodland sites is used in the trends for farmland species and vice versa). Trends are generated from the two data sources using the joint-model methods described by Noble *et al*. (2003a). Generalized linear models (GLMs) are used, with the application of a post-hoc smoothing spline to produce smoothed indices for each species, thereby removing short-term fluctuations that may be caused by sampling error, or minor fluctuations due to weather effects, for example. Such smoothing does however mean that the estimates for the final year of a trend must be treated with caution as they lack the smoothing effect of data in previous years. The nature of smoothed trends, in that data from any given year has an impact on trend values for earlier (and later) years means that existing species indices (and hence indicator) values will be different in subsequent annual revisions.

Data from the CBC and BBS are combined and analysed statistically in a single generalised linear model with site and year effects, as described at http://www.bto.org/about-birds/birdtrends/2013/methods/cbcbbs-trends. Equal weight is given to CBC and BBS sites by assigning each CBC site the mean of the BBS site weighting (for more detail see Freeman *et al*. 2003). Confidence limits on these species trends are generated by bootstrapping; repeated resampling (with replacement) to generate a sample of estimated trend values, with the 2.5% and 97.5% percentiles giving the 95% confidence limits around the trend value for each year (Efron 1982).

For data from other sources different approaches are used, often not allowing the calculation of error in the trend estimates. As the number of species derived from these non-standard sources is small, the lack of

an error structure makes little difference to the overall estimate of error associated with the indicators themselves.

As stated above, trends derived from CBC-BBS data use all the data available for a species. For many species, particularly those considered habitat 'specialists' (see below) (such as nuthatches in the woodland indicator, or grey partridges in the farmland indicator) few data come from 'non-focal' habitats. But for other species, data (and thus trends) in other habitats can make a substantial contribution to the index produced and used in the indicators. For example, dunnock is included in the woodland indicator, as it has a preference for, and occurs in higher densities in, woodland habitats. However, as a common species in farmland hedgerows, and given the large extent of this habitat, farmland dunnocks may make as great a contribution to the woodland indicator as those dunnocks in woodland itself. However, an investigation of the difference between conventional species indices and habitat-specific indices (for which only data from the focal habitat it used) found that the two approaches produces very similar indicators (Newson & Noble 2004). For the water & wetland indicator targeted habitat-based survey data (e.g. WBBS) are used for a number of species, and for the seabird indicator the nature of current, coastal colony-based monitoring means that trends largely reflect changes in marine populations rather than terrestrial birds (e.g. inland-nesting herring gulls), and in some cases bespoke analyses are conducted to exclude inland data (see section 3.4).

Population indices are generated for each species, indexed to a value of 100 in a baseline year. These indices report relative changes in abundance: a rise to 200 reflects a doubling in numbers, a decline to 50 a halving, relative to numbers in the baseline year. For most indicators the baseline is set as 1970, and the final year of the indicator demonstrates change since then; the exceptions are the indicators for water & wetland birds (1975), wintering waterbirds (1975-76) and seabirds (1986) due to the later start to the data series relied upon by these indicators. It is possible; however, to set the baseline to any year within the indicator sequence (e.g. 2000 has been used on occasion). The use of different start and baseline years, and the impact upon the indicator, is discussed in sections 4.2 and 4.3.

The individual habitat indicators and the all species indicator are calculated using the approach outlined by Gregory *et al*. (1999): as the geometric mean of the constituent species indices, with no weightings, i.e. each species has the same relative effect on the indicator. Confidence intervals for these indicators are calculated by bootstrapping index values for each species in each year then averaging for each of the bootstrap runs (currently 199).

The best available data sources for some species do not allow indices to be produced for the complete time period for any indicator they are required for; in such cases, indices are added into the composite indicator in the first year for which they are available. If the indicator is set to a baseline year before the entry date of such species (e.g. if it is baselined to its start year) then they are entered into the composite indicator at the mean value of the indicator for the year in which they enter. This ensures that the addition of new species does not have an artificial impact upon the composite indicator (see Noble *et al*. 2004). However, this approach is not possible if the indicator is baselined to a year after the year in which new species are added: see section 4.2 for further discussion.

Composite indicators, showing average trends, can hide a large disparity in the fortunes of the constituent species. For example, in the UK farmland bird indicator to 2013 the turtle dove had declined by 96% since 1970 whilst a close relative, the woodpigeon, increased by 135% over the same period. To provide some insight into the disparate trends within the indicator, in 2014 new histograms have been published

alongside the indicators as supporting information. These present, in five categories, the percentage of species showing different trends – strong increase, weak increase, little change, weak decrease, strong decrease – over two time periods. The long-term period is that since the start of the indicator (1970 in most cases) although for species entered into the indicator in subsequent years the period is shorter (the longest available trend is used, as long as it exceeds that used within the short-term change measure). The short- term period is the last five years to the penultimate year of data. Assessments are based on smoothed trends where available. The five trend class thresholds are based on average annual rates of change over the assessment period, and are derived from the rates of decline used to assign species to the red and amber lists of Birds of Conservation Concern (Eaton *et al.* 2009). Thresholds are given in table 1.

Table 1: 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
Little change	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%).

In addition to the standard indicator figures, additional figures can be produced to illustrate year on year change in indicator values, by showing the ratio between the index in each year and the year preceding it, although these figures are not published currently. Ratio values above one indicate a between-year increase in the indicator: values below one indicate a decrease. Confidence limits on these ratios are calculated by resampling from the individual species trends. If the value of 1 (meaning no change in the index) falls outside the range of the 95% confidence limits, this means there is a statistically significant between-year change in the indicator.

3. Interpretation and reporting of the wild bird indicators

The procedure used to date for reporting on the wild bird indicators has been for the calculated species trends, generated indicators and some interpretation to be supplied to Defra in the autumn of the year following that of the latest available survey results. This is because much of the data, collected by volunteers participating in a range of different surveys, are not fully collated and verified until the spring following the year of data collection. Subsequent trend analyses and bootstrapping for generating confidence intervals is also a time-consuming procedure that delays the availability of the constituent trends for another few months.

3.1 Recommendations for quality assurance procedures for wild bird indicator updates

The wild bird indicators are produced in line with standard quality assurance procedures related to data collection, data collation and verification and storage, trend analyses and composite indicator construction.

A large proportion of the data derives from annual surveys such as the BTO/JNCC/RSPB Breeding Bird Survey (BBS) which employs standardised field protocols and a rigorous sampling design. However a minority of species trends are derived from other data sources, without a formal sampling design, but nevertheless representing the best estimate of changes in the population status of the species in question.

3.1.1 Data Collection

- For most current surveys, sample sites are allocated following a rigorous stratified random sampling design to current (continuing and recruited) volunteer surveyors. Continuing participants survey the same square as in previous years.

- Most volunteer surveyors are recruited by local Regional Organisers, who are local experts, familiar with the region and are in a position to assess the capabilities of existing and potential surveyors. Volunteers are offered a CD of bird songs and calls of core BBS species, and the opportunity to attend BTO-run training courses and workshops held at locations throughout the UK.

- Each surveyor is sent recording forms, explicit instructions for carrying out the survey and recording information on paper or via the website (BBS Online).

- Surveyors carry out bird surveys on their allocated square, following strict protocols on timing, dates of visits, and information recorded.

- Other surveys, such as the Wetland Bird Survey, Goose and Swan Monitoring Programme and Seabird Monitoring Programme do not use a random sampling approach given the aggregated nature of the species being monitored, but are based on repeat coverage of sites – such as breeding colonies or important wintering sites – identified as being of importance. Although such sites may vary in size and nature, standardised monitoring protocols are followed.

3.1.2 Data Collation and Verification

- Surveyors submit their data to the co-ordinating organisations (in most cases BTO) in one of two ways – by sending their completed paper recording forms, or online via the BBS Online website. Data entered online are subject to checking procedures that query the observer about unusual records, counts, timing or location.

- For surveys with paper form recording, data are input externally, with double-inputting as a check, and added, if necessary, to the database containing the information entered online.

- The entire data set is verified by running various checking programmes to highlight unusual records, counts, timing or locations.

3.1.3 Data Storage

- Most datasets are stored in a fully relational databases (Oracle, Access) held by the respective institutions that are backed up every night. Updates are carried out periodically, and hence, the database permanently contains up-to-date information for each record.

3.1.4 Trend Analyses

- Analytical programmes to produce the species trends are run annually with the most up-to-date datasets available at the time

- The majority of trends are analysed using Generalised Linear Models (GLMs) with full site and year effects and a log-link function. Poisson error terms are used to deal with the distribution of bird count data. Trends are then smoothed using a spline function. Note that because the models have to be re-run each year including the new data, and new annual estimates are fitted to these data, there are inevitable but very small differences in the annual indices estimated each year.

3.1.5 Indicator Construction

- The wild bird indicators are constructed each year from the species-specific smoothed trends from each of the constituent species, following agreed protocols. The same species are used in the indicator each year except where species are added or removed following procedures agreed by the Indicators Steering Group and with extensive consultation. A bootstrapping approach is used to estimate confidence intervals for the indicator.

- Following checks to ensure the programmes have all been successful, the composite indicators and the constituent species trends are provided in a spreadsheet that permits additional checks.

3.2 Assessing change in the wild bird indicators – measuring progress

There are a number of ways of assessing the level of confidence that can be attached to the observed changes in the wild bird indicators. Confidence intervals for the indicators are currently calculated by bootstrapping, a statistical method that estimates the uncertainty in a trend through repeated re-sampling and trend estimation. Confidence intervals for the estimated trends are calculated from percentiles (such as 2.5% and 97.5%) of the sample of estimated trend lines. The procedures currently used provide a measure, and level of confidence, of the indicator value in any particular year (e.g. 2014) relative to the start year of the time series. It is feasible to calculate the change, and confidence in that change, for any other time period (e.g. over five years from 2013 to 2018) but this requires all of the constituent population trends and their bootstraps to be recalculated using the start year (e.g. 2013) as a baseline. The time and resources required for this are an issue and it is not sensible to calculate changes over every possible period. However, long-term trends may occur gradually over a number of years, in which there may be no statistically significant change between any two consecutive years, but a considerable (and significant) change over a longer period. Note that such assessments are made using the smoothed trend which is a better measure of underlying change (see below). The smoothing process means that the index value for a given year will be influenced by data collected in subsequent years. As a result, the final year of an indicator time series. (without the influence of later years) should be regarded as less robust and may change considerably in subsequent annual updates. As a consequence, changes in smoothed indicators are always calculated to the year before last (yr-1), for example in the 2019 update, using data to 2018, the short-term trend was measured over the five years 2013-18. At present changes are tested over the entire sequence of the indicators (e.g. 1970-2018), ten years (e.g. 2008-18) and five years (e.g. 2013-18). The change over the most recent year (e.g. 2018-19) is reported without statistical testing using the unsmoothed indicator.

At present, neither the data for seabirds or wintering waterbirds can be presented with confidence intervals and therefore formal tests of change cannot be applied. The data for seabirds cannot be presented as a smoothed trend as individual population trends are analysed using an imputation procedure that does not include smoothing. Data from surveys of wintering waterbirds are based largely on full counts at colonies or wetland and coastal sites of markedly varying size. Therefore, neither seabirds nor wintering waterbirds can be presented with confidence intervals.

The statistical power to detect change in population trends (whether single species or composite indicators) is affected by: (1) count variability in space and time; (2) the magnitude of the change; (3) the length of the time series; (4) the number of survey plots; and (5) sampling error associated with the survey design. Capacity to detect changes in the indicator is maximised by setting minimum sample size criteria for species inclusion, using as much data as possible from survey programmes with rigorous sampling designs, and by investigating change over as long a time period as possible. Nevertheless, changes of small magnitude over short time periods are unlikely to be statistically significant.

It should be noted that the smoothing procedure also influences the assessments of change over particular periods as well as the confidence in these estimates. Long-term, gradual change in the population of birds can be obscured by year-on-year variability. Typical causes of this are climatic variability (many resident bird populations decline after hard winters whereas various migrant species are adversely affected by remote factors such as Sahelian drought) and sampling error (particularly for low populations of birds or where the species is recorded in only a small number of survey sites). Smoothing overcomes some of this short-term 'noise', providing the best measure of the underlying trend from which most short-term fluctuations due to weather and sampling error have been removed. A number of smoothing methods (e.g. moving averages) are available, but for these indicators we have utilised the smoothing methods used for the BTO's annual reporting of bird population trends in the UK – namely a post-hoc smoothing spline equivalent to the application of Generalized Additive Modelling (GAM). GAMs are a non-parametric technique in which the population trend can be set for any degree of smoothing by altering the degrees of freedom (d.f.) used in the calculation of the model. If the d.f.'s are set to one, a model in which abundance follows a linear function of time is produced (i.e. a straight line), whilst if the d.f.'s are set to equal the number of years in the time series, a model is created in which the estimates for consecutive years are simply joined (equivalent to no smoothing). Using similar data (CBS and BBS) Fewster *et al*. (2000) found that the optimum level of smoothing for such purposes was attained by setting the d.f.'s to equal one third of the number of years in the series, and hence we have used this procedure for these indicators. This is the standard level of smoothing used in all of the specific long-term trends in abundance reported annually in the UK (Baillie *et al*. 2014).

4. The indicators

4.1 The farmland bird indicator

The 19 species contributing to the farmland bird indicator are listed in table 2. Species composition is the same for the UK and England indicators. One further species, Barn Owl, has been identified as a farmland bird suitable for inclusion in the indicator but has not been included to date due to the lack of a suitable population index. Investigation of a number of potential data sources for a Barn Owl index, such as the Barn Owl Monitoring Programme as well as the BBS, concluded that this was not possible currently (Thaxter *et al*. 2008).

The farmland bird indicator can be disaggregated into two 'sub-indicators', for specialist species (12) considered to be largely or wholly dependant on farmland habitats, and generalist species (7) that utilise a wider range of habitats. The split of farmland species to specialists and generalists follows that published in the appendix of Siriwardena *et al*. (1998), which is based on the expert opinion of the authors, albeit in the context of their analyses.

Trends for 18 of the 19 species within the farmland bird indicator are derived from CBC and BBS data to produce annual indices running from 1970 onwards, indexed to 1970. For all but Stock Dove the trends are produced by the joint-modelling approach described above; the disparity between CBC and BBS trends for stock dove in the 1994-2000 overlap period means that trends from the two survey sources could not be modelled jointly, so are anchored to each other in 1994, such that from 1995 onwards the index is derived solely from BBS data. The population index for rook is derived from a combination of BBS data and national rook censuses in 1975 and 1996; the index for rook is introduced into the farmland indicator in 1975.

Table 2: species in the farmland bird indicator

Specialist Farmland Species		**Generalist Farmland Species**	
grey partridge	skylark	jackdaw	kestrel
lapwing	whitethroat	rook	yellow wagtail
goldfinch	linnet	woodpigeon	greenfinch
stock dove	yellowhammer	reed bunting	
corn bunting	starling	corn bunting[s]	
turtle dove	tree sparrow		

4.2 The woodland bird indicator

The 37 species contributing to the woodland bird indicators are listed in table 3. Of these, three (common crossbill, pied flycatcher and capercaillie) are not included in the England indicator, the former two as the English BBS sample is insufficient to produce a robust trend, capercaillie as within the UK it occurs only within Scotland. Trends from 1970 onwards are produced from joint-modelling of CBC-BBS data, with the exception of five species. Five species (nightingale, wood warbler, pied flycatcher, common crossbill and siskin) which were not monitored in a sufficient number of CBC plots to allow a trend to be produced for the period from 1970 to 1994, but BBS trends are available for these species. These species are introduced to the indicator from 1994 onwards, entering the indicator the average index value for that year (if the

baseline is set to an earlier year) (see Noble *et al*. 2004 for more details). Capercaillie is included using a trend generated from national surveys, conducted at six yearly intervals (e.g. Eaton *et al.* 2008; Ewing *et al.* 2012). Hawfinch used to be included in the woodland bird indicator but is now excluded because the bespoke trend based on county bird reports cannot be reliably updated.

As with the farmland bird indicator, the woodland indicator can be disaggregated into specialist (25 species in the UK, 22 in England) and generalist (12 species) sub-indicators. Definitions of specialist and generalist were based upon expert opinion, drawing on multiple sources including Fuller (1994).

Table 3: species in the woodland bird indicator

Specialist Woodland Species		**Generalist Woodland Species**	
capercaillie	siskin	long-tailed tit	tawny owl
sparrowhawk	nuthatch	blue tit	wren
treecreeper	garden warbler	great tit	chaffinch
green woodpecker[s]	blackcap	blackbird	dunnock
great spotted woodpecker	wood warbler	song thrush	lesser whitethroat
lesser spotted woodpecker	chiffchaff	bullfinch	robin
tree pipit	willow warbler		
jay	goldcrest		
common crossbill	spotted flycatcher		
lesser redpoll	pied flycatcher		
nightingale	blue tit		
redstart	marsh tit		
willow tit			

4.3 The water and wetland bird indicator

A water and wetland bird indicator was developed in 2007-08. Expert knowledge was used to assign a range of wetland bird species to one or more of a target set of freshwater waterway and wetland habitats for which, ideally, indicators might be developed. These comprised seven habitat types (fast-moving waterways, slow-moving waterways, standing waters, reedbeds, wet meadows, wet woodland and wet moorland). From population trends for each species (see table 4), composite indicators were developed for four habitats: fast-flowing waters; slow-moving and standing waters combined; reedbeds; and wet meadows (comprising wet grassland and marshes). In addition, an all-species composite 'freshwater birds' index was derived for all 22 species in the four habitat-specific indicators, in addition to the four additional 'generalist' species. There were insufficient data to support indicators for wet woodland or wet moorland.

Table 4: Species in the water & wetland bird indicator

Fast-moving waterway species	**Slow and standing waterway species**	**Reedbed species**	**Wet meadow species**	**Other water and wetland species**
goosander	moorhen	reed warbler	mute swan	grey heron
common sandpiper	coot	sedge warbler	teal	kingfisher

grey wagtail	little grebe	Cetti's warbler	curlew	sand martin
dipper	great crested grebe	reed bunting	lapwing	oystercatcher
	mallard		redshank	
	tufted duck		snipe	
			yellow wagtail	
			little egret	

Unlike the farmland and woodland indicators, which use species trends derived from all habitats, the restricted nature of wetland habitats, and the specialised nature of the birds that use them, means that a different approach was used for the water and wetland indicator. For some species (see table), data from two annual surveys of breeding birds of linear waterways (the Waterways Bird Survey, WBS, 1974 onwards, and the Waterways Breeding Bird Survey, WBBS, 1998 onwards) have been combined with data from the two more widespread schemes, CBC and BBS, to generate indices that represent population changes within water and wetland habitats more appropriately. In other cases, data from the WBS and WBBS alone, or other species-specific data sources have been used. In the selection of the most appropriate trend to use for each species, specific habitat preferences, coverage of the species by the respective surveys, and the sample sizes achieved by the different combinations of data sources included, were all taken into account. For more details, in particular on the habitat-specific sub-indicators, see Noble, Everard & Joys (2008).

As the first waterway-specific survey (WBS) did not start until 1974, the water & wetlands indicator differs from those for farmland and woodland by starting in 1975. However, trends for nine species are incorporated into the indicator in a later year (due to the later period of coverage of the data source, or the time at which the size of the breeding population in the UK reached the agreed threshold level for inclusion, as for little egret). Following standard protocols, new species enter the indicator in the year that the trend for that species starts, the starting index value adjusted to the mean index of all other species for that year to avoid their entry into the indicator having an impact of the value in their year of entry. The data sources and year of entry for all species added to the water and wetland indicator after the standard start year of 1975 are listed below.

Table 5: year of entry for species introduced water & wetland indicator after 1974

Species	**Habitat category**	**Data sources for species trend**	**Enters the water and wetland indicator**
sand martin	Generalist	WBS/WBBS	1977
curlew	Wet meadows	CBC/WBS/BBS/WBBS	1979
lapwing	Wet meadows	WBS/WBBS	1979
reed warbler	Reedbed	CBC/WBS/BBS/WBBS	1980
goosander	Fast-flowing water	WBS/WBBS	1980
Cetti's warbler	Reedbed	CES	1986
teal	Wet meadows	BBS/WBBS	1994
great crested grebe	Slow / standing waters	BBS/WBBS	1994
little egret	Wet meadows	Special surveys/Heronries	2004 2006 in England

4.4 The seabird indicator

Seabird species trends have been part of the all species wild bird indicators since their inception in 1999, and shown separately as an indicator of trends in seabirds for many years. The seabird indicator was initially more comprehensive in species composition due to the inclusion of change measures based on comparisons between the results of the last national seabird census in 2000 and the earlier censuses in 1970 and 1985. Due to the increasingly long period since the last national seabird census, it was decided in 2014 that it was no longer appropriate to extrapolate change measures from 2000 and hence only species with more up to date information could be included. Since 1985, the majority of coastal breeding seabirds have been monitored under the Seabird Monitoring Programme (SMP), in which counts of whole colonies or sample plots within colonies are counted annually or as frequently as possible. These counts are analysed by JNCC on behalf of the broader SMP partnership to calculate population trends for as many species as deemed based on sufficiently robust and representative data. Annual updates are reported on the SMP website. From 2014, the UK and England seabird indicators are produced from the population trends of 13 and 11 seabird species, respectively, as shown in the following table. The UK and England indicators were harmonised in 2014 to cover solely the period for which data are available from the SMP, i.e. from 1985 to the present. For species such as the terns, the data used are from bespoke surveys carried out at reserves and other locations holding all or the bulk of the UK populations. A further refinement to both the UK and England seabird indicators is that for species with substantial inland breeding populations (herring gull, cormorant and common tern), the data used for the seabird and all-species indicators are from coastal colonies only.

In 2014, the UK seabird indicator was further modified by excluding species for which the SMP was not considered to deliver sufficiently representative trends and species for which a large proportion of the population breeds inland rather than on the coast (e.g. black-headed gull, common gull). In 2014, the England seabird indicator was also modified slightly to harmonise it with the UK version of the indicator by applying the same rules for species inclusion and by setting the start year to the same baseline, in 1985. Differences between the UK and England seabird indicators remain however, due to differences in areas occupied by particular seabirds (e.g. Arctic skuas breed only in Scotland (hence UK) but not in England) and in regional data availability.

Until 2014, the England seabird indicator included a breakdown by foraging behaviour. Separate sub-indicators were produced for surface feeders (the aggregated population trends of Black-legged Kittiwake and the four tern species) as well as sub-surface piscivores (the aggregated trends for Common Guillemot, Shag and Cormorant). The following describes the UK and England seabird indicators as currently reported.

The breeding seabird index has now been updated with data up to and including 2019. This follows a brief hiatus in updates since 2016 when the Seabird Monitoring Programme Steering Group made the decision to put the analysis and publication of the annual SMP report on hold enabling staff time to be dedicated to the breeding seabird census, Seabirds Count.

Table 6: Species in the UK and England seabird indicators

Surface-feeding Species	Subsurface Piscivores	Other Seabird Species
black-legged kittiwake	great cormorant	Arctic skua (UK only)
Arctic tern	European shag	herring gull
common tern	common guillemot	great black-backed gull (UK only)
sandwich tern		razorbill (UK only)
little tern		Northern fulmar
		Northern gannet (England only)

4.5 The all-species indicator

In addition to the four habitat-specific breeding bird indicators described above, an indicator based on population trends in all breeding species (in the UK and in England) is also presented in the birds indicators statistical release, but not in the UK biodiversity indicators. As for the other indicators, each species is represented by a single data source and its composition is restricted to species for which sufficient data are available and with at least 300 breeding or 500 breeding pairs in England or the UK, respectively. All of the species included in the farmland, woodland, wetland and seabird indicators are included here, as well as species associated with urban habitats (e.g. collared dove, house martin), with uplands (e.g. hen harrier, red grouse), with heathlands (e.g. Dartford warbler, hobby) and species that occupy a range of habitats (e.g. peregrine, black-headed gull).

Table 7: Additional species in the all-species indicators

avocet	bearded tit	black-headed gull	buzzard
carrion crow	cirl bunting	collared dove	corncrake
cuckoo	Dartford warbler	firecrest	gadwall
golden plover	greylag goose	hen harrier	hobby
hooded crow	house martin	house sparrow	magpie
meadow pipit	Mediterranean gull	mistle thrush	peregrine
pied wagtail	pochard	quail	raven
red-breasted merganser	red grouse	red kite	shelduck
shoveler	stonechat	swallow	swift
whinchat	woodlark		

4.6 The wintering waterbird indicator

The wintering waterbird indicator has been an integral part of the suite of wild bird indicators for both England and the UK since their inception in 1999 but differs conceptually in being a measure of trends in the abundance of wintering waterbirds rather than breeding birds, and for this reason it is reported in a separate graph. There are important implications in the interpretation of changes in the indicator as these may reflect changes in migration and wintering behaviour instead of (or as well as) changes in the

abundance of the source breeding populations. Wintering waterbirds (comprising waders, ducks, geese, swans and other waterbirds such as cormorants and coot) originate from breeding populations within and outside the UK, depending on the species.

Trends for waders and most wildfowl are derived from the BTO/JNCC/RSPB Wetland Bird Survey (WeBS) whereas trends for a suite of wintering geese species (e.g. pink-footed, Greenland white-fronted and Svalbard barnacle geese) are derived from the WWT/JNCC Goose and Swan Monitoring Programme. Schemes to monitor wildfowl date back to 1947 and continued throughout the 1970s and 1980s as National Wildfowl Counts. Wader monitoring (initially the Birds of Estuaries Enquiry (BoEE)) started later. Both schemes were combined in 1993 into the newly created WeBS scheme which continues today. These counts are made at all wetland habitats, including freshwater lakes, ponds, reservoirs, gravel pits, rivers, canals and marshes as well as open coasts and estuaries. The latter habitat provides the majority of data for all the species that tend to congregate in key estuaries over the winter. Counts are made once a month ideally on predetermined priority dates. This allows counts across the whole country to be synchronised and minimises gaps and double-counting.

WeBS core counts provide the information used in assessing population trends. Annual summaries of the monthly counts are analysed each year using the Underhill Index method (Underhill and Prys-Jones 1994) specifically developed for waterbird populations, to produce a time series of index values for each species or subpopulation. In summary, this method includes a calculation to estimate counts for missing site-month combinations, based on counts in other months and all sites: hence making counts comparable across years.

Data for wildfowl are available for the period 1966/67 to present. Data for waders are available only from 1974/75 onwards because a high proportion of counts before this winter were imputed. For species added later to the scheme (i.e. great crested grebe and coot in 1982/83, little grebe in 1985/86, cormorant in 1986/87, data from the first two years following their inclusion were omitted from indices as initial take-up by counters was incomplete.

The UK wintering waterbird indicator is composed of population trends for 46 species, races or populations treated as separate components, and 41 of these are incorporated in the England indicator. The additional five are geese populations of which England holds no significant wintering population. These are presented from the start year of 1970/71 to match the breeding bird indicator but the information for waders and other waterbirds starts later as described above. Presentation of trends below the level of species reflects the fact that many waterbirds (particularly geese) are monitored nationally at a population or flyway level because of differences in the timing of migration and location of wintering areas of the different breeding populations (e.g. Greenland versus European white-fronted geese). As well as the overall wintering waterbird indicator encompassing trends from all 46 species or populations, the indicator is also disaggregated into (i) waders and (ii) ducks, geese and swans.

Table 8: Species in the wintering waterbird indicator

Wildfowl (27)

Bewick's swan	Icelandic greylag goose (UK only)	shelduck
British/Irish greylag goose	mallard	shoveler
dark-bellied brent goose	Nearctic barnacle goose (UK only)	Svalbard barnacle goose (UK only)
eider	Nearctic light-bellied brent goose (UK only)	Svalbard light-bellied brent goose
European white-fronted goose	pink-footed goose	teal
gadwall	pintail	tufted duck
goldeneye	pochard	whooper swan
goosander	red-breasted merganser	wigeon
Greenland white-fronted goose (UK only)	scaup	shelduck

Waders (15)

avocet	golden plover	purple sandpiper
bar-tailed godwit	grey plover	redshank
black-tailed godwit	knot	ringed plover
curlew	lapwing	sanderling
dunlin	oystercatcher	turnstone

Other Waterbirds (4)

coot	great crested grebe	little grebe
cormorant		

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