BTO RESEARCH REPORT 748

Production of smoothed population trends when a key year of data is missing.

Noble, D.G. & Gillings, S.

BTO Birds Science People

ACKNOWLEDGEMENTS: The BBS, on which these analyses rely, is a partnership between BTO, JNCC and RSPB with fieldwork carried out by a large network of dedicated volunteers. This piece of work was undertaken as an additional component of the BTO's annual agreement with Defra and JNCC to produce and publish a suite of wild bird indicators. We are grateful to Karen Thomas and Christine Holleran of Defra and James Williams of JNCC for useful comments on an earlier draft of this report.

Production of smoothed population trends when a key year of data is missing.

David G. Noble & Simon Gillings

BTO Research Report 748

BTO, The Nunnery, Thetford, Norfolk IP24 2PU
Tel: +44 (0)1842 750050 Email: info@bto.org Web: www.bto.org
Registered Charity Number 216652 (England & Wales), SC039193 (Scotland).

CONTENTS

1. INTRODUCTION

Wild bird indicators are produced and published annually by the UK Government (e.g. Defra 2020; https://www.gov.uk/government/statistics/wild-bird-populations-in-the-uk) to provide a robust measure of change in biodiversity as exemplified by populations of wild birds. These indicators are constructed from the annual population indices of individual bird species, aggregated according to their association with different habitats (e.g. farmland birds, woodland birds) in an approach developed in the UK and widely used in many other countries.

In the UK, the majority of constituent population indices are calculated using data from the BTO/JNCC/RSPB Breeding Bird Survey (BBS). Volunteers undertake annual counts of all bird species detected during BBS surveys of their allocated 1-km squares, providing an estimate of relative abundance comparable over time. The BBS has been running for over 25 years, since 1994, and the data can also be combined with its predecessor (the Common Birds Census) to produce even longer-term trends from c.1970 (Freeman *et al*. 2007). The BBS has grown to annual coverage of c.4,000 squares across the UK and is used to provide reliable trends for 120 mainly terrestrial bird species (Harris *et al.* 2022).

Smoothed trends are usually calculated using as many years of data as are available, but the standard approach for estimating change in the smoothed trend is to calculate the difference from year two of the time series to the penultimate year. This follows the recommendation of Fewster *et al*. (1999) who found that the estimated endpoints of smoothed trends (first and last years) were unstable. For example, data for 1994 to 2020 would be used to derive a smoothed trend from which a change measure would be calculated between the values for 1995 and 2019.

In 2020, most volunteers in the UK were unable to conduct their surveys between April and June, because of restrictions on travel and use of outdoor space during the Covid-19 pandemic. Moreover, there were differences in the timing and severity of travel restrictions between England, Scotland, Wales and Northern Ireland, which resulted in regional biases in the timing and extent of the limited survey coverage that was feasible.

Under normal circumstances the 2020 data would have been used in the production of a 1995–2019 change measure, but owing to the aforementioned biases it was only possible to produce BBS trends for a limited subset of bird species in England, and none for the UK or for Scotland, Wales or Northern Ireland (Harris *et al*. 2021, Gillings *et al.* 2022). It was therefore not possible to produce the 2020 update of the terrestrial wild bird indicators, and bird indicators could not be included among the Government's Biodiversity Indicators published in 2022.

There were very few restrictions on travel or use of outdoor space in 2021 and BBS survey coverage bounced back. The 2021 BBS report included an update of population trends for 120 species, based on data for the period 1994 to 2021, excluding all 2020 data, and reporting change estimates for the period 1995–2020(Harris *et al.* 2022).

Producing trends with a missing year of data is not new: routinely published trends since 2001 have omitted all data from 2001 owing to poor coverage during the 2001 Foot and Mouth outbreak. However, omitting data from the penultimate year, a year that marks the end point of the quoted change interval, is not routine. Given the significant use of these trends in wild bird indicators, this report assesses the impact on the direction and statistical confidence in the trends when a key year of data is missing.

2. METHODS

We tested the effects of dropping the 2020 data when producing smoothed trends for the period 1995–2020, by simulating this effect on previous years data where we knew the true trend. Specifically, we analysed the full set of data for the period 1994–2019 using our standard trend workflow. As we usually omit the first and last years when reporting a smoothed trend (Fewster *et al.* 1999), the smoothed trend for this period of data would be 1995–2018. Having extracted these true trends, we then repeated the exercise but with the 2018 data omitted. Estimates for trends were produced for each species along with 95% confidence limits using the standard bootstrapping approach adopted for normal reporting (Harris *et al.* 2022).

A first simple test was to check the direction of any bias in the degraded trend point estimates compared to the true trend point estimates. Rather than base inference on just one year we repeated the production of point estimates for five additional trend periods. For example, we produce trends using data for 1994–2018 with 2017 omitted, for 1994–2017 with 2016 omitted, and so on. Owing to time constraints we were not able to produce confidence limits for the additional periods, only for the key test period (1994–2019), but the point of the additional runs of years was to demonstrate the pattern of positive and negative biases between years.

For the 1995–2018 smoothed trends, produced from 1994–2019 data with and without 2018 omitted, we checked whether the 95% confidence limits for the degraded trend overlapped the point estimate for the true trend estimate; lack of overlap would suggest the degraded trend estimate was significantly different from the true trend estimate.

3. RESULTS

Analysis of the point estimates for the 1995–2018 trend showed that dropping the 2018 data resulted in 75 species having a more positive trend compared to the true trend, and 32 species having a more negative trend (Table 1).

Figure 1 shows examples for Wren, Lapwing and Dipper. In the case of Wren it can clearly be seen that the 2018 value that is omitted in production of the degraded trend is an unusually low value compared to consecutive points. The 2018 value for Dipper is a slightly higher value than consecutive points and the 2018 value for Lapwing falls exactly on the smoothed line. Year to year fluctuations often mean the unsmoothed trend oscillates back and forth around the smoothed trend. We might therefore expect that omitting a different year would produce more negatively biased trends. This is indeed the case. Table 1 shows that whether there are more positive biases or more negative biases tends to switch from one year to the next (for example dropping 2017 rather than 2018). This suggests that omitting the final year of data when producing smoothed trends does not introduce a systematic bias per se (i.e. the prevalence of positives and negatives varied between years in roughly equal balance) and may simply dampen oscillations in the time series.

Figure 1. True and simulated population trends for Wren, Lapwing and Dipper. In each plot the solid blue line shows the true smoothed population trend. The dashed green line shows the degraded smoothed population trend that is produced when the data for 2018 are omitted. Points show the annual values, with the green triangle indicating the 2018 point that was omitted in production of the degraded trend.

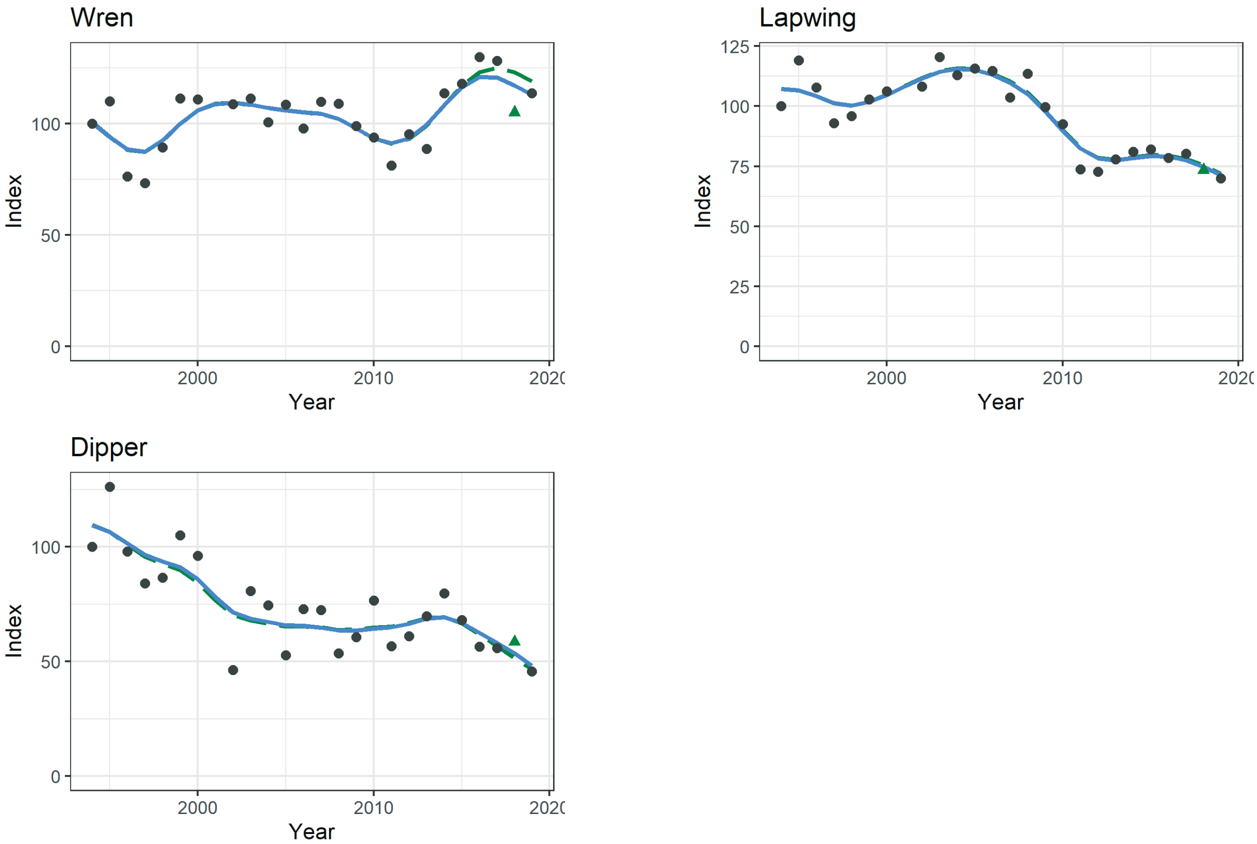


Table 1. Number of species with a positive or negative bias to the degraded population trend compared to the true trend for six different periods. Shading indicates the bias when each year was dropped.

Publication year	Year dropped	Full data range	Smoothed trend range	Negative bias	Positive bias
2015	2013	1994–2014	1995–2013	33	70
2016	2014	1994–2015	1995–2014	38	66
2017	2015	1994–2016	1995–2015	74	32
2018	2016	1994–2017	1995–2016	45	61
2019	2017	1994–2018	1995–2017	66	40
2020	2018	1994–2019	1995–2018	32	75

Figure 2. Histogram of the percentage difference between the simulated change estimate (with a missing year) and the real change using the full dataset for all species tested. The lower two plots plots show the percentage difference between the simulated missing year estimate and the real estimate for the lower and upper confidence limits, respectively.

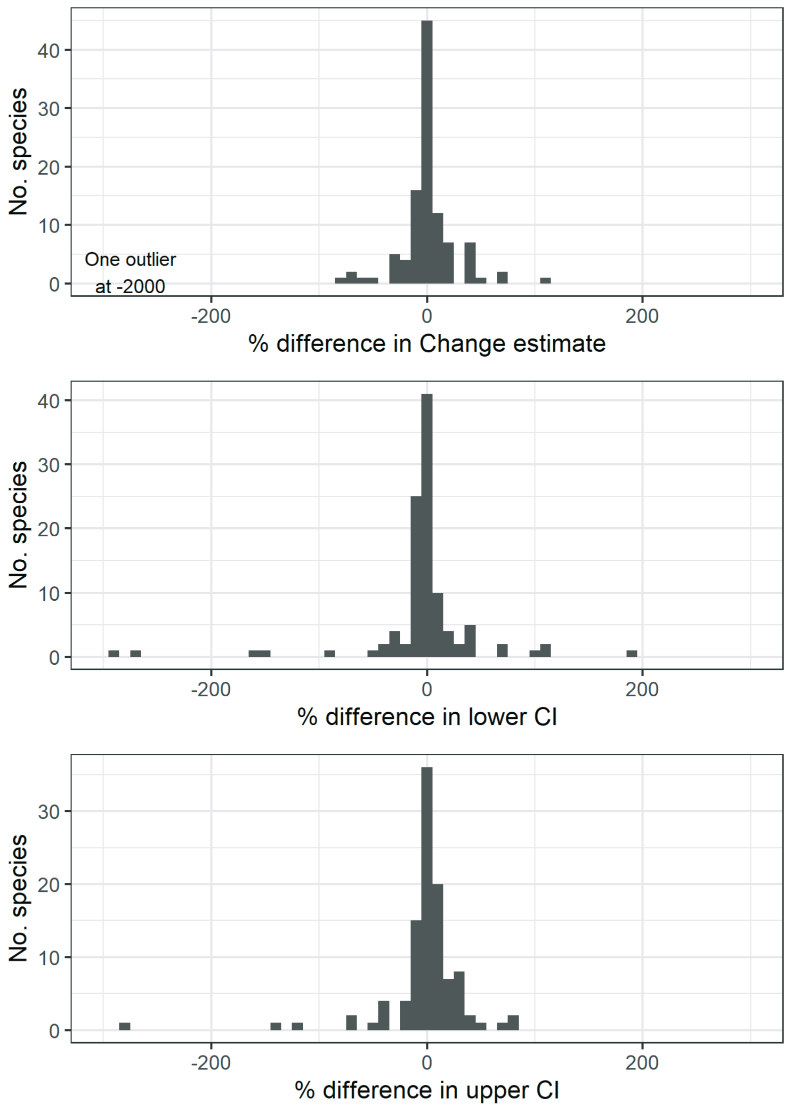


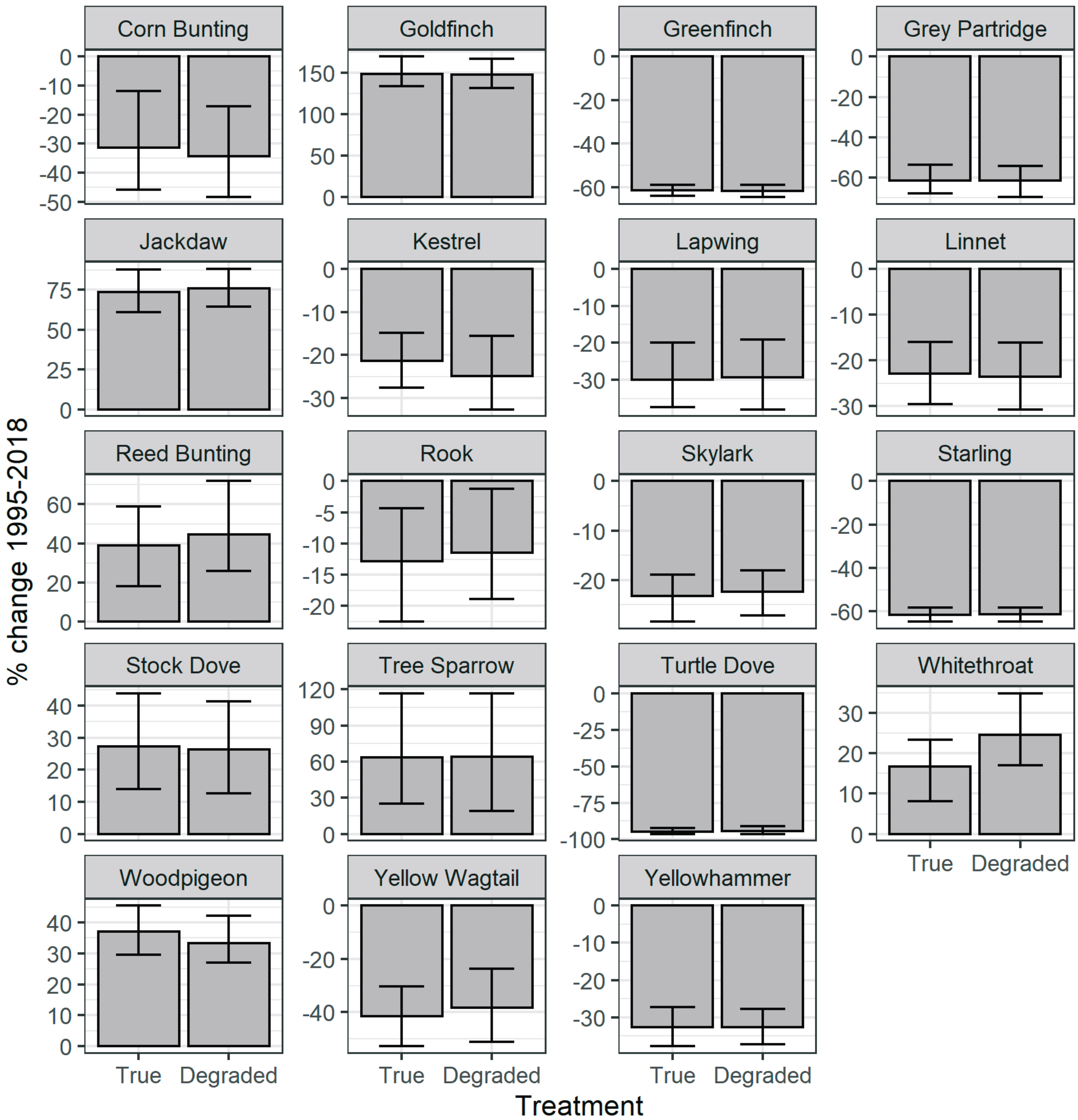
Table 1 reveals that the direction of bias (negative or positive) shows no overall pattern and varies between years and the year dropped (2013 for the 1994–2014 series, 2014 for the 1994–2015 time series, etc).

In short, there is no tendency for the missing year to have either a negative or a positive effect on the calculated trend compared to the real trend based on the full dataset.

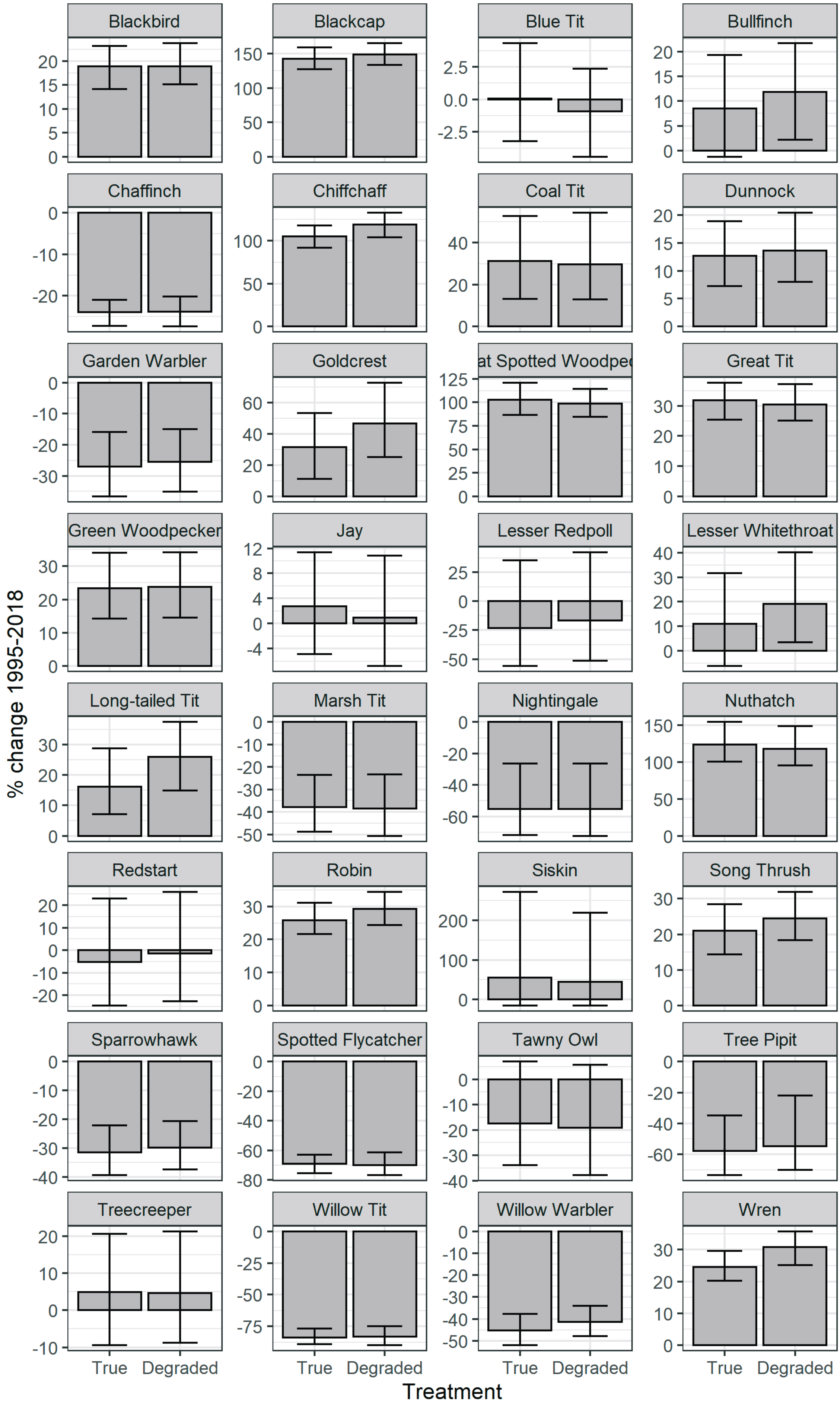
The preceding discussion considers the direction of the bias but does not consider the magnitude of the bias. We first looked at this using the estimates from the degraded 2014–2019 dataset, i.e. missing 2018 data. The topmost of the plots in Figure 2 show that, across species, the differences between the simulated and real estimates are centred and clustered around zero (i.e. most species show no difference and only a few species show a difference with both negative and positive biases evident). This test also looked for any differences in our statistical confidence in these change measures by comparing differences in the lower and upper confidence limits. Importantly, we found that there was little statistical or noticeable difference across all species in the estimates of confidence as manifested by the percentage difference between the degraded and real confidence intervals. Only a handful of species show marked differences in lower or upper confidence limits.

Figure 3. True and degraded trend estimates (1995–2018) for species in the different bird indicator sets: a) farmland, b) woodland, c) wetland. Note that due to the mix of positive and negative trends, the axis scales inevitably differ between species. However, the key message is in the similarity in response within a species, not between species. Error bars show 95% confidence limits.

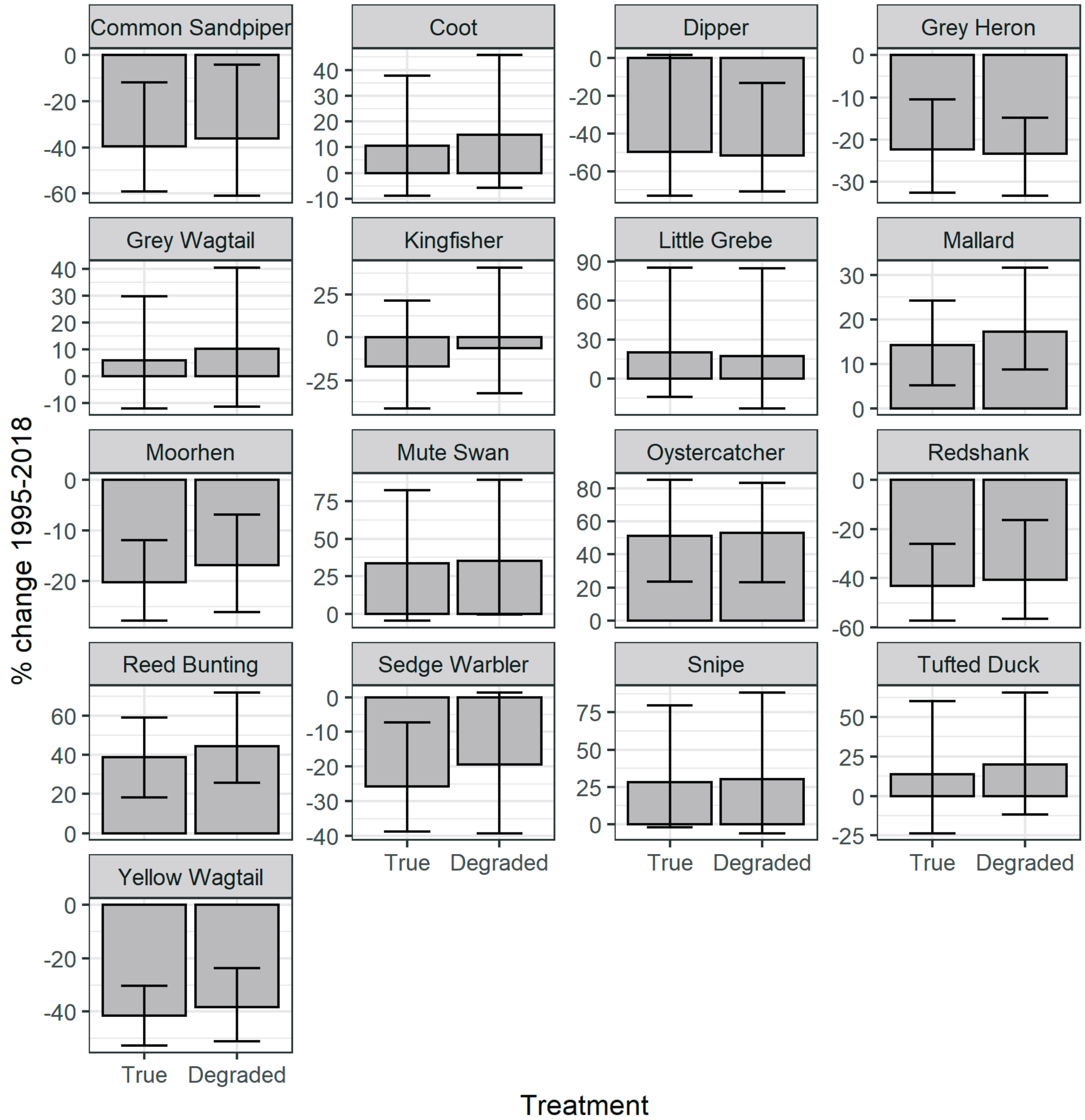
(a) species in the farmland indicator



(b) species in the woodland indicator



(c) species in the wetland indicator



We summarised the true and degraded trend estimates for species in each indicator group (Figure 3) which shows that for the majority of species the difference between true and degraded trends is small, and not statistically significant. For only two species, Whitethroat and Wren, was there a significant difference between the degraded trend and the true trend. Whitethroat true trend = 16.7 (8.2–23.4); degraded trend = 24.6 (17.0–34.9). Wren true trend = 24.5 (20.2–30.0); degraded trend = 30.1 (25.1–35.8).

Only one of the 19 species in the breeding birds of farmland indicator for which BBS trends were compared showed any statistical difference in the estimate of change as result of degrading the dataset to exclude the penultimate year of data. This species was Whitethroat, a relatively widespread and common species whose populations can fluctuate considerably from year to year as a result of climatic conditions on their wintering grounds in the Sahel. Across species, trends were always in the same direction and there was no pattern in the relative magnitude of the estimated change between 1995 and 2018. Differences in the width of confidence intervals were small and no pattern emerged between the degraded and full datasets.

Only one of the 32 species in the breeding birds of woodlands indicator for which BBS trends were compared showed any statistical difference in the estimate of change as result of degrading the data set to exclude a year of data. This species was Wren, one of the most widespread and abundant species and one whose populations can fluctuate considerably from year to year as a consequence of climatic conditions during the winter. Across species, trends were always in the same direction and there was no pattern in the relative magnitude of the estimated change between

1995 and 2018. Differences in the width of confidence intervals were small and no pattern emerged between the degraded and full datasets.

None of the 17 species in the breeding birds of wetlands and waterways indicator for which BBS trends were compared showed any statistical difference in the estimate of change as result of degrading the dataset to exclude a year of data. Trends were always in the same direction and there was no pattern in the relative magnitude of the estimated change between 1995 and 2018. Confidence intervals tended to be larger for the estimates with degraded data but this was not always the case and differences were small.

4. CONCLUSIONS

This exploration of the effects of excluding years of data produced several important findings. Firstly, although dropping any penultimate year of data can result in slightly unbalanced pattern of positive and negative effects on the estimated change, depending on whether the missing year was a particularly good or bad year for that species, there was no overall bias. In other words, over time there was no positive or negative bias. This was tested by six different dropped years and shows there's no systematic effect – i.e. whether more species show a positive or negative effect of dropping the year is year-specific and probably reflects the stochastic nature of unsmoothed values (a low is usually followed by a high).

Secondly, the differences in the estimates of change in the smoothed index over the longer period (1995 to 2018) were small and clustered close to zero. Of a total of 68 species tested, only two species (Wren and Whitethroat) showed any evidence of a statistically significant difference in the estimates. Both of these species are prone to annual fluctuation in numbers as a result of climatic conditions, Wren due to cold winter temperatures and Whitethroat due to rainfall patterns affecting survival during the winter in the UK or on their African wintering grounds. Estimated measures of change over the period 1995–2018 for all other species were all in the same direction and showed very little difference in extent between degraded data and the full dataset.

Thirdly, there was no evidence of reduced confidence in the measures of change estimated from the degraded datasets (with missing penultimate year) compared to the full dataset. Of 68 species tested, the widths of confidence intervals were very similar between the degraded data and the full dataset.

Overall, these analyses of simulated data provide assurance that the BBS trends updated in the latest report (Harris *et al.* 2022), which cover the period 1994 to 2021 but are missing data for 2020, are robust and can be treated with an equivalent level of confidence. They are also unbiased except to the extent that 2020 may have been an unusually good or bad year for particular species (i.e. we don't know the information for 2020 and have to infer the trend from the surrounding years). Moreover, that effect is likely to disappear as further years – both good and bad – are added to the time series. This also provides confidence that the wild bird indicators for breeding farmland, woodland and wetland birds, which are constructed from these trends, will also be robust, will have the same level of statistical confidence, and will, over the long term, be unbiased.

5. REFERENCES

Defra 2020. Wild bird populations in the UK, 1970 to 2019. URL: https://www.gov.uk/government/statistics/wild-bird-populations-in-the-uk

Fewster, R.M., Buckland, S.T., Siriwardena, G.M., Baillie, S.R. & Wilson, J.D. 2000. Analysis of population trends for farmland birds using generalized additive models. *Ecology* **81**: 1970–1984.

Freeman, S.N., Noble, D.G., Newson, S.E. & Baillie, S.R. 2007. Modelling bird population changes using data from different surveys: the Common Birds Census and the Breeding Bird Survey. *Bird Study* **54**: 61–72. doi: 10.1080/00063650709461457

Gillings, S., Balmer, D.E., Harris, S.J., Massimino, D. & Pearce-Higgins, J.W. 2022. Impacts of COVID-19 restrictions on capacity to monitor bird populations: a case study using the UK Breeding Bird Survey. *Bird Study* **68**: 220–232 doi: 10.1080/00063657.2021.2019187

Harris, S.J., Massimino, D., Balmer, D.E., Eaton, M.A., Noble, D.G., Pearce-Higgins, J.W., Woodcock, P. & Gillings, S. 2021. *The Breeding Bird Survey 2020.* Research Report no. **736**. British Trust for Ornithology, Thetford, UK.

Harris, S.J., Massimino, D., Balmer, D.E., Kelly, L., Noble, D.G., Pearce-Higgins, J.W., Woodcock, P., Wotton, S. & Gillings, S. 2022. *The Breeding Bird Survey 2021.* Research Report no. **745** British Trust for Ornithology, Thetford,UK.

Images: Font cover – Yellow Wagtail, Chris Knights / BTO. Back cover – Corn Bunting, Liz Cutting / BTO

Production of smoothed population trends when a key year of data is missing.

This report explores the impact on the direction and statistical confidence in the individual species trends from which the wild bird indicator is composed when including missing years in the dataset, using simulated subsets of real data from previous years. This report was prompted by the impacts of Covid-19 lockdown restrictions on survey effort.

CITATION e.g. Noble, D.G. & Gillings, S. (2023) Production of smoothed population trends when a key year of data is missing.
BTO Research Report **748**, British Trust for Ornithology, Thetford, UK.

ISBN 978-1-912642-43-4

Birds Science People