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Efficacy of methods for producing population trends of breeding waders from Breeding Bird Survey data

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1. Introduction

Launched in 1994, the BTO/JNCC/RSPB Breeding Bird Survey (BBS) is the main scheme that tracks the population changes of the common and widespread birds in the UK. Led by volunteers, it is one of the largest structured bird surveys in the world. The BBS consists of visiting randomly located 1-km squares, and recording all birds seen or heard along two 1-km transects. Each square receives an early (April to mid May) and late (mid May to the end of June) visit, to cover periods of high detectability for as many species as possible. Population trends estimated using BBS data are only reported for species with sufficient data, and therefore provide a reliable measure of change in biodiversity – as represented by populations of wild birds (Massimino et al. 2024). Thirty years of data enables the long-term trends to be generated for 119 bird species (Heywood et al. 2023). The BBS is one of the main initiatives for documenting UK bird population changes and provides an essential indicator of the state of nature. The information is widely used to investigate possible drivers of change and inform UK conservation priorities. Therefore, it is vital to periodically review the analytical procedures, to ensure maximum robustness and representativeness of the results.

The aim of the BBS is to document changes in breeding bird numbers. However, surveyors do not have to specify if observed birds are actively breeding in the square, meaning the counts logged for a square may comprise a mixture of the local breeders of interest, plus late-departing winter visitors, passage migrants and floating non-breeders. For some species these non-breeding individuals may considerably outnumber breeding numbers and mask the trends in the population of interest. The BBS has developed methods for dealing with this problem. For example, many thousands of non-breeding large gulls are counted on BBS squares, but their numbers may not reflect trends in actual breeding numbers. For this reason, trends for Herring Gull *Larus argentatus*, Lesser Black-backed Gull *L. fuscus* and Great Black-backed Gull *L. marinus* are not routinely reported from the BBS (Heywood et al. 2023).

Waders are another problematic group because, for some species, UK populations can begin breeding whilst more northerly populations are still on their wintering grounds or on passage. As waders usually form large flocks, they can generate BBS counts that are orders of magnitude larger than the actual breeding numbers we are trying to monitor. Current filtering methods apply to six wader species (Golden Plover *Pluvialis apricaria*, Curlew *Numenius arquata*, Lapwing *Vanellus vanellus*, Oystercatcher *Haematopus ostralegus*, Redshank *Tringa totanus*, and Snipe *Gallinago gallinago*), whereby a count threshold rule is applied which eliminates counts greater than 10 individuals within the same transect section and distance band. Secondly, for Golden Plover only, we remove counts of non-breeding birds in unsuitable breeding habitat by applying a geographical exclusion rule, which removes any 1-km BBS grid squares inside 18 predominantly lowland 100-km squares covering most of England and parts of eastern Wales (Fig. 1).

These rules were created over 20 years ago when computational processing power was costly. They are necessarily rather coarse and, with greater processing power and additional data sources available to us, now is a good time to investigate their effectiveness and potential alternatives. For instance, the Golden Plover rule causes the exclusion of many BBS squares that fall within the Golden Plover breeding range as defined by *Bird Atlas 2007–11* (Balmer et al. 2013). Specifically, the current rules cause the exclusion of the Peak District and southern Pennines and consequently the UK trends miss a key part of the species' range. By omitting these valid occupied squares we are artificially depressing the English sample size for Golden Plover and falsely limiting the trends we publish. Similar issues could arise for other waders, but we currently do not perform spatial filtering on any other species. This is because the habitat profiles and ranges of other waders are not so discretely defined, so it is not so straightforward to exclude large sections of the UK (Fig. 2). Or more specifically, the breeding and non-breeding habitats are distinct for Golden Plover, whereas Redshank for example, breed and winter on saltmarsh, and likewise, Lapwings breed and winter on farmland. In the case of the count threshold – which eliminates counts of greater than 10 individuals for the six waders – it is possible that this is over-cautious and may be removing genuine breeders, since Lapwing, for example, are semi-colonial nesters (Berg et al. 1992) and are frequently reported in numbers greater than 10 in the BBS data (Fig. 2).

In the UK and Europe, grassland-breeding waders are among some of the most threatened species. This is largely due to deterioration or loss of breeding habitats as a result of intensive agricultural practices and large-scale land drainage (Franks et al. 2018). Wader populations at both a national and European scale continue to decline (Table 1), and of the six wader species considered here, two are already Red-listed

(Curlew and Lapwing) and three are Amber-listed (Oystercatcher, Redshank and Snipe) in the UK (Stanbury et al. 2021). Golden Plover is of particular notice, because of its inclusion in the EU Birds Directive Annex I list of threatened species (European Commission 2015), meaning the UK is obliged to promote its survival as a breeding and wintering species. Therefore having high-quality trend data is essential for monitoring population changes and informing conservation actions. Here, we investigate: 1) the effects of increasing the count threshold on the population trends of six waders in the UK; 2a) the effects of different geographic exclusion rules on the population trend of Golden Plover, and 2b) the average reporting rate for Golden Plover under each exclusion rule in (2a) – as this species does not currently meet the sample size requirement for publication. Overall, we aim to test for any potential biases in the current trends, and in doing so, whether we can create a better approach which provides the most robust data for wader conservation moving forwards.

2. Methods

Trend model

Population trends are estimated using a statistical model that allows us to account for geographical variation in coverage (remote areas are less covered than highly populated ones) and incomplete coverage (not all squares are surveyed every year). Long-term trends are identified using a smooth function, and estimates of population changes over several years (typically five years, 10 years, and the whole survey period) are computed from the smoothed trend. Uncertainty around the indices is estimated by bootstrapping and used to produce confidence intervals around the indices, and their changes. For the UK, species are required to have an average reporting threshold of at least 40 1-km squares per year to be included in the BBS Report, whereas for the individual countries and regions within the UK, a sample size of at least 30 1-km squares is required. The methodology is described in detail in Massimino et al. 2024.

Count-based filtering of BBS wader data

The current trend models for Golden Plover, Curlew, Lapwing, Oystercatcher, Redshank, and Snipe use a count threshold of 10 – meaning that for each of the 10 200-m transect sections and each of the four distance bands, any records > 10 individuals are changed to zero, on the assumption these represent flocks of non-breeding birds. This large count elimination is performed before the sample size calculations and thus effects the later sample size thresholding. We questioned whether this thresholding was too stringent, causing records of genuine breeding individuals to be discarded. We therefore tested a new count threshold on the UK BBS data, arbitrarily chosen as 20, whereby any records > 20 in each 200-m transect section and distance band were changed to zero. The paired analyses were otherwise identical and used the current geographical exclusion rule for Golden Plover.

Spatial filtering of Golden Plover BBS data

In the UK, Golden Plovers breed on upland heathland and bogs, and in northern areas, on lowland bogs and grasslands. Populations that breed further north than the UK do not depart from the UK until late spring and may be encountered on lowland farmland and coastal sites, and sometimes in upland margins. The existing approach for removing these non-breeding flocks has been to remove all counts falling in 18 predominantly lowland 100-km grid squares in England and Wales (Fig. 1, blue box) but this is judged to be overly conservative and removes part of the true breeding range in northern England. We tested five new spatial exclusion rules applied to the 1-km BBS grid squares in England and Wales only, and compared each to the current trends:

1. We excluded all BBS squares within the current 100-km excluded grid squares except 'SK' which includes most of the Peak District (Fig. 1).
2. We excluded all BBS squares within the current 100-km excluded grid squares except 'SK', 'SD' and 'SE' which broadly includes the Peak District and the Pennines (Fig. 1).
3. We used a more refined method of excluding all BBS squares outside the English upland national parks (NPs) in the north of England (Peak District, North York Moors and Yorkshire Dales) as some of the park boundaries were outside of the three included squares in rule 2 (Fig. 1).
4. We excluded all BBS squares outside the Golden Plover breeding range defined in the second (1988–1991) and third (2007–2011) atlases combined (having removed all non-breeding and winter records; Fig. 3, dark blue cells).

5. To account for possible small-scale variation of the range margins, and for feeding movements, we excluded all BBS squares outside the Golden Plover breeding range defined in the atlas data in rule 4, with a 10-km buffer around each 10-km atlas grid square (Fig. 3, light blue polygons).

As we have no way of knowing which counts related to breeding versus passage birds we can only assess the effectiveness of these rules using the following proxy measures: i) the number of BBS squares retained for analysis (which determines the sample size for trend analysis); ii) the number of BBS squares removed that fell inside the known breeding range (as an indication of potential true breeding birds omitted); and iii) the number of squares with more than 50 Golden Plovers (as an indicator that birds were potentially in a passage flock). For each dataset resulting from the five spatial exclusion rules, we also produced population trends for the UK and England and compared these against the current published trends to see how changes to the inclusion rules affected the emergent trends.

Spatial filtering of other species

Currently, we do not perform spatial filtering on any species other than Golden Plover. However, certain summer visitors to the UK are also passage migrants – i.e. only stop in the UK to re-fuel before heading further north to their breeding grounds in Iceland, Fennoscandia or Greenland. It may therefore be appropriate to apply spatial filtering to additional species, using their atlas breeding ranges, to exclude any potential transient birds. Two such species we investigated were Wheatear *Oenanthe oenanthe* (Fig. 4) and Whinchat *Saxicola rubetra* (Fig. 5). For each species we produced population trends for the UK using their respective atlas breeding ranges and compared these against their current published trends with no spatial filtering.

3. Results

Effects of wader count threshold on trends

Figure 6 plots the trends for all six wader species (Golden Plover, Curlew, Lapwing, Oystercatcher, Redshank, and Snipe) comparing the effect of using a count threshold of 10 and a count threshold of 20, with their respective confidence intervals. For Curlew, Lapwing, Oystercatcher, Redshank, and Snipe, the trends with a count threshold of 20 are very similar in shape to the current trends, and so are not influenced by the more stringent threshold (Table 2). Golden Plover loses the most count data as a result of the thresholding (whether 10 or 20; Table 2). Additionally, with no spatial filtering of the Golden Plover data, but applying a count threshold of < 10, there are 193 squares (with count > 0) located outside the atlas range (21.6%; Fig. 3), compared to 213 outside (23.8%) when using a count threshold of < 20.

For Golden Plover we also compared the above population trends for the current location exclusions with those produced from using the atlas range exclusions, and the atlas range + 10 km buffer, with the increased count threshold of 20 (Fig. 7). Under all three rules, a count threshold of 20 caused more fluctuation in the trends, but the overall relationship still showed a gradual decline, as seen in the current trends with a count threshold of 10.

Spatial filtering of Golden Plover BBS data

The initial BBS dataset contains Golden Plover data for 894 1-km squares. The existing crude spatial filtering using the 18 100-km squares reduces this sample size by 41% but also leads to the exclusion of 62 BBS squares from within the breeding range (Table 3). Alternative spatial exclusion methods retain more BBS squares and do not lead to the removal of so many squares from breeding areas. The exclusion rule which retained the greatest number of BBS squares – with only a 13% loss – was rule 2 (including the three upland grid squares), while also having by far the fewest BBS squares which fell outside the breeding range. However, this may be at the expense of including large flocks, since 96 squares contained more than 50 birds – or 1.4–2.5 times more than all the other rules. Count-based filtering can deal with these squares (Table 3) but this suggests that 100-km filtering is not effective in isolation. Exclusion rule 4 based on the atlas range without a buffer leads to inclusion of the fewest large flocks, with a 30% reduction in sample size, and thus omits less data than the existing rule.

Effects of new location exclusion rules on trends

The UK population trends for all five Golden Plover location exclusion methods followed a broadly similar pattern to the current reported trend (Fig. 8). However, exclusion rule 3 which used the English upland national park boundaries resulted in the most negative trend between 2007 and 2018 (Fig. 8). During the same interval, the other rules had slightly higher indexes than the current trend, but by 2023 were closer to the current trend. The trend using the atlas distribution (exclusion rule 4) had a slightly higher index after 2000, while the trend with the additional 10-km buffer (exclusion rule 5) declined faster than the current trend between 1995 and 2000 and ended in 2023 with the lowest index of all. The trend line produced for no location exclusions only differed from the current trend between 2014 and 2018 where the index was higher.

Golden Plover trends in England

The Golden Plover exclusion rules have the biggest impact in England, and currently, we do not publish the results for Golden Plover in England since the sample size across all years does not meet the threshold of 30 for inclusion in the BBS Report. Comparing the average sample sizes for England only (Table 4), shows that under all five of the new Golden Plover location exclusion rules, the sample sizes would pass the threshold for publication. Also, the English population trends for all five location exclusion rules followed a broadly similar pattern to the trend under the current rule (Fig. 9), but with lower indexes. The three exclusion rules with the lowest sample sizes in England (current, rule 1 (+'SK') and rule 3 (+3 NPs); Table 4) were all substantially higher. Moreover, the Golden Plover England trend using the current rule is not significant for the 10-year trend (-25%, CIs; -51%, +1%; Table 4), whereas using the atlas range the trend in England has smaller confidence intervals with a significant 10-year trend (-23%, CIs; -39%, -2%; Table 4), and likewise for the atlas range plus 10-km buffer (-24%, CIs; -41, -6; Table 4).

Effect of atlas range location exclusion on other species

We also investigated the difference in trends for two other migrant species – Wheatear and Whinchat. In Figure 10 we compare the current trends (with no location exclusions) with the trend using the respective species' atlas distributions, and in both species, they are very similar. Presumably, even though there may be large numbers of passage birds, removing extralimital records in these two species has little effect because only small numbers of birds are being removed and not large flocks. However, the differences in sample size (with the current count threshold of > 10; Table 5) shows that for Whinchat in England, using the atlas distribution results in this species being just below the threshold for publication, compared to the current trend model which is just above the threshold – though the former is perhaps the more representative result.

4. Discussion

In this study we consider the effectiveness of methods for ensuring BBS trends for waders reflect true breeding numbers. We show that the current methods to remove transient and other non-breeding individuals – using spatial-filtering and count-based filtering – have varying impacts on emergent trends across species. The impacts were greatest for Golden Plover, which we detail below, along with our future recommendations.

Count exclusions summary

The current count threshold rule for six wader species (Golden Plover, Curlew, Lapwing, Oystercatcher, Redshank, Snipe) consists of removing counts that are higher than 10 within the same transect section and distance band. Although this rule was created more than 20 years ago, our assessment suggests it remains effective at preventing very high non-breeding counts from being used in the trend model. For example, after applying the threshold to the Golden Plover data, there are no squares with total counts of > 50 birds for all the geographical exclusion rules tested (Table 3). The reduction in total counts due to the application of the rule varies from approximately 50% for Golden Plover to < 1% for Snipe (Table 2). We tested the use of a count threshold of 20 instead of 10 and found that the number of excluded birds was quite low, ranging from 8% of all counts for Lapwing to 0% for Snipe. However, the effect of using a threshold of 20 on the trends was evident for Golden Plover, where the annual index was more irregular with pronounced peaks in some years, making the smoothed trend more fluctuating when compared to the trend estimated using a threshold of 10. Golden Plovers are not irruptive breeders – possibly on account of the demands of egg-laying (Crick 1992) – therefore we would expect their numbers to vary more gradually and so the irregularity is indicative

of measurement error rather than true population fluctuations. No major effects were noted for the other species. In addition, for Golden Plover, the count threshold alone is not sufficient to prevent non-breeding birds from appearing in the trends, since there are 193 BBS squares outside the atlas range with counts less than 10.

Geographic exclusions summary

The current geographical exclusion rule for Golden Plover consists of excluding 18 predominantly lowland 100-km grid squares, encompassing most of England and parts of eastern Wales. This rule is rather coarse and causes the exclusion of 62 occupied 1-km BBS squares that fall within the Golden Plover's breeding range. Among the excluded squares are some core breeding areas for Golden Plover, such as the Peak District and the southern Pennines (Balmer et al. 2013). Including three more 100-km squares would mitigate this issue, but at the cost of including several 1-km squares with very high counts of presumed non-breeding birds. This might be remedied by the 10-count threshold as all high counts would be excluded, however it still relies on a very coarse geographic criterion which cannot be easily generalised to other species. In contrast, using the species' breeding range, as defined by the atlases, would simultaneously allow for the inclusion of all breeding areas and the exclusion of counts from non-breeding areas at a finer resolution. This is a more general approach that could be extended to filter out non-breeding areas for other species. It relies on species having well-defined and reasonably static patterns of habitat use and distribution. By including both previous breeding atlases this method caters for species that have contracted in range. However, for species undergoing rapid range expansion the latest atlas data could underestimate current range and lead to the exclusion of valid BBS counts from expanding range margins. For smaller scale variations, one solution could be to include a buffer around the atlas breeding range. Here we recommend using a buffered range map for Golden Plover because they are known to forage over 8 km from their breeding territory (Pearce-Higgins and Yalden 2003) and this would also accommodate any slight changes to the breeding areas (or if they were missed during the atlas data collection).

5. Recommendations and further developments

1. The count threshold rule for the six waders should be kept at 10 birds in the same transect section and distance band.
2. The geographic exclusion rule for Golden Plover, currently based on the 100-km squares, should be replaced by one based on the atlas range with a 10-km buffer area. This has negligible effect on the UK trend but allows us to publish an England trend.

Future work should investigate other species to see which trends may benefit – in terms of being more representative – from using filtering by their atlas range. These will need to be species which haven't experienced range expansions since the atlas data collection period. Species with significant movements of birds that are not (yet) breeding during April–June and that occur in large aggregations are likely to be the best candidates – e.g. duck species – since the results for non-flocking species showed very little effect. Ultimately, we should adopt the method that, based on analysis of the data and expert knowledge of the species, leads to the spread of data (spatial, temporal, count based) that best reflects breeding birds. Temporal filtering, to exclude counts before or after certain calendar days, was not considered here for the following reasons: while each bird population has an assumed breeding period (i.e. range of dates when breeding occurs) due to resource availability and/or migration route, the behaviours are extremely sensitive to environmental changes (Newson et al. 2016) and the onset of detection is advancing (Massimino et al. 2021); In addition to this, the fact that in the UK we have distinct populations with different migration and breeding phenologies merging for a time, we believe that identifying the correct range of dates for any species is too problematic. Overall, we have shown that the current geographical exclusion rule needs to be refined to make the trends more accurate, while the 10-count threshold rule seems to work as envisioned but potential changes may be considered in the future.

Figures

Figure 1. 100-km grid squares in Britain with the locations of all the UK national parks (dark blue), highlighting the locations of the current 18 Golden Plover exclusion squares in England and Wales (transparent blue), the single re-included square under exclusion rule 1 (SK) and the three re-included squares under exclusion rule 2 (SD, SE, SK).

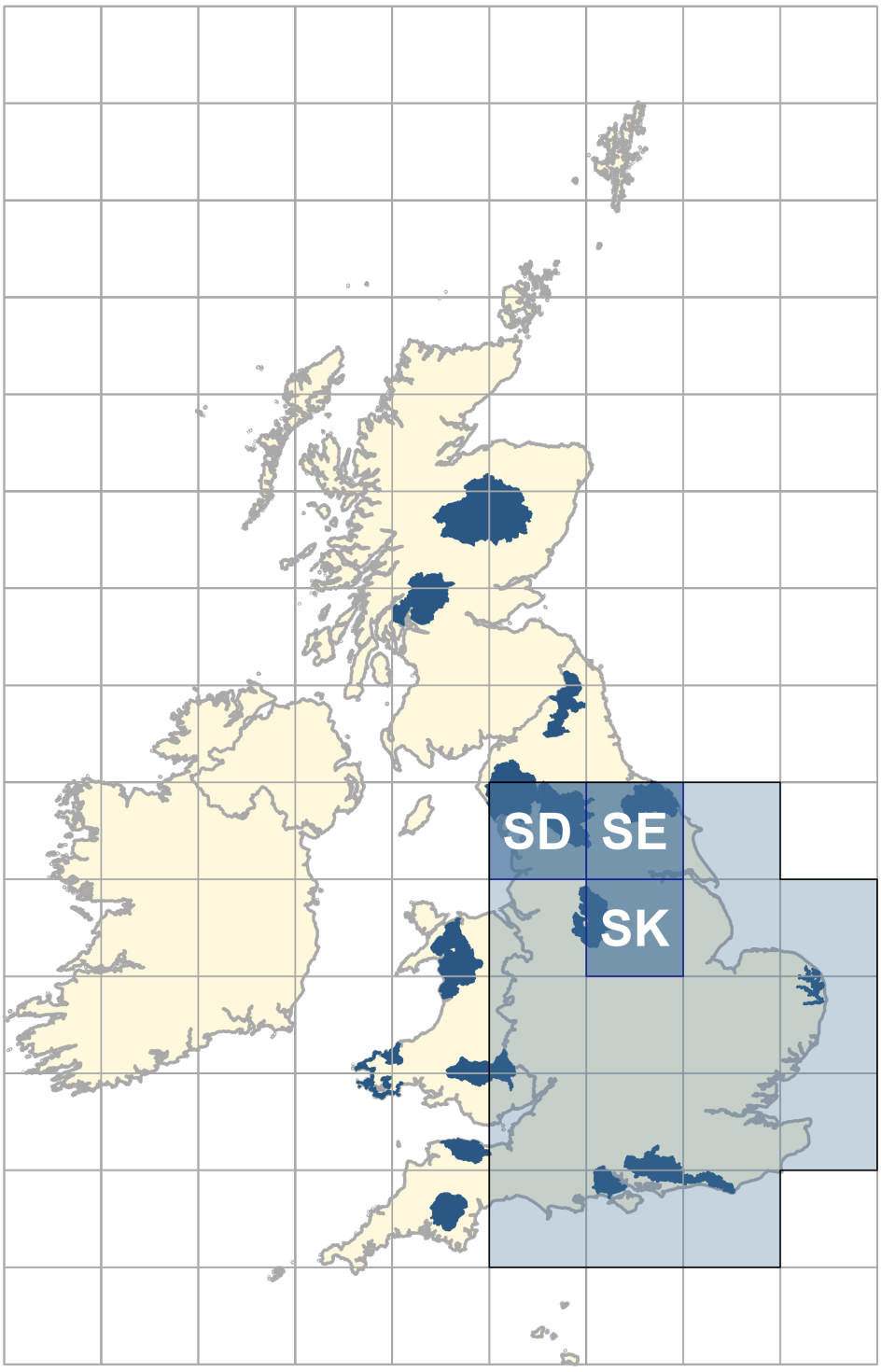


Figure 2. Maps of the distribution of large wader counts. The locations of all 1-km BBS squares (1994–2023) with birds present (grey) for six UK breeding wader species – Golden Plover, Oystercatcher, Lapwing, Snipe, Curlew and Redshank – and those squares with counts greater than 10 in any transect section or distance band (red). Large counts are scattered which reinforces why we can't use spatial filtering for other waders.

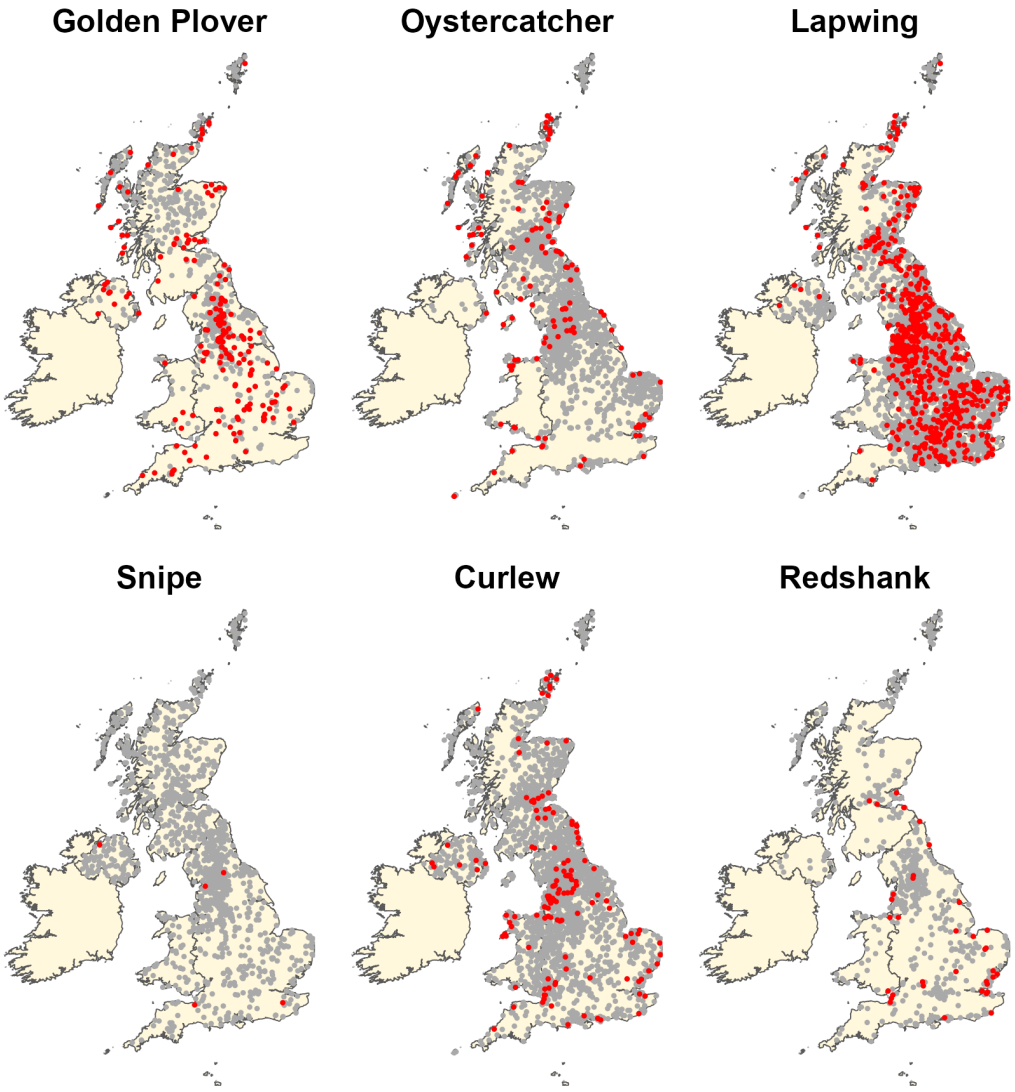


Figure 3. The distribution of 10-km squares with breeding Golden Plover from the second and third bird atlases combined (dark blue), plus the 10-km buffer around this range (light blue). Points show the locations of 1-km BBS squares (1994–2023) with Golden Plover inside (black) or outside (red) the Golden Plover atlas range. Note this is after applying the 10-bird rule (i.e. a count threshold of > 10 in the same section and distance band).

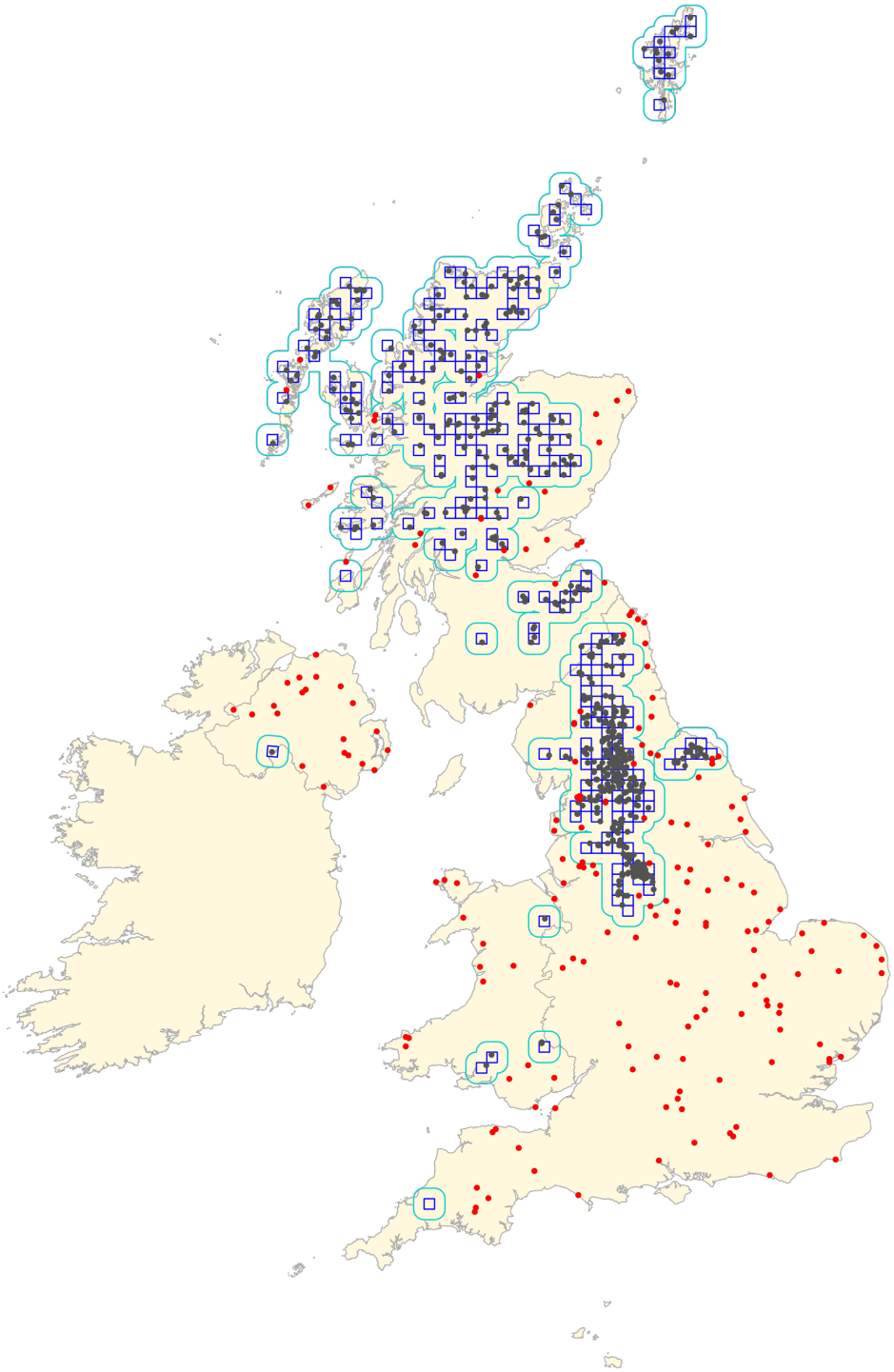


Figure 4. The distribution of 10-km squares with breeding Wheatear from the second and third bird atlases combined (dark blue), plus the 10-km buffer around this range (light blue). Points show the locations of 1-km BBS squares (1994–2023) with Wheatear inside (black) or outside (red) the Wheatear atlas range. Note this is after applying the 10-bird rule (i.e. a count threshold of > 10 in the same section and distance band).

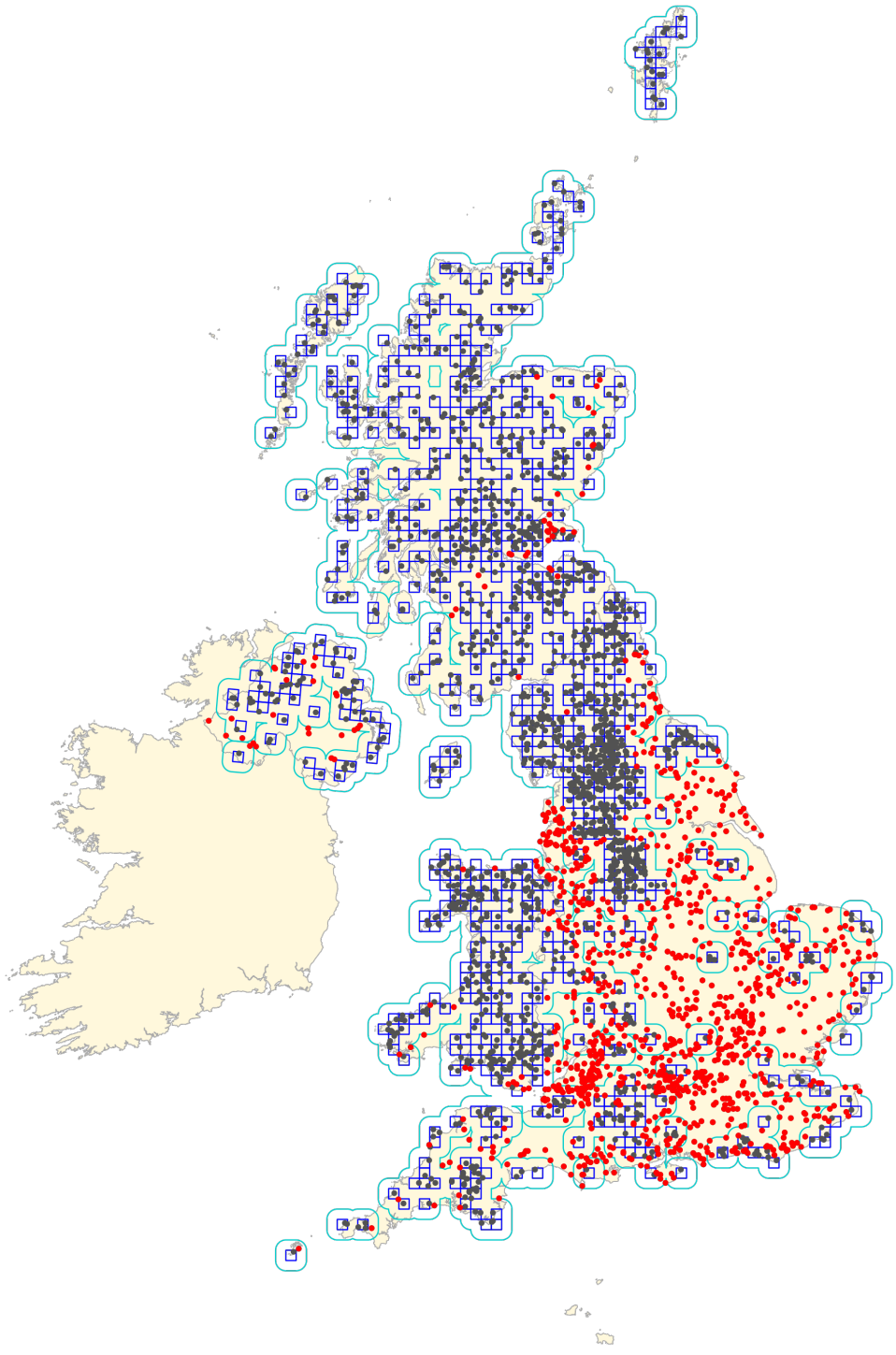


Figure 5. The distribution of 10-km squares with breeding Whinchat from the second and third bird atlases combined (dark blue), plus the 10-km buffer around this range (light blue). Points show the locations of 1-km BBS squares (1994–2023) with Whinchat inside (black) or outside (red) the Whinchat atlas range. Note this is after applying the 10-bird rule (i.e. a count threshold of > 10 in the same section and distance band).

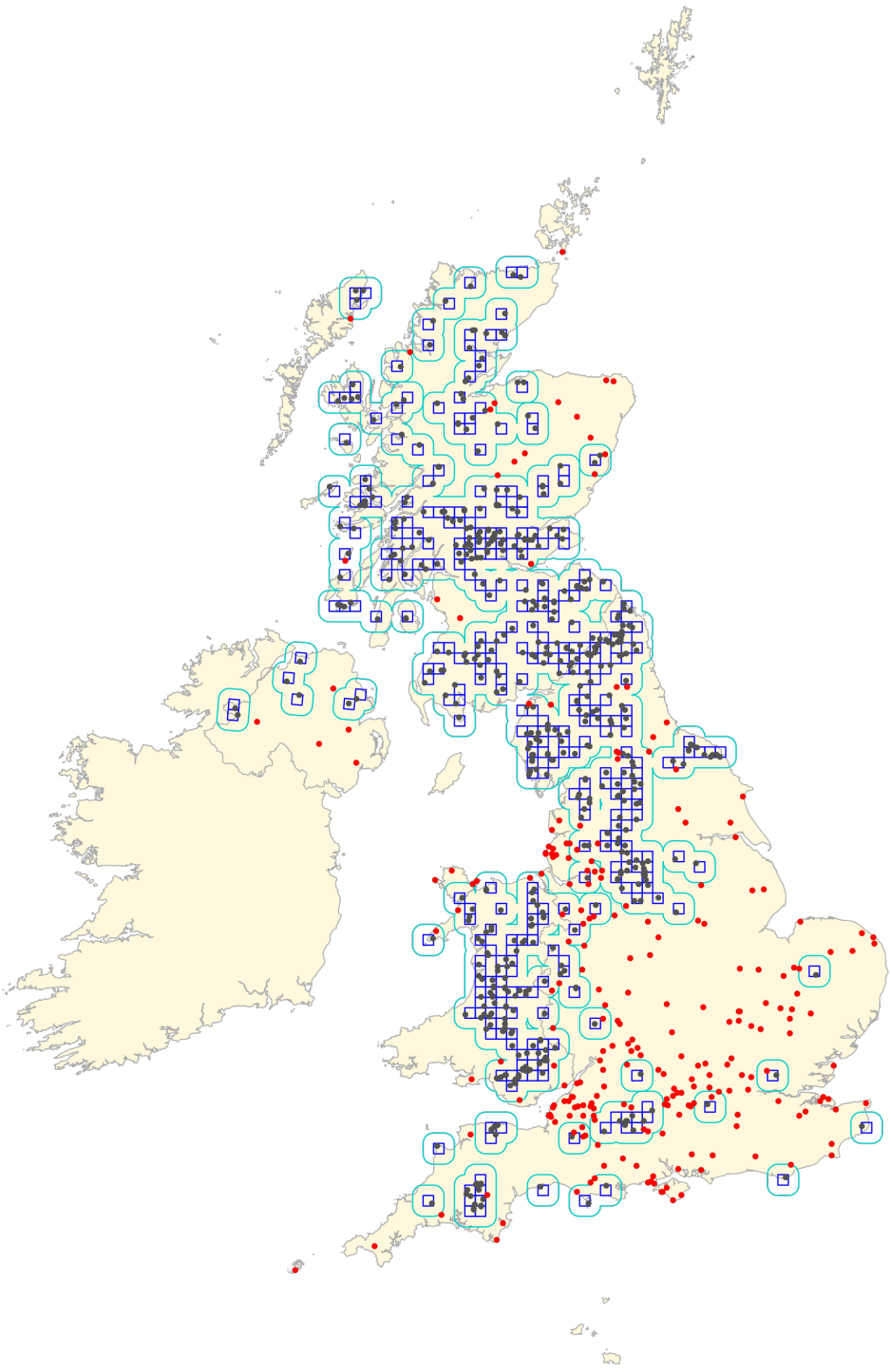


Figure 6. BBS index for 6 UK wader species (1994–2023) comparing the smoothed trends (lines) using the count threshold of 10 (green) with the current location exclusion rule and count threshold of 20 (purple). The points are the unsmoothed annual index values, and the pale shaded areas are the 95% confidence intervals.

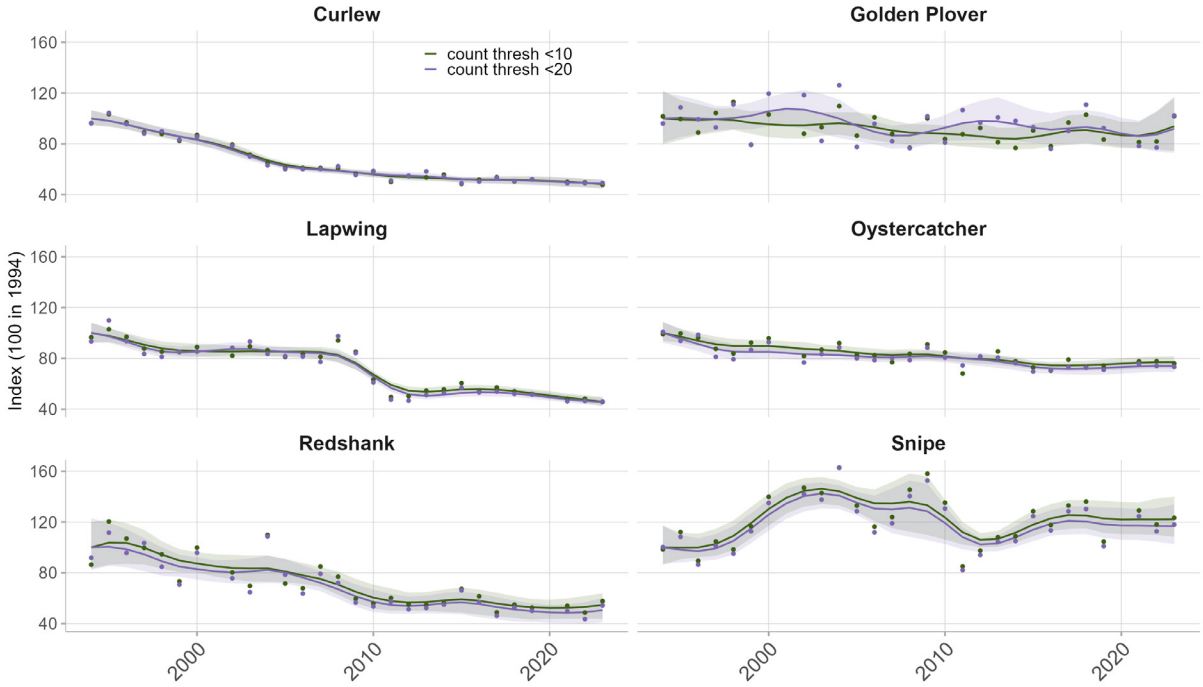


Figure 7. BBS index for UK Golden Plover (1994–2023) comparing the smoothed trends (lines) of the current location exclusion rule with a count threshold of < 10 (green) with two other location exclusion rules using the atlas range and the atlas range + 10-km buffer (blue) for two count thresholds (< 10 and < 20). The points are the unsmoothed annual index values, and pale shaded areas are the 95% confidence intervals.

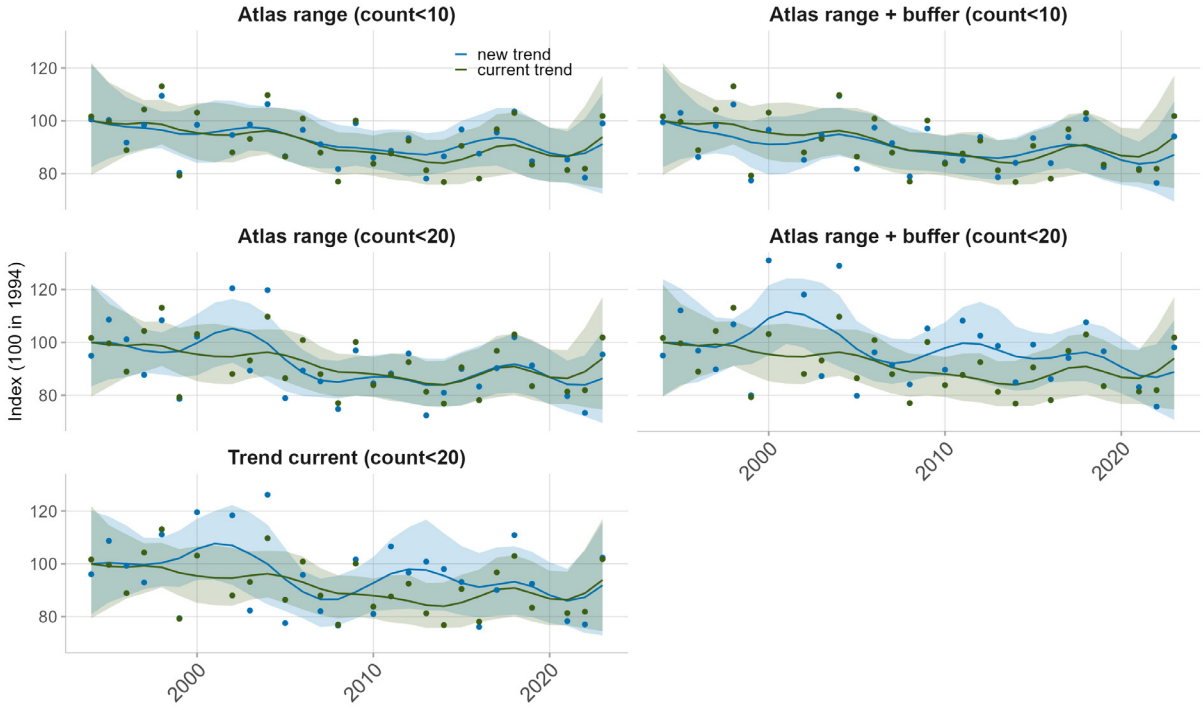


Figure 8. BBS index for UK Golden Plover (1994–2023) comparing the smoothed trends (lines) using the current location exclusion rule (green) with five new location exclusion rules (see text for description) and no location exclusions (blue), using a count threshold of 10 in each case. The points are the unsmoothed annual index values, and the pale shaded areas are the 95% confidence intervals.

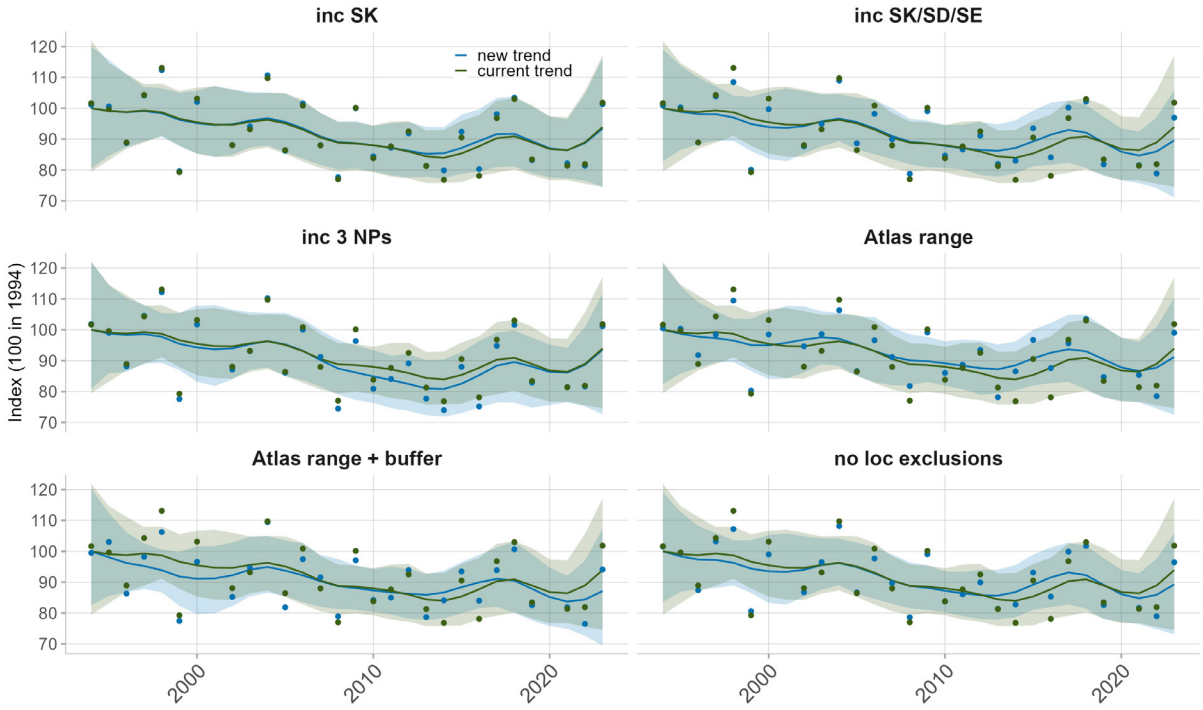


Figure 9. BBS index for England Golden Plover (1994–2023) comparing the smoothed trends (lines) using the current location exclusion rule (green) with five new location exclusion rules (see text for description) and no location exclusions (blue), using a count threshold of 10 in each case. The points are the unsmoothed annual index values, and the pale shaded areas are the 95% confidence intervals.

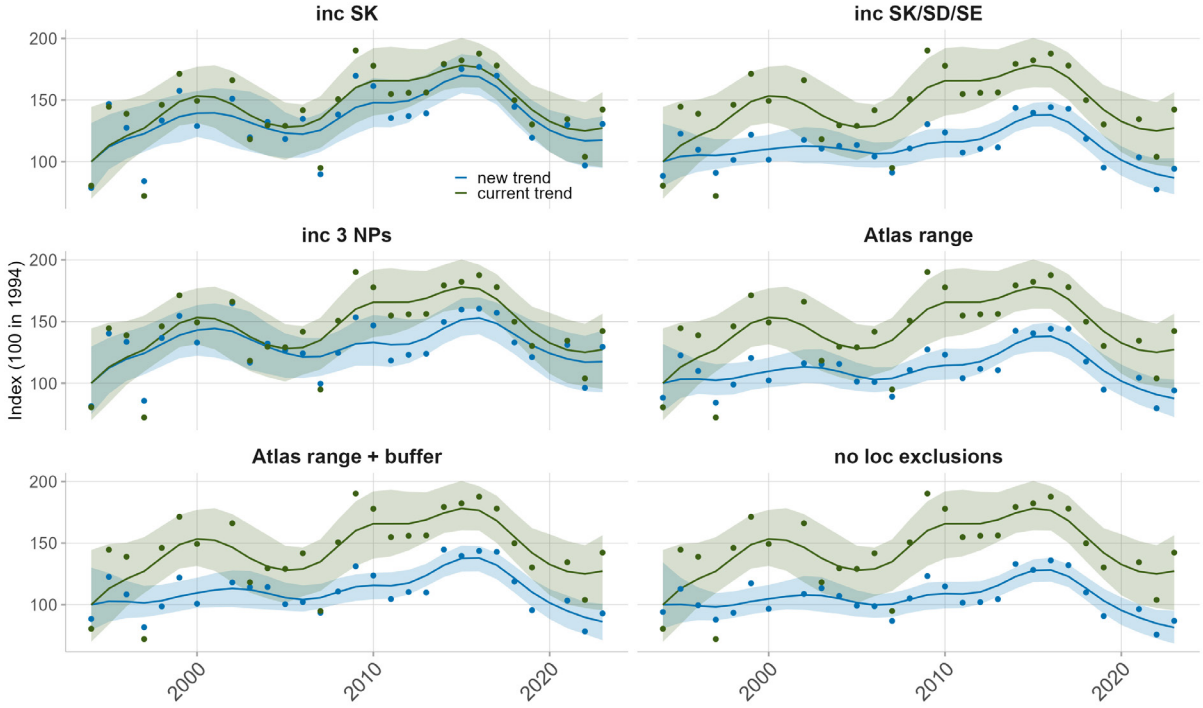
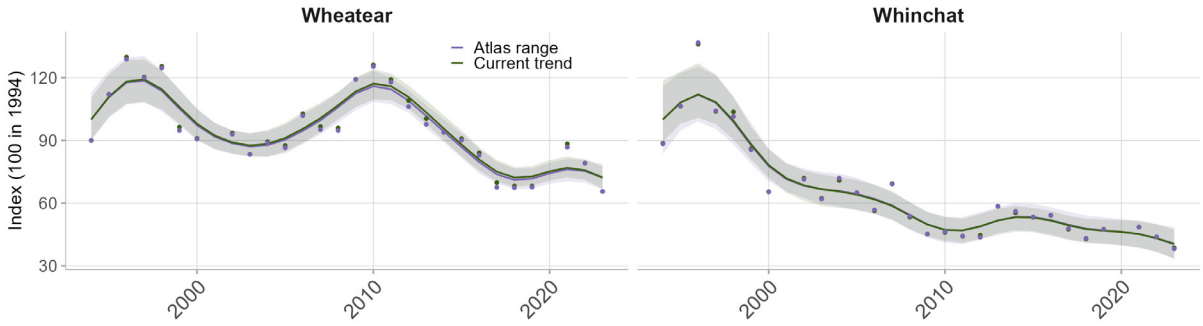


Figure 10. BBS index for UK Wheatear and Whinchat (1994–2023) comparing the smoothed trends (lines) using the current trend (green) with the atlas range location exclusion (purple). The points are the unsmoothed annual index values, and the pale shaded areas are the 95% confidence intervals.



Tables

Table 1. Trend statistics and conservation status of six UK wader species.

Species	UK trend 27-year (BBS data)	UK trend since 1970s (WBS–WBBS data)	UK Birds of Conservation Concern	Pan-European Common Bird Monitoring Scheme (1980–2022)
Curlew	-50%	-39%	Red	-43%
Golden Plover	-10%	n/a	Green	-17%
Lapwing	-51%	-63%	Red	-56%
Oystercatcher	-21%	23%	Amber	-25%
Redshank	-49%	-86%	Amber	-65%
Snipe	22%	-90%	Amber	-55%

Table 2. The total number of individuals of six wader species across all BBS squares and all years, before and after applying filtering to remove large counts. NB all above counts are before the routine 2001 and 2020 data exclusions (foot-and-mouth and COVID-19 years, respectively).

Species	Total individuals before filtering	Count threshold	Total individuals after filtering	% of individuals retained	% squares removed with > 50 total count
Golden Plover	44,346	10	21,643	48.8	100
		20	23,154	52.2	100
Oystercatcher	75,007	10	64,154	85.5	100
		20	68,425	91.2	96
Lapwing	180,787	10	145,821	80.7	100
		20	160,078	88.5	86
Snipe	16,847	10	16,770	99.5	n/a
		20	16,824	99.9	n/a
Curlew	116,572	10	110,939	95.2	100
		20	113,229	97.1	95
Redshank	13,155	10	11,126	84.6	100
		20	11,991	91.2	100

Table 3. Results of different spatial filtering rules on BBS Golden Plover (GP) data in the United Kingdom. The number of missing 1-km BBS squares from the atlas breeding range and number of 1-km BBS squares with large total counts (> 50) for different exclusion rules, with no count threshold per transect section in the UK. NB applying the count threshold does not alter the number of BBS squares in the atlas range as the count is changed to zero rather than deleted. Numbers in brackets are with a count threshold of 10 applied.

		Golden Plover exclusion rule					
	All GP data (UK)	**Current 100-km exclusion**	**1. inc 'SK'**	**2. inc 'SK', 'SD', 'SE'**	**3. inc 3 upland national parks**	**4. All atlas GP breeding range**	**5. All atlas GP breeding**
Number of BBS squares (no count threshold)	894	range	589	780	674	626	670
Number of BBS squares omitted from atlas range	0	+10-km buffer	54	6	27	n/a	n/a
Number of BBS squares with total count > 50	115 (0)	61 (0)	67 (0)	96 (0)	64 (0)	39 (0)	61 (0)

Table 4. Population change estimates (with 95% confidence intervals) and sample sizes for Golden Plovers (GP) in the UK and England for each exclusion rule. Changes significantly different from zero are shown in bold.

		Golden Plover exclusion rule					
	All GP data (UK)	**Current 100-km exclusion**	**1. inc 'SK'**	**2. inc 'SK', 'SD', 'SE'**	**3. inc 3 upland national parks**	**4. All atlas GP breeding range**	**5. All atlas GP breeding**
UK							
Average sample size	119	+10-km buffer	79	108	93	103	107
all years change estimates % (CIs %)	77 (-14, 205)	-10 (-36, 23)	-11 (-36, 22)	-13 (-35, 16)	-10 (-33, 19)	-11 (-33, 20)	-14 (-37, 18)
5-year change estimates % (CIs %)	-11 (-37, 27)	-2 (-21, 32)	-3 (-22, 31)	-8 (-24, 14)	0 (-20, 28)	-6 (-23, 16)	-7 (-26, 20)
England							
Average sample size	70	24	34	63	47	61	62
all years change estimates % (CIs %)	27 (-54, 296)	11 (-35, 84)	4 (-32, 42)	-14 (-38, 21)	4 (-31, 62)	-12 (-38, 21)	-13 (-40, 19)
10-year change estimates % (CIs %)	-33 (-65, 20)	-25 (-51, 1)	-22 (-43, -2)	-25 (-42, -4)	-11 (-37, 14)	-23 (-39, -2)	-24 (-41, -6)
5-year change estimates % (CIs %)	22 (-16, 75)	-26 (-44, -12)	-27 (-43, -15)	-32 (-44, -21)	-21 (-38, -5)	-31 (-43, -19)	-32 (-44, -20)

Table 5. Sample sizes in England and UK for Wheatear and Whinchat, comparing the model using the atlas distribution exclusion rule and the current trend model.

	Average sample size ENG – atlas	**Average sample size ENG – original**	**Average sample size UK – atlas**	**Average sample size UK – original**
Wheatear	168	200	336	372
Whinchat	27	31	73	78

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Cover image, Golden Plover by David Scott / BTO; back cover image, Golden Plover chicks, by David Scott / BTO

Efficacy of methods for producing population trends of breeding waders from Breeding Bird Survey data

This report investigates the efficacy of methods for producing population trends from BTO/JNCC/RSPB Breeding Bird Survey data for six breeding wader species in the UK. It examines the effects of increasing the count threshold on the population trends for these six species, and also explores the effects of different geographic exclusion rules on the population trend of Golden Plover. Overall, it aims to test for any potential biases in the current trends, and in doing so, determines whether we can create a better approach which provides the most robust data for wader conservation moving forwards.

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