JNCC Report 740

The use of EU Birds Directive (Article 12) species' status and trends reports for Habitats Regulations (2019) in England & Wales, Scotland, and Northern Ireland

Pilot study: Common Snipe *Gallinago gallinago*

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Summary

Following EU exit, the UK is no longer required to undertake reporting under Article 12 of the Birds Directive (and Article 17 of the Habitats Directive) every six years. However, the need to undertake broadly equivalent reporting has been transferred to the Habitat Regulations. Under Regulation 9A of the Habitats Regulations 2019 (and equivalent regulations in Scotland and Northern Ireland), each country within the UK is required to report to the UK Secretary of State on the status of European protected species and habitats. This country-level reporting is a change from the UK-scale reporting previously undertaken under Birds and Habitats Directives. The first reports are due in 2025. Within two years of receiving these reports, the Secretary of State will then publish a UK composite report of the assessments.

This report forms part of a series of pilot assessments, undertaken by JNCC and the Country Nature Conservation Bodies (CNCBs), to prepare the ground for the first round of Habitats Regulations reporting in 2025.

The British Trust for Ornithology (BTO) was commissioned by JNCC to carry out a pilot study to examine the best data, approaches, and methods to calculate metrics for the Habitats Regulations reporting, using Snipe (*Gallinago gallinago*) as an example species. Snipe was chosen for the following reasons:

1) the species has breeding and wintering populations in the UK, therefore the information on trends needs to be gathered for both seasons;

2) the species is abundant in winter but relatively uncommon during the breeding season, therefore it presents challenges for the assessment of trends for areas with less availability of survey data, but still has enough data to produce trends for most areas;

3) it is a habitat specialist which also poses challenges in terms of spatial modelling.

The Birds Directive required member States to report on all Regularly Occurring Migratory Species, as well those receiving added protection and listed under Annex 1 of the Directive. Within a species, breeding populations were reported separately from non-breeding populations (i.e. those birds over-wintering in a country or stopping over on migration). Reporting on population size estimates; population trends; and distribution and changes in distribution. Under the Birds Directive, the values of each parameter were simply reported, and the status of the species was not assessed by each Member State.

Since the 2019 UK Birds Directive Report, there have been changes in the extent and suitability of the datasets used to calculate these metrics. For example, the additional years of data for The Breeding Bird Survey (BBS), an annual UK-wide monitoring scheme, designed to comprehensively monitor population trends that began in 1994 (Harris *et al*. 2022).

This report examines the use of the Breeding Bird Survey (BBS) for reporting population size and short-term population trends. Long-term trends (1980 to 2022) required combining data from the Common Bird Census (CBC), the predecessor of BBS which ran from 1962 to 2000, with BBS data. However, CBC coverage was very sparse outside of southern England so long-term trends for Scotland, Wales and Northern Ireland may be difficult to estimate. For some rarer species, including Snipe, CBC coverage is low and data from schemes such as the Waterways Breeding Bird Survey (WBBS) and its predecessor Waterways Bird Survey (WBS) may provide alternative approaches to trend estimations (BTO 2023a). The use of Rare Breeding Bird Panel (RBBP) data is also discussed for rare breeding species.

Another key challenge for the Habitat Regulations Reporting is the lack of up-to-date information on species' distributions. Previously, in the 2019 UK Birds Directive report, the UK Bird Atlas 2007-11 was used to provide species distribution information (Balmer *et al.* 2013). However, this information is now over 10 years old so the report examines whether information on species distributions and range changes could be obtained from BBS data. In addition, methods for using BBS data to estimate range changes and to produce distribution maps or update Atlas distribution maps are considered.

In addition, the use of Wetland Bird Survey (WeBS) data is explored for short and long-term wintering population trends.

This pilot study allowed us to investigate methods to produce the information needed for the Habitat Regulations reporting, using Snipe as an example species. Snipe was chosen because it presents challenges that we expect they will emerge with other relatively uncommon habitat specialists, therefore the methods used here can likely be applied to most other species for which data are sufficient. However, for some parameters, the choice of the best method will depend on the species. The table below summarise the key considerations for specific parameters.

Table A. Key considerations and data sources for Habitat Regulations reporting parameters.

Parameter	Data Source	Consideration
Breeding population size	BBS or Woodward *et al*. (2020) or RBBP	BBS – is most recent, so use if sample size is sufficient; RBBP for species < 2000 pairs in UK.
Long-term breeding Population trends	CBC/BBS	joint CBC+BBS or WBS+WBBS data (the latter for species that mainly breed along waterways) should be used where sample size is sufficient – usually only possible for England and UK.
Short-term breeding population trends	BBS	If sample size insufficient, use RBBP or expert opinion on direction of trend.
Short/long-term wintering population trends	WeBS	Data are sufficient to estimate trends for approximately 90 species at UK scale, mostly since 1966 and 52 species at country scale (see latest WeBS report).
Breeding distribution maps	BBS-based models or Bird Atlas 2007 to 2011	BBS-based models more up-to-date but potentially less accurate and requires much more resource to develop and validate.
Short-term trends in breeding distribution.	BBS-based models or changes between two most recent Atlases 1990 to 2010	BBS-based models more up-to-date but potentially less accurate and requires much more resource to develop and validate. Inter-Atlas period is neither short-term or recent.

The following areas where identified where further work may help assess the quality of some of the estimates.

- **Calibrate BBS-based population estimates**. Population estimates from BBS data rely on the assumptions of the distance sampling approach (Buckland *et al.* 2001). Ideally, the estimates should be validated and calibrated using independent data.

Collecting independent data would require significant resources but would be useful to assess and improve the accuracy of population estimates.

- **Estimate the uncertainty around the short-term trends in breeding distribution**. If BBS data are used to estimate short-term trends in breeding distribution, calculating confidence intervals would prove useful when the sample size is low. This could be done by bootstrapping, which may be consuming in terms of computing time and power but would be straightforward to set up.

- **Integrating BirdTrack data to estimate distribution and distribution changes**. Integrating BBS data with BirdTrack data could potentially help improve the accuracy of all estimates of distribution and distribution changes. Previous research on population trends (Boersch-Supan 2019) has shown encouraging results for species and areas with good coverage. However, there is no established protocol to obtain species distribution from opportunistic data and it would require significant resources. The use of BirdTrack data could also be tested for estimating changes in winter distribution, which is currently a significant challenge for many species because we don’t have a general survey scheme for wintering birds.

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1 Introduction

Every six years, all EU Member States are required, under Article 12 of the EU Birds Directive, to report on the implementation of the Directive. In 2019 the UK published the 11th UK Birds Directive Report, for which metrics were based on data available several years earlier. As the UK has now left the EU, it will no longer undertake six-yearly reporting under Article 12 of the Birds Directive (and Article 17 of the Habitats Directive). However, the need to undertake broadly equivalent reporting has been transferred into the Habitat Regulations through the EU Exit Statutory Instruments which amended the Regulations in each of the four countries. Under Regulation 9A of the Habitats Regulations 2019 (and equivalent regulations in Scotland and Northern Ireland), each country within the UK is required to report to the UK Secretary of State on the status of European protected species and habitats. The first reports are due in 2025. Within 2 years of receiving these reports, the Secretary of State will then publish a UK composite report of the assessments. This country-level reporting is a change from the UK-scale reporting previously undertaken under Birds and Habitats Directives.

JNCC and the Country Nature Conservation Bodies (CNCBs) are undertaking a series of pilot assessments of European protected species and habitats to prepare the ground for the first round of Habitats Regulations reporting in 2025. These pilot assessments will inform the methods to be used, the resource requirements (both staff time and any costs of evidence collation) and the project planning and governance.

The British Trust for Ornithology (BTO) was commissioned by JNCC to carry out a pilot study to examine the best data, approaches, and methods to calculate metrics for the Habitats Regulations reporting, using Snipe (*Gallinago gallinago*) as an example species. Snipe was chosen for the following reasons:

1) the species has breeding and wintering populations in the UK, therefore the information on trends needs to be gathered for both seasons;

2) the species is abundant in winter but relatively uncommon during the breeding season, therefore it presents challenges for the assessment of trends for areas with less availability of survey data, but still has enough data to produce trends for most areas;

3) it is a habitat specialist which also poses challenges in terms of spatial modelling.

The three main parameters required for reporting under Article12 of the Birds Directive were population size estimates; population trends; and distribution and changes in distribution. Unlike the Habitats Directive, the Birds Directive reporting did not require the values of these parameters to be compared against favourable reference values to assess whether a species had achieved a Favourable Conservation Status. Under the Birds Directive, the values of each parameter were simply reported, and the status of the species was not assessed by each Member State. The Birds Directive required member States to report on all Regularly Occurring Migratory Species, as well those receiving added protection and listed under Annex 1 of the Directive. Within a species, breeding populations were reported separately from non-breeding populations (i.e. those birds over-wintering in a country or stopping over on migration). Previous Bird Directive reports from the UK on Snipe have included separate parameters for the breeding population and the wintering population, which will also be composed of bird that bred outside the UK.

Since the 2019 UK Birds Directive Report, there have been changes in the extent and suitability of the datasets used to calculate these metrics. The Breeding Bird Survey (BBS) is an annual UK-wide monitoring scheme, designed to comprehensively monitor population trends that began in 1994 (Harris *et al*. 2022). Its continued growth means that we should be able to estimate population size for more species, including Snipe, directly from BBS data, rather than using BBS data to extrapolate from a previous survey (often small scale). For most common UK bird species, BBS data will also allow estimates of short-term population trends, while long-term trends are generally available from 1980 to 2022 (the recommended window for long-term trends) by combining data from the Common Bird Census (CBC), the predecessor of BBS which ran from 1962 to 2000, with BBS data. However, CBC coverage was very sparse outside of southern England so long-term trends for Scotland, Wales and Northern Ireland may be difficult to estimate. For some rarer species, including Snipe, CBC coverage is low and data from schemes such as the Waterways Breeding Bird Survey (WBBS) and its predecessor Waterways Bird Survey (WBS) may provide alternative approaches to trend estimations (BTO 2023a)

A key challenge of updating the UK Birds Directive report since 2019 is the lack of up-to-date information on species' distributions. Previously, in the 2019 UK Birds Directive report, the UK Bird Atlas 2007-11 was used to provide species distribution information (Balmer *et al.* 2013). However, this information is now over 10 years old so we examined whether information on species distributions and range changes could be obtained from BBS data. Although the BBS is carried out annually, it is not as spatially extensive as the Bird Atlas and many areas, particularly areas with limited accessibility and low human population densities are sparsely monitored. Moreover, the BBS was designed primarily to calculate population trends. We examine methods for using BBS data additionally to estimate range changes and to produce distribution maps or update Atlas distribution maps.

2 Population size estimates

2.1 Breeding population

In the 2019 UK Birds Directive report, breeding population sizes for most species were extrapolated, using BBS data, from previously published estimates of population size. For 28 common birds the original population estimates came directly from BBS data using distance analysis to convert counts into population estimates where this method was considered sufficiently robust (Newson *et al.* 2008) but for the remaining 200+ species, the original population estimates come from a diverse range of sources including estimates derived in the 1970s by extrapolating territory-mapping-derived densities, periodic censuses, bespoke surveys and analyses (see Woodward *et al.* 2020). The extent to which original populations need to be extrapolated to bring them up to date varies according to the year of the original estimate.

For Snipe, the original population estimate for Great Britain (GB) came from O'Brien *et al.* (2004), while Northern Irish estimates came from Colhoun *et al.* (2015). The original population estimates were then updated using the percentage change in relative abundance between the year of the original population estimate and the final year of BBS data. However, the GB population size estimate made by O'Brien *et al.* (2004) was taken from 32 surveys carried out over 15 years, which makes the uncertainty in this estimate very high. If we were to update these estimates for each of the three GB countries, two extrapolation steps would be required: firstly, to update the GB estimate and, secondly, to divide the up-to-date estimate between countries based on relative abundance estimated from BBS data. This would add further uncertainty to the estimates.

Here we examine the possibility of running bespoke snipe population estimates from BBS data using BBS distance bands to convert counts into population estimates, using a similar method as Newson *et al.* (2008). This is more feasible now than for the 2019 UK Birds Directive Report as there is now more BBS distance data and computing processing power is now considerably greater than previously.

2.1.1 Methods

We used BBS data from the early visit carried out between April and mid-May in 2022. We used the early visit counts as this coincides with the likely period of higher detectability.

The first step consisted of using distance sampling models for estimating detectability and allowing for bird counts to be converted into estimates of bird densities (Buckland *et al.* 2001). To this aim we fitted half normal distributions to the BBS count data from the first two bounded distance bands (0 m to 25 m and 25 m to 100 m), using the 'mrds' package (Thomas *et al.* 2010) for R (R Development Core Team 2014), and assuming all birds on the transect line (zero distance) were detected.

The second step consisted of using a Horvitz-Thompson-like estimator (Huggins 1989) to compute the density within the surveyed area and extrapolate it to the whole country, based on the BBS stratification. To this aim we used the 'dht' function of the 'mrds' package (Laake *et al.* 2021), which also allows for estimating the uncertainty around the final population estimates (accounting for both the uncertainty from by the detection model and from the sampling procedure).

Finally, we compared the estimate obtained using this method to the one reported in Woodward *et al.* (2020), which used the same methods described above to obtain UK and GB estimates of Snipe populations.

2.1.2 Results

The method allowed us to produce a population estimate for the UK and the constituent countries, which we report in Table 1, together with the number of BBS squares with Snipe and, for comparison, the estimates previously produced by Woodward *et al.* (2020). Note that our method produces estimates of individuals and hence requires a conversion calculation to pairs, while Woodward *et al.* report estimates of breeding pairs.

Table 1. Population estimates based on BBS data compared to those reported in Woodward *et al.* (2020).

Population estimate data source	UK	England	Northern Ireland	Scotland	Wales
BBS estimates for 2022 (**individuals**)	195,200 (95% CI: 154,600 – 246,500)	55,800 (95% CI: 43,600 – 71,300)	11,800 (95% CI: 6,200 – 22,200)	125,400 (95% CI: 92,100 – 170,700)	2,300 (95% CI: 900 – 5,600)
Number of BBS squares with Snipe	214	117	11	81	5
Woodward *et al.* (2020) estimates for 2016 (**breeding pairs**)	66,500	N/A	N/A	N/A	N/A

2.1.3 Discussion

Our method allowed us to obtain population estimates for Snipe for the UK and the four constituent countries, importantly also with confidence intervals which account for the uncertainty associated with both the detectability model and the sampling procedure. If we calculate the number of breeding pairs by halving the number of individuals, our estimates are 47% higher than those previously published. For Snipe, the estimates in Woodward *et al.* (2020) derive from different field approaches, including transects, the Brown and Shepherd method, and the 'field by field' method (O'Brien 2004). These studies were conducted two decades earlier and adjusted several times to account for estimated population trends. A potential source of inaccuracy using BBS estimates could be the heterogeneity in detection probability between males and females. Distance sampling is considered to be robust to non-modelled heterogeneity in detection probability between sub-populations (Burnham *et al.* 1980). However, extreme levels of heterogeneity may cause the total population to be underestimated (Rexstad *et al.* 2023). Inaccuracies may also arise from halving the number of individuals to obtain number of pairs. As both heterogeneity in detectability and halving the number of individuals is more likely to cause underestimates, these are unlikely to be the source of discrepancy between the estimates in Woodward et al (2020) and the ones obtained from BBS data.

While it is difficult to judge whether our BBS-based estimate or the one from Woodward *et al.* (2020) is the most accurate, our method allows us to produce country-based estimates and potentially estimates for any area where there are enough BBS squares, including SPAs (chapter 6 in this report). However, sample sizes are small for some countries, especially for Northern Ireland and Wales, with only 11 and 5 BBS squares, respectively, where Snipe was detected in 2022. Northern Ireland deserves a separate mention because Colhoun *et al.* (2015) carried out a complete survey of all potentially suitable breeding habitats in 147 tetrads, which were randomly selected within all 10 km squares; this relatively recent survey is likely to have produced a robust estimate thanks to its well-structured sampling, while the BBS-based estimates (which are more than five times higher than those by Colhoun *et al.*), are probably very weak in this case due to the low sample size. Therefore, we suggest that: for the UK, England, and Scotland we use BBS-based estimates; for Northern Ireland, we use the estimates from Colhoun *et al.* (2015), given that these are from a complete survey and the BBS sample size is very small; for Wales we use the BBS estimates even if the sample size is very small as an alternative estimate is not available.

2.2 Wintering population

The latest estimate of the UK wintering population is from 2004/2005 (Musgrove *et al.* 2011; Frost *et al.* 2019). We used this estimate as the UK baseline estimate and split this estimate into the four constituent countries using the proportion of relative abundance by country from the most recent UK Bird Atlas (Balmer *et al.* 2013). Then we used the country-specific winter population trends from the Wetland Bird Survey (WeBS, Frost *et al.* 2021) to update the estimates to the latest winter for which data are available (2019/20).

The sum of country-specific populations estimated in this way is not the same as the UK population estimate, because the total UK estimate, the relative abundance by country and the population trends all come from different sources, each of which come with their associated uncertainty. While the Bird Atlas and the WeBS are structured survey that produce statistically robust estimates of abundance and trends, the initial population estimates were “essentially a best guess, informed by scant data” (Musgrove *et al.* 2011), therefore we consider our final population estimates as based mainly on expert opinion from very limited data.

2.3 Final output

Table 2. Breeding population for reporting.

Total breeding population	**UK**	**England**	**Northern Ireland**	**Scotland**	**Wales**
Year or period	2022	2022	2013	2022	2022
Population size (**breeding pairs**)	97,600 (95% CI: 77,003 – 123,200)	27,900 (95% CI: 21,800 – 35,600)	1123 (95% CI: 527 – 1782)	62,700 (95% CI: 46,000 – 85,300)	1100 (95% CI: 500 – 2800)
Type of estimate	Best estimate and 95% confidence interval	Best estimate and 95% confidence interval	Best estimate and 95% confidence interval	Best estimate and 95% confidence interval	Best estimate and 95% confidence interval
Method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Based mainly on expert opinion from a limited amount of data

Total breeding population	**UK**	**England**	**Northern Ireland**	**Scotland**	**Wales**
Sources	BBS	BBS	Colhoun *et al.* 2015	BBS	BBS
Reason for change since previous report (main reason in bold)	Improved knowledge / more accurate data. **Different method.**	-	-	-	-

Table 3. Wintering population for reporting.

Total wintering population	**UK**	**England**	**Northern Ireland**	**Scotland**	**Wales**
Year or period	2019/20	2019/20	2019/20	2019/20	2019/20
Population size (individuals)	604,000	243,000	36,000	199,000	50,000
Type of estimate	Best estimate	Best estimate	Best estimate	Best estimate	Best estimate
Method used	Based mainly on expert opinion from very limited data	Based mainly on expert opinion from very limited data	Based mainly on expert opinion from very limited data	Based mainly on expert opinion from very limited data	Based mainly on expert opinion from very limited data
Sources	Musgrove *et al*. 2011; WeBS	Musgrove *et al*. 2011; BirdAtlas 2007-11; WeBS	Musgrove *et al*. 2011; BirdAtlas 2007-11; WeBS	Musgrove *et al*. 2011; BirdAtlas 2007-11; WeBS	Musgrove *et al*. 2011; BirdAtlas 2007-11; WeBS
Reason for change since previous report (main reason in bold)	**Genuine change.** Improved knowledge / more accurate data. Different method.	-	-	-	-

3 Population trends

3.1 Short-term trends

3.1.1 Breeding population

UK Snipe breeding population trends (including confidence intervals) from 2011 to 2022 are readily calculated from BBS data. Likewise, trends for England and Scotland are feasible. Trends for Wales and Northern Ireland are more problematic because of small sample sizes. On average there were five 1-km squares per year with Snipe present in Wales, and 13 per year in Northern Ireland, compared to 110 per year in England and 87 per year in Scotland. Where there are between 10 and 20 squares per year, we can generally produce an estimate of short-term population trends, but with the caveat that they are based on a limited amount of data. These measures are also based on smoothed indices that best convey the underlying trends. Where there are below 10 squares per year expert opinion is needed to evaluate the robustness of those estimates or to provide assessments, at least in direction of trend.

3.1.2 Wintering population

Winter population trends from 2008/2009 to 2019/2020 are readily available from WeBS data.

Given that we are looking at trends over more than a decade rather than year-to-year fluctuations, we present trends calculated using smoothed indices, for both the breeding and wintering seasons. Smoothed indices are thin-plate splines fitted to the annual indices using degrees of freedom about one third of the total number of years.

3.1.3 Final output

Table 4. Breeding population short-term trends for reporting.

Breeding	UK	England	Northern Ireland	Scotland	Wales
Short-term trend period	2010–2021	2010–2021	2010–2021	2010–2021	2010–2021
Short-term trend direction	stable	increasing	stable	stable	uncertain
Short-term trend magnitude	-2% (95% CI: -25% – +30%)	+41% (95% CI: +15% – +82%)	+13% (95% CI: -37% – +72%)	-13% (95% CI: -39% – +22%)	-
Short-term trend method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Based mainly on extrapolation from a limited amount of data	Complete survey or a statistically robust estimate	Insufficient or no data available
Sources	BBS	BBS	BBS	BBS	BBS

Table 5. Wintering population short-term trends for reporting.

Wintering	UK	England	Northern Ireland	Scotland	Wales
Short-term trend period	2008/09–2019/20	2008/09–2019/20	2008/09–2019-20	2008/09–2019/20	2008/09–2019/20
Short-term trend direction	decreasing	decreasing	decreasing	decreasing	decreasing
Short-term trend magnitude	-35%	-34%	-46%	-57%	-26%
Short-term trend method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate
Sources	WeBS	WeBS	WeBS	WeBS	WeBS

3.2 Long-term trends

3.2.1 Breeding population

For most common UK bird species, long-term trends of breeding population are available from 1980 to 2022 from combined CBC-BBS data. However, CBC data is sparse for Snipe, with very low sample sizes, especially in the period immediately prior to the start of the BBS (i.e. 1985 to 1993 when snipe was only found on an average of seven sites every year). For this reason, and for consistency with the data source used in the previous UK Birds Directive, we decided to use smoothed joint WBS/WBBS trends, which has a sample size that is marginally higher (nine sites per year in the period 1985 to 1993 and 15 on average in the whole period 1980 to 2021). Moreover, WBS and WBBS are more intensive surveys and provide more data per site, albeit focused on riparian habitats. For Snipe, the sample size for Northern Ireland, Scotland and Wales is so small that no reliable figure can be estimated, however given the dramatic declines at UK level and in England, it is reasonable to assume that the trend direction is negative.

3.2.2 Wintering population

Winter population trends from 1979/1980 to 2019/2020 are readily available from WeBS data.

Given that we are looking at long-term trends rather than year-to-year fluctuations, we present trends calculated using smoothed indices, for both the breeding and wintering seasons. Smoothed indices are thin-plate splines fitted to the annual indices using degrees of freedom about one third of the total number of years.

3.2.3 Final output

Table 6. Breeding population long-term trends for reporting.

Breeding	UK	England	Northern Ireland	Scotland	Wales
Long-term trend period	1980–2021	1980–2021	1980–2021	1980–2021	1980–2021
Long-term trend direction	decreasing	decreasing	decreasing	decreasing	decreasing
Long-term trend magnitude	-90% (95% CI: -99% – -71%)	-88% (95% CI: -99% – -53%)	-	-	-
Long-term trend method used	Based mainly on extrapolation from a limited amount of data	Based mainly on extrapolation from a limited amount of data	Based mainly on expert opinion with very limited data	Based mainly on expert opinion with very limited data	Based mainly on expert opinion with very limited data
Sources	WBS+WBBS	WBS+WBBS	Dario Massimino, BTO	Dario Massimino, BTO	Dario Massimino, BTO
Additional information	WBS/WBBS data is of poor quality for this species	WBS/WBBS data is of poor quality for this species	Very limited data but considering the large declines in the UK and England, it is very likely that the trend direction is negative.	Very limited data but considering the large declines in the UK and England, it is very likely that the trend direction is negative.	Very limited data but considering the large declines in the UK and England, it is very likely that the trend direction is negative.

Table 7. Wintering population long-term trends for reporting.

Wintering	UK	England	Northern Ireland	Scotland	Wales
Long-term trend period	1979/80–2019/20	1979/80–2019/20	1979/80–2019/20	1979/80–2019/20	1979/80–2019/20
Long-term trend direction	increasing	increasing	unknown	increasing	increasing
Long-term trend magnitude	+75%	+68%	unknown	+161%	+109%
Long-term trend method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Insufficient or no data available	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate
Sources	WeBS	WeBS	N/A	WeBS	WeBS

4 Breeding distribution maps

The last atlas of breeding and wintering birds in Britain and Ireland used data collected in years 2007 to 2011 (Balmer *et al.* 2013). In the previous Article 12 reporting, we used maps of breeding distribution calculated from the Bird Atlas data using a bespoke method to identify mainly continuous areas of breeding range. While the breeding distribution of many species may not have substantially changed since then, other species may have expanded, contracted, or shifted their range considerably and hence maps based on data from 2007 to 2011 could be out of date. We therefore investigated alternative methods to produce up-to-date maps for the test species – Snipe – using the most recent available data.

The BBS is the main scheme to monitor population changes of common breeding birds in the U.K. Although it is not specifically designed to produce distribution maps, it has the advantage that data are collected every year and therefore it gives a very up-to-date picture of presence and relative abundance across the UK We tested the use of BBS data to produce distribution maps for the same period of the Bird Atlas (2008 to 2011) so that we could validate these BBS-based maps using the Atlas ones, which to date are the best estimate of bird species distribution in the U.K. We did this for Snipe (our pilot species) and four other species representing a combination of abundant and less abundant, northerly, and southerly distributed: Curlew *Numenius arquata*, Skylark *Alauda arvensis*, Nuthatch *Sitta europaea* and Spotted Flycatcher *Muscicapa striata*.

4.1 Methods

We used BBS data from years 2007 to 2011. For Snipe, Curlew, Skylark and Nuthatch, we used the data from the first visit to the site, commonly called “early visit” and carried out between April and mid-May, as this coincides with the likely period of higher detectability; for Spotted Flycatcher, we used the data from the second visit to the site, commonly called “late visit” and carried out between mid-May and the end of June, as this species is a trans-Saharan migrant which arrives in the UK in May.

The first step consisted of using distance sampling models for estimating detectability and allowing for bird counts to be converted into estimates of bird densities (Buckland *et al.* 2001). To achieve this, we fitted half normal distributions to the BBS count data from the first two bounded distance bands (0 m to 25 m and 25 m to 100 m), using the ‘mrds’ package (Thomas *et al.* 2010) for R (R Development Core Team 2014), and assuming all birds on the transect line (zero distance) were detected.

The second step consisted of fitting a Density Surface Model (DSM) to estimate bird density in each 1-km square of the British National Grid (Ordnance Survey, 2013). We used an approach based on Generalised Additive Models with logarithmic link function and quasi-Poisson error structure. Covariates were the percentage cover in the 1 km square of seven land cover classes (broadleaved/mixed woodland, coniferous woodland, mountain/heath/bog, improved grassland, semi-natural grassland, arable land, and built-up area) from the Land Cover Map 2000 (Haines-Young *et al.* 2000). We also included a three-dimensional (easting, northing and elevation) thin plate penalised spline to account for spatial patterns not linked to any covariates, as nearby areas were more likely to have similar densities. We tested two different degrees of smoothing by setting the dimension of the basis (*k* parameter of the *s* function of the R package mgcv, Wood 2017) to 10 or 100. The first value produces a very smooth function that accounts for very broad scale variation, while the second value allows for a wigglier surface and is more useful for species that have finer spatial patterns that are not explained by land cover only. Finally, we included a categorical variable for islands to account for large differences in density between an island and the mainland (Massimino *et al.* 2015). We fitted the DSMs using the ‘dsm’ package

(Miller *et al.* 2021), which automatically adjusts counts using the distance sampling model run in the previous step. The procedure was repeated for each year from 2008 to 2011. We then used the DSM to calculate the expected density of each species across every 1-km square of the U.K, in each year. Finally, we calculated the median expected density across the four years in each 1 km square, for each species.

To produce a presence/absence map, we had to find the most appropriate threshold to classify 1 km squares into either "present" or "absent", according to the median expected density in the four years considered. We used 56 different thresholds between 10^{-5} and 10 and downscaled the results to 10 km resolution (same resolution of the Atlas maps), using the rule that if at least one 1 km square in a 10 km square was classified as "present", then the whole 10 km square was classified as "present".

We validated the BBS-based distribution maps using the Bird Atlas, considering that this is the best estimate of species distribution in the U.K. to date. We calculated the number of 10-km squares where:

1) the BBS-based range maps correctly predict presence;
2) the BBS-based range maps correctly predict absence;
3) the BBS-based range maps predict presence while the Atlas show absence (false presences);
4) the BBS-based range maps predict absence when the Atlas shows presence (false absences). We chose the threshold which minimises the largest of false presences or false positives.

4.2 Results

The comparison of our BBS-based presence map to the Bird Atlas map showed very different performance across species (Table 8). At one extreme was Skylark, for which the BBS-based model performed very well with only 2% discrepancies with the Atlas, and at the other extreme were Snipe (our pilot species) and Curlew, for which discrepancies were 26% of all 10 km squares (Figure 1).

Table 8. Performance of BBS-based spatial models, for each of the five species considered, measured as number of false presences and false absences, compared to the Bird Atlas. The dimension of the basis k for the smoothing and the threshold used to determine presence and absence at 10 km squares level are also shown.

Species	Dimension of the basis (*k*)	Threshold	False positives (% over all 10 km squares)	False negatives (% over all 10 km squares)
Curlew	100	0.03	13%	13%
Snipe	**10**	**0.5**	**13%**	**13%**
Skylark	100	2	1%	1%
Spotted Flycatcher	10	0.7	8%	7%
Nuthatch	100	0.2	5%	6%

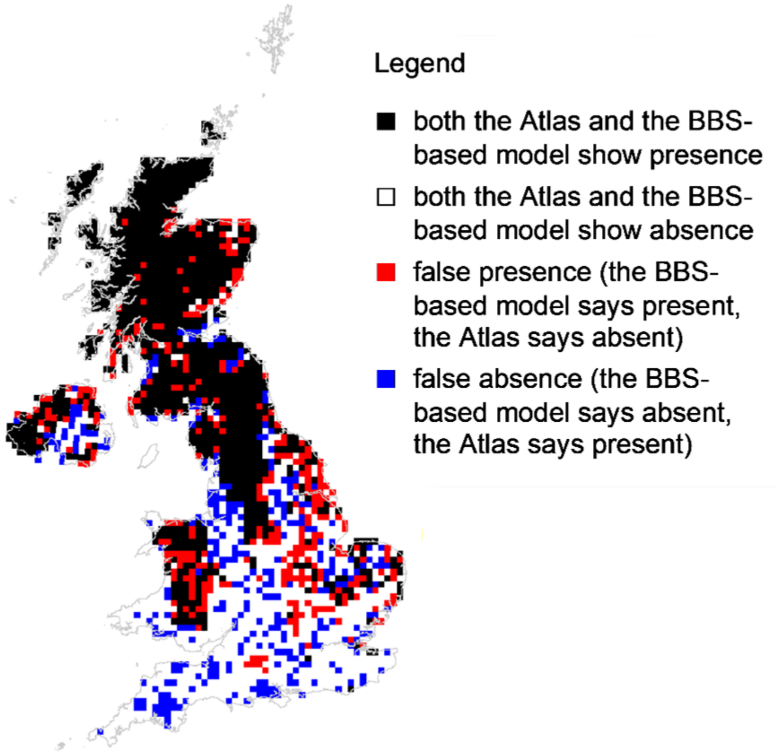

Figure 1. Comparison between BBS-based presence and the Bird Atlas for **Snipe**, with a resolution of 10 km. **Black**: both the Atlas and the BBS-based model show presence. **White**: both the Atlas and the BBS-based model show absence. **Red**: false presences (the BBS-based model says present, the Atlas says absent). **Blue**: false absences (the BBS-based model says absent, the Atlas says present).

4.3 Discussion

The purpose of this exercise was to test whether presence maps based on modelling of BBS data give us an accurate picture of current species range. We tested the accuracy of these time-aligned maps against the most recent Bird Atlas, representing the most comprehensive stock-take of bird distributions in the UK.

BBS-based model performance varied substantially across species. Performance was worst for Snipe, our pilot species, and Curlew. False presences for Snipe were particularly evident in Welsh uplands and in some areas of the East Midlands, while false absences were more evident in Southern England. This may be due to Snipe habitat selection which is not very well described by the explanatory variables in the DSM. Given the high inter-species variability of BBS-based model performances, the decision whether to use these for the purposes of Habitats Regulations reporting may depend on the species. If BBS-based maps work well for a particular species, they allow us to have an accurate and very up-to-date picture of its current range. However, if BBS-based maps are not accurate enough, there appears to be no advantage in using the most recent data and the Atlas maps should be considered instead. The choice may also depend on whether the range of a species is likely to have changed substantially since the last Atlas surveys were conducted (see Section 5.1 of this report). In which case, the BBS-based models may be more useful, even at the cost of some accuracy. A decision tree could be a used to determine, for a species, whether BBS-based maps or Atlas maps provide the best indicator of range.

A potential way to improve the accuracy of BBS-based maps could consist of integrating BBS data with BirdTrack data. BirdTrack is an opportunistic recording scheme which allows participants to record lists of species they have detected during a self-selected time interval spent at a self-selected location (Boersch-Supan 2019; BTO 2023b). BirdTrack has the advantage of a finer spatial coverage compared to BBS, but the data analysis poses greater challenges because of the unstructured nature of the survey. To date, there is no established protocol to obtain estimates of distribution from such data and previous research on population trends has shown that this type of analysis works well in areas with good BirdTrack coverage but not where the dataset is poor or for uncommon species (Boersch-Supan 2019). For these reasons, we consider that the use of BirdTrack data could potentially form a stand-alone project but cannot yet be part of routine analyses.

4.4 Conclusion

BBS-based presence models for Snipe showed a relatively large number of misclassified 10-km squares. Considering this and the fact that Snipe is unlikely to have changed its range substantially (see Section 5.1 of this report), we suggest that the Bird Atlas map still represents the best picture of Snipe range. This may be different for other species, especially if BBS-based presence models work better for them and/or they have shown larger range changes.

4.5 Final output

Table 9. Estimates of the breeding distribution for reporting.

Parameter	UK	England	Northern Ireland	Scotland	Wales
Sensitive species	No	No	No	No	No
Year of period	2007–2011	2007–2011	2007–2011	2007–2011	2007–2011
Breeding distribution map	Included as shapefile	Included as shapefile	Included as shapefile	Included as shapefile	Included as shapefile
Breeding distribution surface area (km^2)	163,600	54,500	9,800	89,000	10,300
Breeding distribution method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate
Additional maps: Sources	Bird Atlas 2007–11	Bird Atlas 2007–11	Bird Atlas 2007–11	Bird Atlas 2007–11	Bird Atlas 2007–11

5 Breeding distribution trends

5.1 Short-term trends in breeding distribution

Under this parameter, we are required to provide a measure of short-term trend (2013 to 2024 or as close as possible to this) in breeding distribution. Previously the distribution change between the two most recent UK Bird Atlases were used for this, but as the most recent Bird Atlas uses data from 2007 to 2011 and more than a decade old, this is no longer appropriate for assessing recent change (i.e. within the last 12 years). Here we devised a method using BBS data to estimate short-term range change.

5.1.1 Using BBS data to calculate range change

We used snipe BBS data from a 12-year time period, using data from 3 years for start and end of period (i.e. 2009 to 2011, 2018 to 2021 (but excluding 2020)). We then determined whether snipe was present or absent in each 1 km square in each block of years (i.e. combining results within the three-year ranges). 10 km squares that were not monitored in both of the time-periods were removed. Where there was uneven sampling effort within a 10 km square between periods, we randomly sampled (without replacement) 1 km squares within the 10 km to obtain equal sample sizes. 10 km squares were assigned a presence if snipe was present in greater than 50% of 500 runs of random sampling.

The presence (score of 1) or absence (0) of snipe on each 10 km square in each time period were multiplied by a weighting factor to account for the variation in monitoring effort between different parts of the UK. In the BBS, 1 km squares are randomly allocated, but more squares are allocated in BBS regions (very roughly matching UK counties) where there are more volunteers. As a result, sampling effort is higher in more populated areas of the UK. To account for this, we gave each 10 km square a weight calculated by dividing the total area of the BBS region (i.e. the number of 10 km squares) by the number of 10 km squares monitored in the region in this analysis. Finally, the weighted presence/absence scores were multiplied by the proportion of the 10 km square that was on land (Table 10 and Figure 2).

The distribution area in each time period was calculated as the sum of these weighted presence/absence scores. Short-term change in distribution was calculated as:

(distribution area 2018 to 2021 – distribution area 2009 to 2011)/
distribution area 2009-2011.

Confidence intervals around the distribution change could be produced using bootstraps but were not possible within the timeframes of this project.

Table 10. Number (No.) of monitored 10 km squares (total and with Snipe), estimated distribution area in both periods and estimated distribution change.

Country	Percent of 10 km squares monitored in both periods	No. monitored 10 km squares (monitored in both periods)	No. monitored 10 km squares with Snipe in 2009–2011	No. monitored 10 km squares with Snipe in 2018–2021	Distribution area (km^2, with regions weighted by size) 2009–2011	Distribution area (km^2, with regions weighted by size) 2018–2021	Distribution % change
UK	50.6	1,509	224	237	54,204	53,765	+0.8%
England	70.9	1,029	115	121	16,758	16,751	0
Northern Ireland	44.4	75	18	23	3,676	5,159	+40.3%
Scotland	25.1	272	84	85	32,455	30,654	-5.5%
Wales	50.8	132	7	8	1,314	1,202	-8.6%

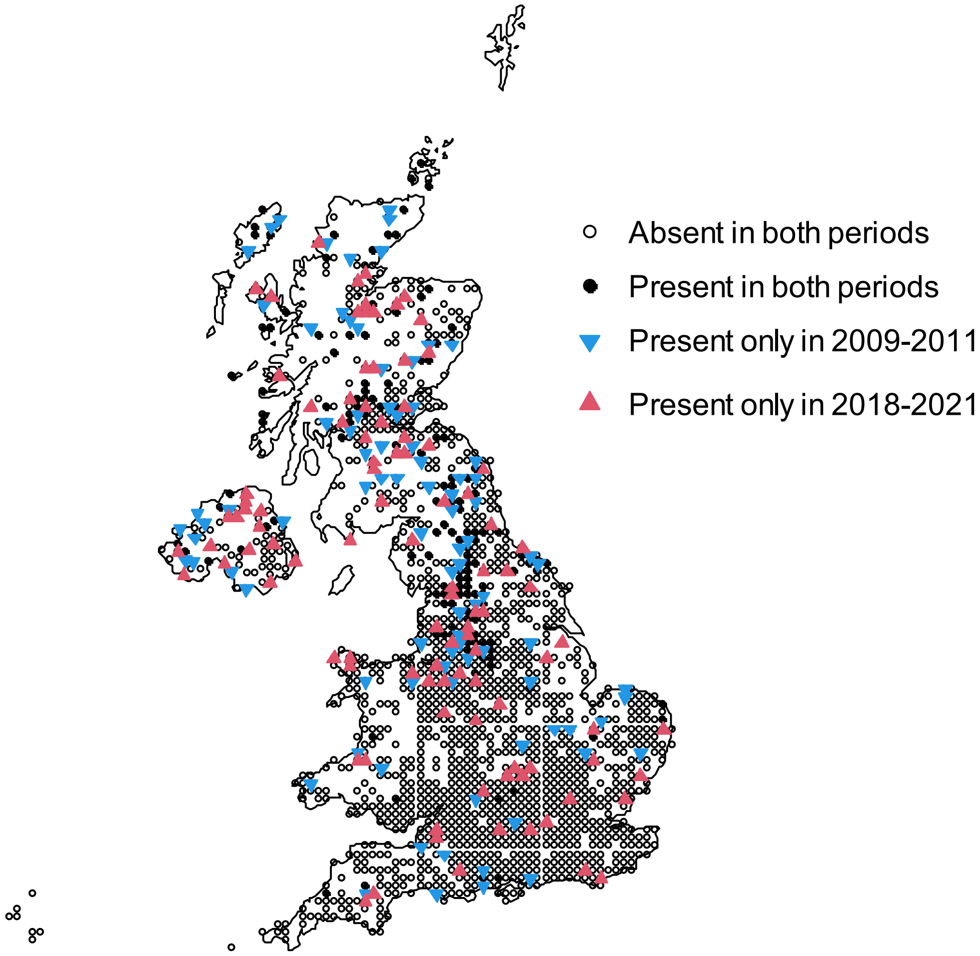

Figure 2. BBS monitoring of Snipe from 2009 to 2011 and 2018 to 2021 in 10 km squares. Open circles = 10 km squares which were monitored in both periods, but no Snipe were observed in either. Black circles = 10 km squares with snipe observed in both periods. Blue downwards triangles = 10 km squares with snipe observed in early period but not late (range loss). Red upwards triangles = 10 km squares with snipe observed in late period but not early (range gain).

5.1.2 Discussion

Here we invented a method that will allow us to make an estimate of short-term range change using BBS data. BBS data is designed to indicate population trends over time but is less effective identifying distribution. The exercise in Section 4 of this report, to produce distribution maps from the BBS data, demonstrated that extrapolating distribution spatially from BBS data is problematic for this species. Extrapolating distribution change is less problematic, as observed changes in distribution are simply weighted by the area they represent, rather than used to model where the gains and losses may have occurred. We note that the estimate for Northern Ireland is substantially different from the other countries and is the only large increase in range. This may be a genuine change or may be caused by low precision in the estimates. Examining the uncertainty in these estimates of distribution change was not possible given the timescales in this pilot study but could be included if this method were used across all species. The alternative to using this method would be to estimate distribution change using the most recent two Bird Atlas results (1988–1991 and 2007–2011). The decision on whether to use more up-to-date BBS data, or more extensive Atlas data for reporting distribution change, will largely depend on the how flexible the reporting framework is, and the relative importance of appropriate time period versus best data.

5.1.3 Final output

Table 11. Short-term trends in breeding distribution for reporting.

Short-term trend	UK	England	Northern Ireland	Scotland	Wales
Short-term period	2009/2011 – 2018/2021	2009/2011 – 2018/2021	2009/2011 – 2018/2021	2009/2011 – 2018/2021	2009/2011 – 2018/2021
Short-term direction	Stable	Stable	Increasing	Stable	Stable
Short-term trend magnitude	+1%	0	+40%	-6%	-9%
Short-term trend method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate
Sources	BBS	BBS	BBS	BBS	BBS

5.2 Long-term trends in breeding distribution

Under this parameter, we are required to provide a measure of long-term trend (1980 to 2024 or as close as possible to this) in breeding distribution. Although not perfectly matched to the ideal time period requirement, the distribution change over the 40 years between the most recent (2008/11 data, Balmer *et al*. 2013) and the first (1968/72, Sharrock 1976) UK Bird Atlas is likely to represent the best approximation.

5.2.1 Final output

Table 12. Long-term trends in breeding distribution for reporting.

Long-term trend	UK	England	Northern Ireland	Scotland	Wales
Long-term trend period	1968/72 – 2008/11	1968/72 – 2008/11	1968/72 – 2008/11	1968/72 – 2008/11	1968/72 – 2008/11
Long-term trend direction	decreasing	decreasing	decreasing	stable	decreasing
Long-term trend magnitude	-31%	-50%	-36%	-6%	-45%
Long-term trend method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate
Sources	Bird Atlas 1968/72; Bird Atlas 2007/11	Bird Atlas 1968/72; Bird Atlas 2007/11	Bird Atlas 1968/72; Bird Atlas 2007/11	Bird Atlas 1968/72; Bird Atlas 2007/11	Bird Atlas 1968/72; Bird Atlas 2007/11

6 UK National Site Network (SPAs) coverage

6.1 Population size inside the Natura 2000 (SPA) network

The methods described in Section 2 (population size estimates) can also be applied to estimating the population size within the SPA network.

For the breeding season, we used the exact same method based on the distance sampling analysis of BBS data which we used for country-level estimates, but this time we applied it to the subset of BBS squares that fall in SPAs (based on the SPAs shapefile downloaded from the JNCC Resource Hub 2023). As BBS data are collected at 1-km square level and some squares may partially overlap SPAs, we used a threshold of 50% to identify squares belonging to SPAs (i.e. if more than 50% of the BBS square overlaps an SPA, then the square is considered part of the SPA, otherwise it is discarded). Northern Ireland and Wales had a very small number of BBS squares in SPAs. In Northern Ireland, there were only four squares with Snipe in SPAs, and in Wales there were none. Therefore, we were not able to produce population estimates for these two countries.

For the winter season, we used the population estimates in the UK and England obtained as described in Section 2 and reported in Section 2.2, and used the winter counts in the UK, England, and in the SPAs of the UK and England from the Wetland Bird Survey (WeBS, Frost *et al.* 2021) to assess population sizes in SPAs. WeBS data were insufficient to estimate the population size in SPAs of Scotland, Wales, or Northern Ireland. Similarly, as for Section 2, the initial population estimates for the UK were “essentially a best guess, informed by scant data” (Musgrove *et al.* 2011), therefore we consider our final population estimates as based mainly on expert opinion from very limited data.

6.1.1 Final output

Table 13. Breeding population in the SPA network.

Breeding population in SPAs	UK	England	Northern Ireland	Scotland	Wales
Population size inside the Natura 2000 (SPA) network (**breeding pairs**)	21,500 (95% CI: 14,100 – 32,700)	4,400 (95% CI: 2,600 – 7,500)	-	12,400 (95% CI: 6,800 – 22,700)	-
Type of estimate	Best estimate and 95% confidence interval	Best estimate and 95% confidence interval		Best estimate and 95% confidence interval	-
Method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Insufficient or no data available	Based mainly on extrapolation from a limited amount of data	Insufficient or no data available

Table 14. Wintering population in the SPA network

Wintering population in SPAs	UK	England	Northern Ireland	Scotland	Wales
Population size inside the Natura 2000 (SPA) network (**individuals**)	353,000	129,000	-	-	-
Type of estimate	Best estimate	Best estimate	N/A	N/A	N/A
Method used	Based mainly on expert opinion from very limited data	Based mainly on expert opinion from very limited data	Insufficient or no data available	Insufficient or no data available	Insufficient or no data available

6.2 Short-term trend of population size within the SPA network

The method described in Section 3.1 (Short-term trends) can also be applied to estimating the population trends within the SPA network.

For the breeding season, we used the same shapefile of the SPAs and the same criteria for matching BBS squares with SPA (still with a threshold of 50% to identify squares belonging to SPAs) as described in Section 3.1. Trends for countries other than England were problematic because of small sample sizes. On average there were ten 1 km squares per year with Snipe present in Scotland, and only 1 per year in Northern Ireland, compared to 23 per year in England. No Snipe was detected in BBS squares in SPA in Wales. Where there are between 10 and 20 squares per year we can generally produce an estimate of short-term population trends, but with the caveat that they are based mainly on extrapolation from a limited amount of data. Where there are below 10 squares per year expert opinion will need to be sought.

For the wintering season, we calculated trends from WeBS data collected in sites within SPAs. WeBS data were insufficient to estimate the population size in SPAs of Scotland, Wales or Northern Ireland.

6.2.1 Final output

Table 15. Breeding population short-term trends within the SPA network for reporting.

Short-term trend of breeding population within the network	UK	England	Northern Ireland	Scotland	Wales
Direction	Increasing	Increasing	Unknown	Uncertain	Unknown
Method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Insufficient or no data available	Based mainly on extrapolation from a limited amount of data	Insufficient or no data available

Table 16. Wintering population short-term trends within the SPA network for reporting.

Short-term trend of wintering population within the network	UK	England	Northern Ireland	Scotland	Wales
Direction	Decreasing	Decreasing	Unknown	Unknown	Unknown
Method used	Complete survey or a statistically robust estimate	Complete survey or a statistically robust estimate	Insufficient or no data available	Insufficient or no data available	Insufficient or no data available

7 Overall conclusions and recommendations

This pilot study allowed us to investigate methods to produce the information needed for the Habitat Regulations reporting, using Snipe as an example species. Snipe was chosen because it presents challenges that we expect they will emerge with other relatively uncommon habitat specialists, therefore the methods used here can likely be applied to most other species for which data are sufficient. However, for some parameters, the choice of the best method will depend on the species. Here we summarise the considerations that need to be taken into account for some specific parameters.

- **Breeding population size.** Data from targeted complete surveys should be used where available for the area of interest. If these are not available, BBS data should be used if the sample size is sufficient and if the conversion from individual to pairs is feasible. The great advantage of using BBS data is that the data are very recent, and estimates can be produced at country level or for bespoke areas (such as the SPA network). If BBS data cannot be used, we suggest that the estimates from Woodward *et al*. (2020) should be used. Woodward *et al.* (2020) have thoroughly examined the available literature to obtain historic estimates of population estimates which they have extrapolated to the present using recognised trend measures. Woodward et al (2020) therefore represent an easily accessible source of population estimates, but these are only available for the UK and Great Britain. Data from the Rare Breeding Bird Panel (Eaton *et al.* 2022) may also be used and are easily accessible for the UK and constituent countries; however, these are only available for species that have fewer than 2000 breeding pairs in the UK.
- **Population trends**. For the long-term breeding population trends, joint CBC+BBS or WBS+WBBS data (the latter for species that mainly breed along waterways) should be used where sample size is sufficient. This will usually be possible for the UK or England. For the short-term trends, BBS will usually be the primary source of information. Where sample size is not sufficient, data from the Rare Breeding Bird Panel may be used if available, otherwise expert opinion may be sought to estimate the direction of the trend. Options for the wintering population trends are limited to WeBS, which allows us to estimate population indices for approximately 90 species, in most cases since 1966 and, depending on sample size, at country level.
- **Breeding distribution maps**. The distribution from BBS-based spatial models or the Bird Atlas 2007-11 may be used. The choice will depend on the accuracy of the BBS-based models, how much the species distribution has changed, and resources available to undertake the BBS calculations, which may need species-specific adjustments.
- **Short-term trends in breeding distribution**. Either the two most recent atlases or methods based on BBS data can be used, with different trade-offs between appropriate time period, most accurate data, and costs. Using the two most recent atlases would maximise accuracy, as data collection for bird atlases is targeted to describe distribution and distribution changes; using the two most recent atlases would also reduce costs because atlas data are readily available, and no bespoke analysis would be needed. However, the short-term time frame using the atlases would be approximately 1990 to 2010, which is now very different from (and does not even overlap with) the requested 2013 to 2024. In contrast, using BBS data would allow us to obtain a reasonably reliable estimate at little extra cost using very recent information. Methods to calculate short-term distributional changes using BBS data would also be useful in the future to get a picture that is constantly up to date, considering that there will always be significant time gaps between atlases.

7.1 Further developments

We identify the following areas where further work may help assess the quality of some of the estimates.

- **Calibrate BBS-based population estimates**. Population estimates from BBS data rely on the assumptions of the distance sampling approach (Buckland *et al.* 2001). Ideally, the estimates should be validated and calibrated using independent data, which has been done in the past but only for specific species and areas. Collecting independent data would undoubtedly require significant resources but would be extremely useful to assess and improve the accuracy of population estimates.
- **Estimate the uncertainty around the short-term trends in breeding distribution**. If BBS data are used to estimate short-term trends in breeding distribution, calculating confidence intervals would provide a measure of the uncertainty around the estimates, which would be particularly useful when the sample size is low, as in the case of Northern Ireland for Snipe. This could be done by bootstrapping, which may be consuming in terms of computing time and power but would be straightforward to set up.
- **Integrating BirdTrack data to estimate distribution and distribution changes**. Integrating BBS data with BirdTrack data could potentially help improve the accuracy of all estimates of distribution and distribution changes. Previous research on population trends (Boersch-Supan 2019) has shown encouraging results for species and areas with good coverage and opportunistic data have been used in bird atlases, such as the European Breeding Bird Atlas (Keller *et al.* 2020). However, there is no established protocol to obtain species distribution from opportunistic data at the resolution required for the present work, therefore the use of BirdTrack data would need a separate project which would require significant resources. Potentially, the use of BirdTrack data could also be tested for estimating changes in winter distribution, which is currently a significant challenge for many species because we don't have a general survey scheme for wintering birds.

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