BTO Research Report No. 303

Modelling bird population changes using data from the Common Birds Census and the Breeding Bird Survey

Authors

S. N. Freeman, D.G. Noble, S.E. Newson & S.R. Baillie

October 2002
Revised March 2003

A report by the British Trust for Ornithology

British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU
Registered Charity No. 216652

CONTENTS

Page No.

LIST OF TABLES

Page No.

LIST OF FIGURES

Page No.

. EXECUTIVE SUMMARY

1. Population trends of common and widespread terrestrial birds in the UK are derived from the two main sources of data; the Common Birds Census (CBC) run from the early 1960s to 2000, and the BTO/JNCC/RSPB Breeding Bird Survey (BBS) run from 1994 to the present. In this report, we compare species trends from both surveys during the period of overlap, and in the different geographical areas covered by these surveys, in order to assess the potential for producing long-term combined CBC-BBS trends.

2. Based on a comparison of CBC and BBS trends for 73 species that are routinely monitored by both surveys, it is demonstrated that combined CBC/BBS indices can be produced for the period of overlap (1994 to 2000) for 66 of these species within Southern Britain (defined as a square bounded by easting 3000 and northing 5000), where the majority of CBC survey effort is focused. For these species, the difference in trends between the two surveys is not significant. The remaining seven species show significantly different CBC and BBS trends within Southern Britain. For four of these species, differences are likely to be related to a high level of power resulting from the high species abundance in the case of the Wren, Robin, Blackbird and Chaffinch. However, a real problem may exist in combining CBC and BBS trends for the Stock Dove, Pheasant and Chiffchaff and possibly also Coal Tit.

3. A comparison of BBS trends within and outside Southern Britain (defined as a square bounded by easting 3000 and northing 5000) shows that for a significant proportion of species (38 of 73 species: 52%), trends within Southern Britain are not representative of trends elsewhere. Therefore CBC data should not automatically be used to produce population indices for the UK as a whole. In this study, Southern Britain was chosen as an area within which to compare trends, based on work by Fuller *et al*. 1985, which showed that farmland CBC plots at least were representative of this land area. It could be argued that calculating trends within England, which covers a broadly similar area, may be more appropriate. In this case, boundaries should be agreed before routine analyses is introduced and trends examined in comparison with Southern Britain as defined here.

4. Results show that it is possible to produce combined CBC-BBS trends for Southern Britain for the majority of species monitored. A comparison of trends within and outside the area of good coverage of the CBC suggests that for about half of the species tested, a combined CBC-BBS index using data from the entire UK could be justified, on the assumption that regional differences in trends during the 1990s were similar to those in the preceding decades. When producing combined CBC/BBS indices, data from both surveys for the full overlap period should be used. The reason for this is that if a single or small number of years were used for 'attaching' trends from the two surveys and that these years were not representative of the underlying trend, parts of the resulting index are likely to be biased.

5. A number of points were raised as a result of this work with respect to future combining of CBC and BBS indices. Further work would be needed to evaluate the use of weighting within any combined indices for which a simulation using hypothetical data may be an appropriate approach. In terms of optimising precision and smoothing, the use of Generalised Additive Models (GAMs) should be explored. However, the main problem is the large amount of computing time that would be required to calculate, via the bootstrap method, standard errors in such analyses.

2. INTRODUCTION

The Common Birds Census (CBC) was introduced in 1961, at the request of the then Nature Conservancy, to monitor national trends of widespread and abundant breeding bird species in the UK. These data have been fundamental in highlighting declining trends in a number of species and have underpinned many recent conservation initiatives, including the Birds of Conservation Concern, the government's populations of wild birds indicators, the UK Biodiversity Action Plan and the State of the UK's Breeding Birds. However, the CBC has a number of limitations as a national monitoring scheme. It involves the mapping of bird territories from observations during seven to ten visits per year, making it relatively time-consuming and expensive for both observers and BTO staff. Secondly, because observers select their own CBC plots, mainly in farmland or woodland, there is unrepresentative habitat coverage and a bias towards the southern and eastern areas of the UK where observer densities are greatest (Gregory *et al*. 1995). Whilst the CBC plots are probably not representative of the UK as a whole, farmland CBC plots at least have been found to be representative of most of lowland farmland in England south of the river Humber and east of the River Severn (Fuller *et al.* 1995), within a square of easting 3000 and northing 5000 of the National Grid, referred hereafter as Southern Britain (shown in Figure 1).

To address the limitations of the CBC methodology, the BTO in collaboration with the Royal Society for the Protection of Birds (RSPB) and Joint Nature Conservation Committee (JNCC) introduced the Breeding Bird Survey (BBS) in 1994, which uses the line transect method for recording birds. BBS survey squares are randomly selected from a list of all 1 km squares in the National Grid that comprise the UK, excluding coastal squares with less than 50% land. Use of volunteers is maximised through a stratified random sampling design. Initially, the number of squares allocated to each of the BTO's 83 regions (roughly counties or groups of counties) was a fixed proportion of the number of potential volunteers in the region, estimated using BTO membership information. For regions with relatively few potential volunteers, a minimum level of coverage was set. Within each region, squares are selected randomly, and allocated to volunteers through a network of voluntary regional organisers (ROs). Organisers receive a list of target squares for their region, and to maintain the random design of the survey, are asked to allocate them to volunteers in the order generated. Because the stratified sampling design results in unequal representation of regions across the UK, annual counts are weighted by the inverse of the proportion of the area of each region that is surveyed that year.

Because the BBS requires fewer visits to each site, and through its active promotion as a national monitoring scheme, a much greater and, importantly, random coverage of the UK was achieved. In 2000, 2248 BBS squares were surveyed, compared to 212 CBC plots. The long-term aim has been to replace the CBC with the BBS following a period of overlap, during which trends could be compared and calibrated. In this study, we compare species trends calculated from the CBC and BBS surveys for 73 species for which annual indices are routinely calculated by both surveys during the period of overlap (1994 to 2000) and examine the potential for producing combined CBC/BBS indices.

3. METHODS

Both CBC and BBS data have been analysed using log-linear Poisson regression models fitted in SAS (SAS 1996) to model a matrix of annual site counts, with site and year effects (ter Braak *et al*. 1994). The year effect is an annual index of total numbers, whilst the site effect describes how species abundance at sites differ from one another. The last index of a run of years is set to an arbitrary value 1 and other indices are measured relative to this. Because survey sites are independent of one another, it is possible to combine the data across surveys, regardless of survey type, by multiplying the likelihoods of the two surveys and maximising the joint likelihood. This naturally accommodates the difference in precision of the estimates of the two sources, as a consequence of the difference in sample sizes. In the fitting of the joint model, the annual indices in the CBC and BBS in a given year are set equal and it is assumed that the error distributions for the two surveys are the same. A likelihood ratio test against the two models with distinct annual indices follows, and permits an assessment of the difference between the two trends.

In order to produce a useful index jointly derived from the CBC and the BBS, it is essential that the data from the two surveys are comparable and show similar species trends for any species analysed this way. It is already known that the majority of CBC plots are in southern and eastern England and that farmland CBC plots, whilst representative of farmland in Southern Britain, are not representative of Britain as a whole (Fuller *et al*. 1985). Therefore the first analysis in this study compares CBC trends with trends calculated from BBS data within Southern Britain by testing the significance of the interaction between year and survey type. Data from all habitats are included in these analyses. This amounts to a comparison of the fit of the joint model with the fit of the two separate CBC and BBS models. If these trends are significantly different from one another, combining data from both surveys into a single long-term index is not advisable and an alternative approach would be required.

The next critical analysis performed was to establish whether trends calculated for BBS data within and outside Southern Britain are significantly different from one another. In these analyses, an additional variable, 'square' was employed where 'square' = 1 for a site in Southern Britain and 0 otherwise. Adding to the model for BBS data a year*square interaction enables a formal assessment of the significance of the difference in relative annual indices, between the two geographic areas for the time period 1994 to 2000.

Because BBS observers are not uniformly distributed throughout the UK, BBS indices have routinely weighted the data by observer coverage within each BTO region for each year. CBC data have never been weighted this way and for consistency BBS data are not weighted in the models presented in this report, except where otherwise stated. To demonstrate the effect of this weighting on the resulting BBS indices a comparison between weighted and unweighted BBS indices within Southern Britain is shown for the period 1994 to 2000. A simulation demonstrating the effect of weighting and carried out on hypothetical data is also shown in an appendix.

4. RESULTS

4.1 BBS versus CBC within Southern Britain

The first comparison in this study compares BBS and CBC trends all within Southern Britain for the period 1994-2000. Of 73 species routinely monitored by both the CBC and BBS (illustrated in Figure 2), seven species (Pheasant, Stock Dove, Wren, Robin, Blackbird, Chiffchaff and Chaffinch) showed trends that were significantly different between surveys (Table 1). Because inclusion of the entire CBC data set from 1964 may provide more information on site effects and adds power to detect any differences, an additional comparison between the two surveys was performed using CBC data for the period 1964-2000. Again, differences between indices were found for the seven species highlighted above, but an additional species, the Coal Tit produced trends that were significantly different between the two surveys (Table 1). Trends for four example species, Moorhen, Great Spotted Woodpecker, Coal Tit and Long-tailed Tit are illustrated in Figure 3.

4.2 BBS inside and outside Southern Britain

The comparison between indices calculated from BBS squares within Southern Britain with indices calculated using BBS squares outside Southern Britain for the period 1994-2000 found that trends for 38 of the 73 species in this study were significantly different from one another (Table 2). This suggests that including BBS data from outside Southern Britain to combine with CBC data may not be advisable for these species. Trends for all species, within and outside Southern Britain are illustrated in Figure 4.

4.3 Combined BBS/CBC indices within Southern Britain

Combined CBC-BBS indices were calculated for all species for the period 1994-2000 shown in Figure 5. Because of the greater number of sites surveyed by the BBS, trends from BBS data were estimated more precisely, and it is not surprising to find that the combined indices are closer in pattern to the BBS trends.

4.4 Weighted versus unweighted BBS indices within Southern Britain

Weighted and unweighted indices were calculated using the same BBS dataset for 73 species, to compare the effect of the weighting process on the resulting indices. A visual comparison of the indices suggests that the weighting factor is unlikely to have a major influence on CBC / BBS indices, at least within the defined area of Southern Britain. However, further consideration is needed regarding the role of weighting, which is a central part of BBS survey design. Weighting allows accurate treatment of different regional trends within a larger region e.g. Southern Britain. However, it should be noted that CBC analyses have not routinely been weighted in the past. Trends for four example species, Moorhen, Great Spotted Woodpecker, Coal Tit and Long-tailed Tit are illustrated in Figure 6.

5. DISCUSSION

5.1 BBS versus CBC within Southern Britain

Comparison between BBS and CBC trends within Southern Britain for years in which the surveys overlap, (1994 to 2000) found a significant difference in trends for seven of 73 species, which were Pheasant, Stock Dove, Wren, Robin, Blackbird, Chiffchaff and Chaffinch. For four of these species (Wren, Robin, Blackbird and Chaffinch), the sample size of sites surveyed are among the highest of any species (mean of >1700 BBS squares per year; mean of >180 CBC plots per year), which means that the confidence intervals associated with these indices are very small. Although the trends show up as different in a formal statistical test, visually there is a marked similarity (Figure 7). The significant difference between BBS and CBC trends found for these species is likely to reflect the large sample size and our power to detect a difference, and it is therefore arguable that despite the formal differences, a combined index remains a biologically useful one for these species within Southern Britain.

Differences between the CBC and BBS trends for Pheasant, Stock Dove and Chiffchaff are more difficult to explain, although in the case of Chiffchaff, the inter-annual changes match perfectly in direction. All three species are recorded on a relatively high number of BBS squares and CBC plots (mean of >500 BBS squares per year; mean of >75 CBC plots per year), and so have relatively small confidence intervals. There may be additional reasons, perhaps related to the difference in methodology between the two surveys (line transect versus territory mapping, timing of visits), that results in the difference in trends observed here. CBC plots do not cover upland or urban areas particularly well but none of these species are characteristic of those habitats. When CBC and BBS were compared for the period 1964-2000, the Coal Tit was also found to have significantly different trends for the years of the overlap. This may perhaps be related to differences in habitat coverage between the two surveys, if Coal Tit trends in coniferous forests (poorly monitored by the CBC) differ from those in other habitats.

Apart from the species mentioned above, this analysis shows that for the majority of species, the different methodology of the two surveys and potential differences in habitat coverage within Southern Britain has had little effect on the changes in abundance derived from the two surveys. This can be confirmed by examining the plots in Figure 2, which show the similarity in the direction of inter-annual changes in numbers for most species, from farmland raptorial species such as Kestrel to small wetland insectivores such as Sedge Warbler. However, although no statistical differences in trends were detected for the remaining 66 species, some of the apparent lack of difference in trends derived from the BBS and the CBC may be due to lack of statistical power. The plots in Figure 2 for Mute Swan, Marsh Tit and Tree Sparrow suggest differences in the overall trend as well as differences in the pattern of inter-annual changes. These differences were not detected, probably because of the small sample sizes used to generate the indices.

For those species where there was no significant difference between BBS and CBC indices in Southern Britain, production of a joint index derived from the two schemes *for this area*, is justified. However some caution should be taken in extrapolating this conclusion to the period prior to 1994, because it is not possible to validate the assumption that both surveys always showed similar trends. For species where the years of overlap suggest a significant, and a biologically substantial, difference, to produce a combined index using BBS data (1994-2000) and CBC data (1964-1994) is unwise, as there is every reason to suggest that the two methods do not yield consistent results.

5.2 BBS inside and outside Southern Britain

Comparing BBS trends within and outside Southern Britain showed a significant difference for 38 of 73 species. This suggests that for the majority of species, combined CBC/BBS indices should only be produced using data from within Southern Britain. This is not unexpected given the known regional differences in population trends reported in the annual BBS reports. The reasons for the difference in

trends between inside and outside of Southern Britain may be due to differences between these areas in a range of factors from landscape, habitat features and climatic conditions to degree of migratory behaviour in that area. A comparison between BBS inside and outside Southern Britain for all species is shown in Figure 8, highlighting those species for which trends are significantly different.

5.3 Production of combined BBS/CBC indices

Combined indices for Southern Britain were calculated for all species for the period of overlap 1994 to 2000. It is also possible to produce combined indices that span the period from the start of the CBC in to the end of the period of overlap by using all data, from both surveys i.e. CBC for 1965-2000 and BBS for 1994-2000. The trends prior to 1994 would be greatly dominated by CBC data, although these trends would be affected slightly by the BBS data through the parameters correlation structure. Because of the larger number of BBS squares surveyed relative to CBC plots, the combined CBC/BBS trends post 1994 were closer in pattern to the BBS than to the CBC trends. However, because of the intensive nature of the territory mapping methodology, CBC data are likely to be more accurate estimates of true numbers at the individual site level than the BBS. An examination of the level of variance around BBS indices suggested levels four times as great as with the CBC (Field & Gregory 1999). Therefore analysis of CBC and BBS data should perhaps reflect this heterogeneity of variance, and consider its influence upon resulting inference (McCullogh & Nelder 1989; Chapter 10). Models considering this feature of the two sets of data could be considered but for non-normal errors, required by the small numbers present in these data sets, this is not straightforward and these were beyond the scope of the present study.

The results so far have demonstrated that combined CBC-BBS indices are justifiable for most species in Southern Britain. A more difficult question is how to produce combined CBC-BBS indices for the relatively large number of species which show different population trends within and outside the defined area of Southern Britain. If there is no difference in trends (through the analysis of BBS data) between the defined area of Southern Britain and outside this area, then it may be justifiable to use the CBC and BBS data sets from the whole of the UK when producing combined CBC/BBS indices. An important assumption in this process is that the lack of difference in population trends in these different geographical areas holds for the period prior to that tested. This is untestable because there are insufficient historical data from the areas outside Southern Britain: hence the introduction of the BBS in 1994. Clearly, combined historical UK indices are especially likely to be unreliable if the two surveys are incompatible and the BBS suggests a difference between Southern Britain and elsewhere. The tests and decisions involved in calculating short and long-term population trends from CBC/BBS data are shown in Figure 9.

The formal tests of equality carried out in this report should inform decisions made about combining surveys, or combining regions, in the production of a single index. However, we do not advocate merely producing a combined index if, and only if, trends in the two surveys (regions) do not differ significantly after a formal test. Where such a test is significant, yet the two trends appear acceptably similar ‘to the eye’, the significance is a consequence of the high power inherent in a large data set to detect even a small difference. In such cases it may be argued that the production of a joint index remains credible for practical purposes. To identify such species from the BBS/CBC comparison, we plotted the Pearson correlation coefficient for the two surveys against the *p*-values, shown in Figure 10. Identified by the filled triangles are those species, Robin and Wren, with very high correlations in spite of highly significant test statistics. Conversely, we note three species (represented by filled squares) for which formal tests were not nearly significant, yet their trends show negative correlation. Given this fact, although the lack of significance may be used to justify a combined index, the negative correlations act as a warning that the lack of significance may be due to low power/small sample sizes. It would be wise to treat joint indices for these species with caution in this light.

A similar figure was derived for the regional comparisons of Table 2 (Figure 11). Here, once more, are very common species (Blackbird, Robin and Wren) exhibiting high correlation between regions in spite of a formally significant difference. One species alone, Reed Warbler, stands out as producing

both a negative correlation and a very high *p*-value. This species, however, is presently largely restricted to the Fuller square, and trends for this square and the entire UK should scarcely differ as a consequence.

An additional regional weighting as routinely used by the BBS in calculating the annual trend estimates (see Noble *et al*. 2001), could be applied to the data. This would have the advantage that it would help correct for different levels of coverage, even within the area of Southern Britain as defined above. Comparison of weighted versus unweighted BBS trends in this study suggests that for the majority of species, the weighting process has little effect on the resulting indices within Southern Britain. A similar comparison between regionally weighted and unweighted combined CBC/BBS indices could be made to examine the affect of regional weighting on combined indices, for which simulations using hypothetical survey data may be most appropriate. However, note that the sampling strategy is entirely different for the two surveys. BBS squares are selected randomly. CBC sites have irregular boundaries, making the weighting process more complication, and more importantly are selected not randomly but by the observers themselves. Weighting may therefore be inappropriate and has not been applied to CBC data in the past. Before combined CBC/BBS trends were calculated on a routine basis, it would also be important to decide whether it would be more appropriate to produce trends within a specified area with a greater political meaning e.g. England, rather than in this study a square of easting 3000 and northing 5000 of the National Grid. If this were the case, it would be important to establish that CBC and BBS trends within this area (England) were comparable.

Another point that should be considered is whether Generalised Additive Models (GAMs) could be used to improve precision and provide smoothing of species trends. Smoothed population trends are required for the routine reporting of population changes, for calculating alerts and for conservation listings (Baillie *et al.* 2002). The GAM approach, whilst comparable with other analysis techniques has been shown to be best suited to long-term non-linear trends (Fewster *et al*. 2000). Once the complexity of the trend has been specified, the GAM will provide the optimal fit to the data. Other methods commonly used for determining trends, the log-linear Poisson regression and the Mountford method produce abundance estimates with lower precision. The main problem with this approach is the computational time that would be required to complete such analysis on BBS/CBC data with such a large number of sites given that the confidence limits for these trends are produced by bootstrapping. Currently GAMs have been fitted to CBC data using the FORTRAN program GAIM (Hastie & Tibshirani 1990). Alternative methods for fitting smoothed trends to the combined CBC/BBS data may need to be explored.

Acknowledgements

We are grateful to the thousands of volunteers who have contributed to the BTO Common Birds Census (CBC) and BTO/RSPB/JNCC Breeding Bird Survey (BBS), which provided the data on which these analyses are based. The CBC was funded by the Joint Nature Conservation Committee (JNCC) on behalf of English Nature, Scottish Natural Heritage, Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland, whilst the BBS is jointly funded by the BTO, JNCC and the Royal Society for the Protection for Birds (RSPB). We thank Rhys Green, Nicholas Aebischer and Steve Buckland for comments on the report, Helen Baker and Richard Gregory for helpful discussions and those attending the BBS workshop for helpful input: Ian Bainbridge, Helen Baker, Jessa Battersby, Andy Brown, Stephen Cane, Fred Currie, John Custance, Andy Douse, David Gibbons, Jane Goodwin, Richard Gregory, Phil Grice, Ian McLean, Stephen Reynolds, David Smallshire, David Stroud and John Tully. Report production is by Angela Rickard.

References

Baillie, S.R., Crick, H.Q.P., Balmer, D.E., Beaven, L.P., Downie, I.S., Freeman, S.N., Leech, D.I., Marchant, J.H., Noble, D.G., Raven, M.J., Simpkin, A.P., Thewlis, R.M. and Wernham, C.V. (2002) *Breeding Birds in the Wider Countryside: their conservation status 2001*. BTO Research Report No. 278. BTO, Thetford.

Fewster, R.M., Buckland, S.T., Siriwardena, G.M., Baillie, S.R. & Wilson, J.D. (2000). Analysis of population trends for farmland birds using generalised additive models. *Ecology* **8**, 1970-1984.

Field, R.H. and Gregory, R.D. (1999). *Measuring population changes from the Breeding Bird Survey*. Research Report No. 217, British Trust for Ornithology, Thetford.

Fuller, R.J., Marchant, J.H. & Morgan, R.A. (1985) How representative of agricultural practice in Britain are Common Birds Census farmland plots? *Bird Study* **32**, 56-70.

Gregory, R.D., Baillie,S.R., Bashford, R.I. (1995). Monitoring breeding birds in the United Kingdom. Proceedings of the European Bird Census Committee (EBCC) meeting in Estonia.

Hastie, T.J. & Tibshirani, R.J. (1990) *Generalized Additive Models*. Chapman & Hall, London.

McCullagh, P. & Nelder, J.A. (1989). *Generalized Linear Models*. 2nd edition. Chapman & Hall, London.

Noble, D.G., Raven, M.J.& Baillie, S.R. (2001). *The Breeding Bird Survey 2000*. Research Report No. 265, British Trust for Ornithology, Thetford.

SAS. Institute Inc. (1996). SAS/Stat Software: Changes and Enhancements through Release 6.11. SAS Institute, Inc., Cary, North Carolina.

ter Braak, C.J.F., Van Strien, A.J., Meijer, R. & Verstrael, T.J. (1994). Analysis of monitoring data with many missing values: Which method? Bird Numbers 1992. Proceedings of the 12th International Conference of IBCC and OEAC Noordwijkerhout, The Netherlands. Statistics Netherlands, Voorburg/Heerlen & SOVON, Beek-Ubbergen.

Table 1. Comparison between i) BBS and CBC indices within Southern Britain for the period 1994 to 2000 and ii) BBS and CBC indices within Southern Britain using CBC indices calculated for the period 1965 to 2000 and BBS for 1994 to 2000, to increase the power of the tests. Significant findings at the 5% level are highlighted in bold. Pearson correlation coefficient is also given (without *p*-value) for the two indices 1994-2000.

	i) BBS vs CBC (94-00)			*ii) BBS (94-00) vs CBC (65-00)*	
Species	χ^2_6	*p*	r	χ^2_6	*p*
Little Grebe	4.28	0.6384	0.326	4.52	0.6061
Mute Swan	1.89	0.9293	0.404	3.54	0.7391
Shelduck	3.77	0.7071	0.463	4.56	0.6007
Mallard	1.35	0.9689	0.901	1.91	0.9281
Tufted Duck	1.55	0.9562	0.591	1.96	0.9232
Sparrowhawk	2.16	0.9049	-0.023	2.58	0.8595
Buzzard	4.2	0.65	0.890	6.94	0.3266
Kestrel	1.04	0.9841	0.795	1.83	0.9343
Red-legged Partridge	1.66	0.9484	0.572	2.23	0.8969
Grey Partridge	1.38	0.9672	0.940	1.9	0.9287
Pheasant	**22.82**	**0.0009**	-0.171	**33.55**	**<0.0001**
Moorhen	6.12	0.4099	0.650	6.89	0.3313
Coot	2.88	0.8232	0.485	2.51	0.8679
Lapwing	3.23	0.7795	0.634	5.4	0.4934
Curlew	3.51	0.7421	-0.174	3.93	0.6863
Woodcock	9.79	0.134	0.085	12.37	0.0542
Stock Dove	**14.3**	**0.0265**	-0.315	**17.07**	**0.009**
Woodpigeon	2.3	0.8898	0.652	2.69	0.8466
Turtle Dove	1.22	0.9757	0.842	1.93	0.9256
Collared Dove	3.44	0.752	0.926	4.7	0.5834
Cuckoo	7.7	0.2606	0.681	9.75	0.1357
Little Owl	2.32	0.8885	0.618	2.75	0.8399
Tawny Owl	8.03	0.2359	-0.412	10.81	0.0943
Green Woodpecker	6.81	0.3392	0.852	7.25	0.2981
Great Spotted Woodpecker	7.65	0.265	0.653	8.18	0.225
Skylark	9.42	0.1512	0.623	11.48	0.0746
Swallow	8.92	0.1782	0.225	11.03	0.0876
House Martin	4.96	0.5487	0.025	2.81	0.8322
Crow	2.05	0.9149	0.792	3.35	0.7638
Jackdaw	2.35	0.8847	0.831	3.48	0.7467
Magpie	0.82	0.9915	0.645	1.13	0.9802
Jay	5.4	0.4938	0.310	6.99	0.3215
Great Tit	6.07	0.4155	0.860	6.33	0.3871
Blue Tit	3.25	0.7765	0.914	3.82	0.7006
Coal Tit	11.1	0.0853	-0.493	**17.57**	**0.0074**
Marsh Tit	6.59	0.3605	0.239	8.6	0.1975
Willow Tit	5.02	0.5411	0.657	6.88	0.3323
Long-tailed Tit	5.99	0.4245	0.803	7.94	0.2425
Nuthatch	4.75	0.5762	0.551	5.52	0.4787
Treecreeper	9.12	0.1668	0.222	10.68	0.0988
Wren	**19.06**	**0.0041**	0.991	**18.24**	**0.0057**
Robin	**28.37**	**<0.0001**	0.941	**26.17**	**0.0002**
Redstart	7.08	0.3135	-0.247	7.53	0.2742
Blackbird	**12.84**	**0.0457**	0.837	**12.75**	**0.0471**
Song Thrush	5.98	0.4249	0.818	7.1	0.3118
Mistle Thrush	4	0.6773	0.100	4.29	0.6373
Reed Warbler	4.91	0.5559	0.818	7.15	0.3073
Sedge Warbler	2.37	0.883	0.948	2.43	0.8763

Blackcap	9.74	0.136	0.979	11.47	0.0749
Garden Warbler	7.33	0.2913	0.082	6.26	0.3945
Whitethroat	1.13	0.9802	0.983	1.62	0.9509
Lesser Whitethroat	6.4	0.3799	0.771	8.65	0.1945
Willow Warbler	2.49	0.8698	0.965	4.64	0.5912
Chiffchaff	**29.37**	**<0.0001**	0.680	**30.56**	**<0.0001**
Goldcrest	6.36	0.3844	0.924	10.14	0.1189
Spotted Flycatcher	3.02	0.8059	0.571	4.12	0.66
Dunnock	8.07	0.233	0.834	6.86	0.3339
Meadow Pipit	3.59	0.7313	0.445	4.65	0.59
Tree Pipit	2.15	0.9058	0.551	2.52	0.8658
Pied Wagtail	2.43	0.8765	0.806	1.97	0.922
Grey Wagtail	3.03	0.8053	0.436	2.52	0.8659
Yellow Wagtail	7.8	0.2528	0.382	9.36	0.1545
Starling	0.87	0.9902	0.799	1	0.9858
House Sparrow	2.27	0.8936	0.586	2.64	0.8526
Tree Sparrow	2.49	0.8698	-0.143	2.79	0.8346
Greenfinch	2.16	0.9048	0.865	2.78	0.8364
Goldfinch	5.6	0.4694	0.083	6.36	0.3843
Linnet	5.04	0.5388	0.743	7.36	0.2891
Bullfinch	6.58	0.3612	0.778	8.84	0.1828
Chaffinch	**12.87**	**0.0451**	0.657	**12.67**	**0.0485**
Corn Bunting	3.97	0.6803	0.815	6.35	0.3854
Yellowhammer	6.27	0.3934	0.859	5.96	0.4278
Reed Bunting	3.05	0.8023	0.883	3.55	0.7378

Both comparisons between BBS and CBS indices identified seven species out of 73 where the trends were significantly different: Chiffchaff, Chaffinch, Blackbird, Pheasant, Stock Dove, Wren and Robin. A further species, the Coal Tit produced significantly different trends when CBC indices for 1965 to 2000 were compared to BBS indices for 1994 to 2000.

Table 2. Comparison between BBS indices calculated within and outside Southern Britain for the period 1994 to 2000. Significant differences are highlighted in bold. Pearson correlation coefficient is also given (without *p*-value) for the two regions.

Species	χ^2_6	*p*	r
Little Grebe	4.17	0.6543	0.013
Mute Swan	5.66	0.4626	0.582
Shelduck	6.76	0.3435	-0.078
Mallard	6.12	0.4103	0.667
Tufted Duck	**18.29**	**0.0056**	**0.217**
Sparrowhawk	3.37	0.7608	0.745
Buzzard	**17.82**	**0.0067**	**0.686**
Kestrel	**20.01**	**0.0028**	**0.281**
Red-legged Partridge	**13.04**	**0.0423**	**0.708**
Grey Partridge	7.7	0.2611	0.807
Pheasant	**18.25**	**0.0056**	**0.608**
Moorhen	**8.49**	**0.2042**	**-0.286**
Coot	5.46	0.486	0.696
Lapwing	10.08	0.1212	0.885
Curlew	**19.43**	**0.0035**	**0.231**
Woodcock	3.49	0.7457	0.583
Stock Dove	**24.04**	**0.0005**	**-0.263**
Woodpigeon	2.16	0.9048	0.907
Turtle Dove	4.13	0.6589	0.141
Collared Dove	4.26	0.6414	0.801
Cuckoo	**15.92**	**0.0142**	**0.643**
Little Owl	11.02	0.0877	-0.462
Tawny Owl	1.94	0.9251	0.420
Green Woodpecker	**16.96**	**0.0094**	**-0.709**
Great Spotted Woodpecker	4.94	0.5514	0.831
Skylark	**56.47**	**<0.0001**	**-0.139**
Swallow	**49.11**	**<0.0001**	**0.458**
House Martin	**54.93**	**<0.0001**	**-0.020**
Crow	**19.81**	**0.003**	**0.222**
Jackdaw	3.21	0.7819	0.892
Magpie	**14.74**	**0.0224**	**0.384**
Jay	**13.55**	**0.0351**	**-0.307**
Great Tit	**27.32**	**0.0001**	**0.227**
Blue Tit	**25.97**	**0.0002**	**0.664**
Coal Tit	8.53	0.2016	0.676
Marsh Tit	9.17	0.1645	0.148
Willow Tit	7.44	0.2824	-0.051
Long-tailed Tit	**19.71**	**0.0031**	**-0.033**
Nuthatch	10.47	0.1062	0.330
Treecreeper	**13.32**	**0.0382**	**-0.213**
Wren	**86.13**	**<0.0001**	**0.841**
Robin	**33.78**	**<0.0001**	**0.828**
Redstart	7.08	0.3134	0.477
Blackbird	**17.32**	**0.0082**	**0.926**

Song Thrush	**14.31**	**0.0264**	**0.740**
Mistle Thrush	10.23	0.1152	-0.091
Reed Warbler	1.98	0.9217	-0.480
Sedge Warbler	**16.66**	**0.0106**	**0.581**
Blackcap	3.74	0.7118	0.964
Garden Warbler	6.51	0.3687	0.376
Whitethroat	10.64	0.1001	0.808
Lesser Whitethroat	**16.34**	**0.0121**	**0.319**
Willow Warbler	**123.13**	**<0.0001**	**-0.595**
Chiffchaff	**12.65**	**0.049**	**0.828**
Goldcrest	**43.56**	**<0.0001**	**0.686**
Spotted Flycatcher	6.15	0.4066	0.183
Dunnock	**19.61**	**0.0032**	**0.248**
Meadow Pipit	**38.26**	**<0.0001**	**-0.353**
Tree Pipit	**20.55**	**0.0022**	**-0.748**
Pied Wagtail	10.3	0.1127	0.555
Grey Wagtail	**21.05**	**0.0018**	**0.397**
Yellow Wagtail	6.49	0.3707	0.205
Starling	**44.62**	**<0.0001**	**-0.164**
House Sparrow	**42.99**	**<0.0001**	**0.279**
Tree Sparrow	**34.25**	**<0.0001**	**-0.382**
Greenfinch	7.13	0.3087	0.783
Goldfinch	**26.32**	**0.0002**	**0.099**
Linnet	**33.44**	**<0.0001**	**0.282**
Bullfinch	12.26	0.0564	0.861
Chaffinch	7.12	0.3097	0.763
Corn Bunting	5.2	0.5181	0.642
Yellowhammer	10.13	0.1193	0.648
Reed Bunting	11.95	0.0631	0.139

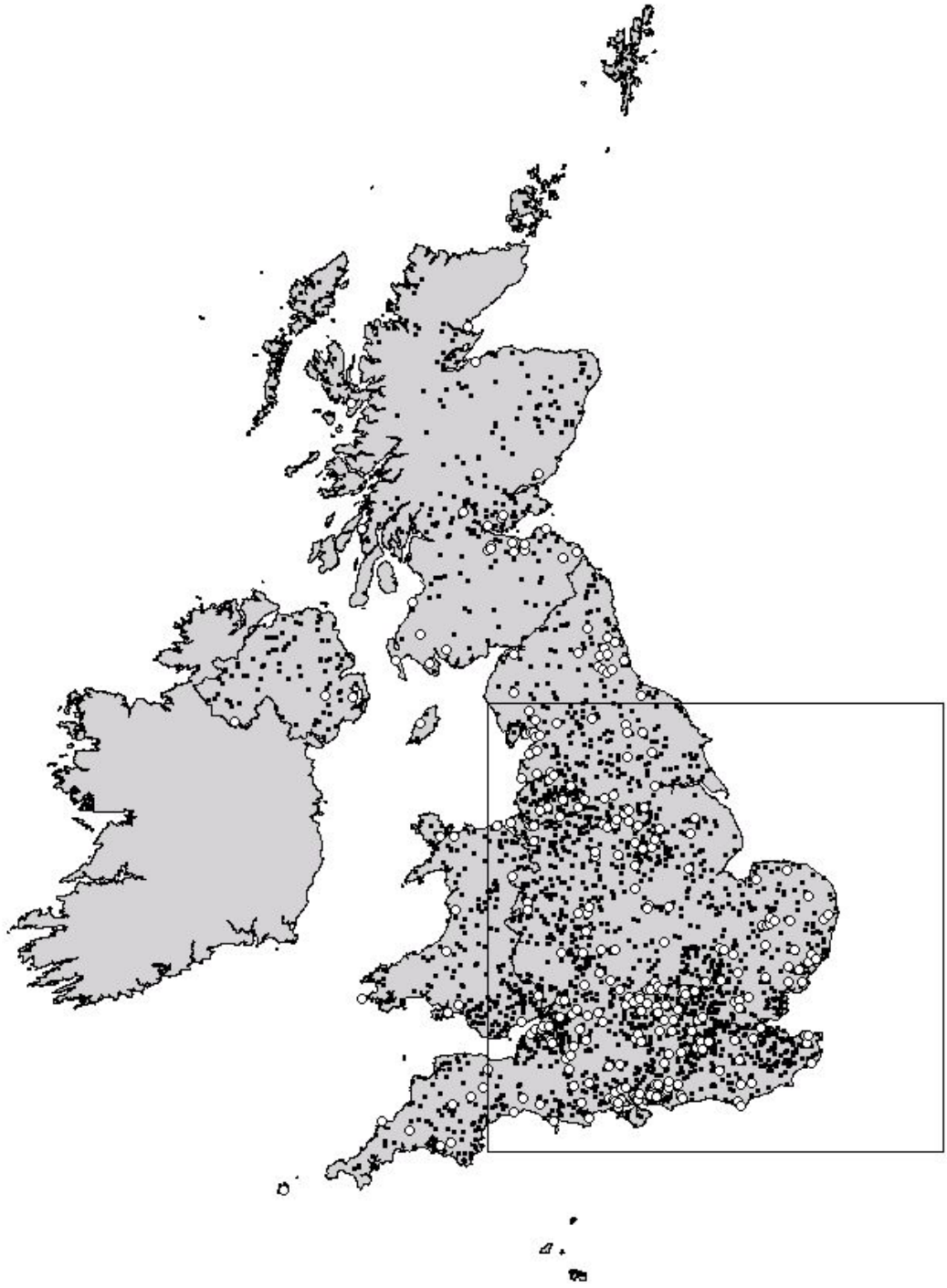
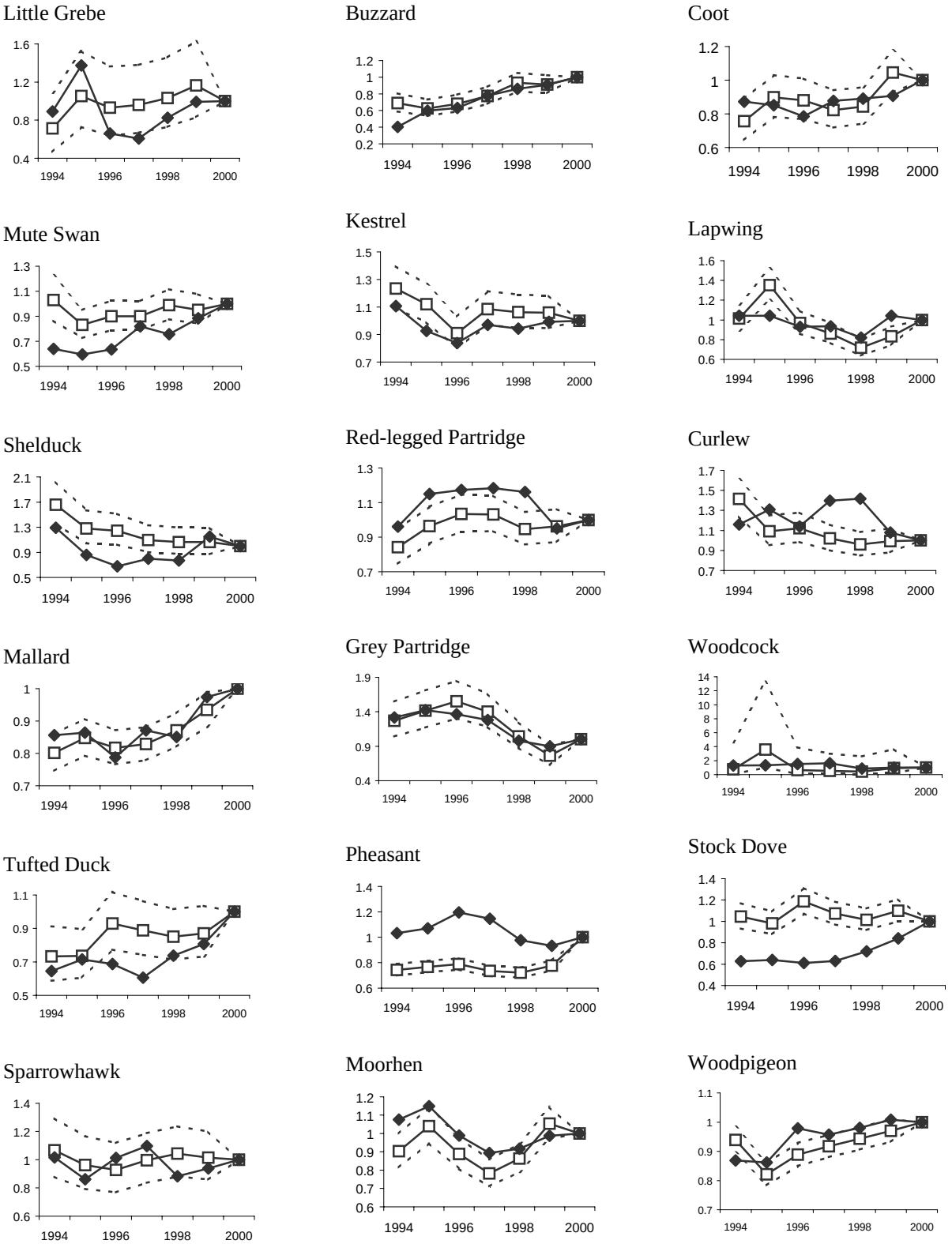
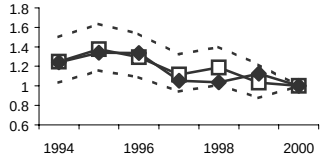


Figure 1. Map of the UK showing the boundary of Southern Britain used in the analyses presented in this report and the location of BBS squares (▪) and CBC plots (○) in 2000. The boundary of Southern Britain is defined by an easting of 3000 and northing of 5000 of the National Grid (after Fuller *et al.* 1985).

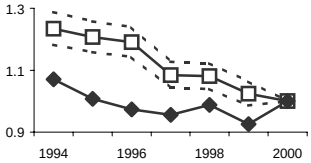
Figure 2. Comparison between BBS (□) and CBC indices (♦) for Southern Britain for 73 species routinely indexed by both surveys for the period 1994 to 2000. The dashed lines represent upper and lower 95% confidence intervals of the BBS indices. Indices are measured relative to the year 2000, which is set to 1.



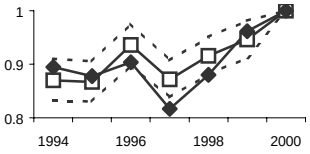
Turtle Dove



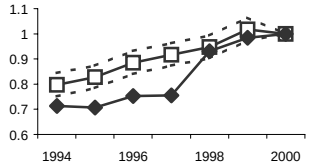
Skylark



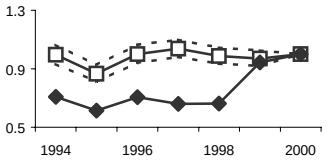
Great Tit



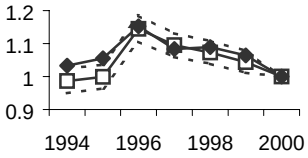
Collared Dove



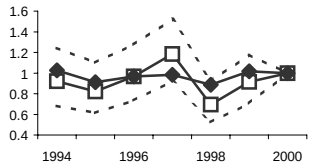
Swallow



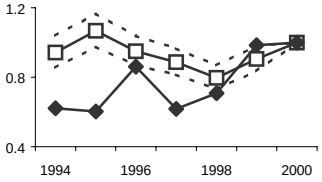
Blue Tit



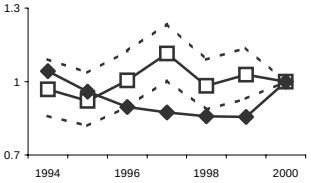
Little Owl



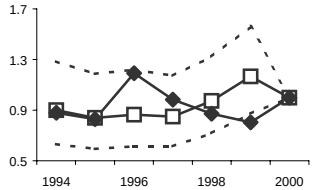
House Martin



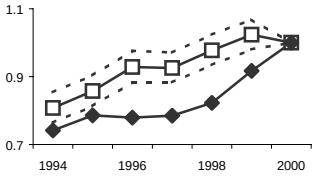
Coal Tit



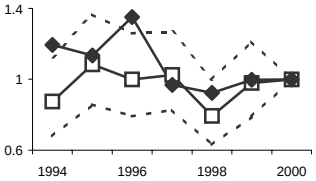
Tawny Owl



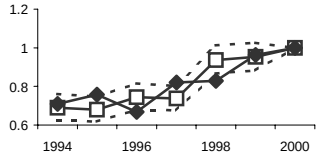
Crow



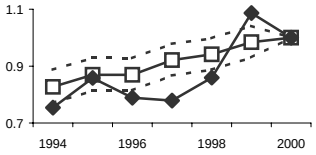
Marsh Tit



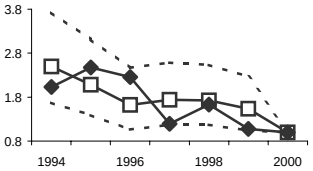
Green Woodpecker



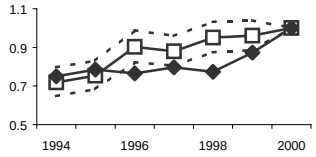
Jackdaw



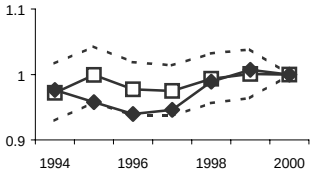
Willow Tit



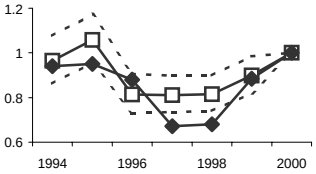
Great Spotted Woodpecker



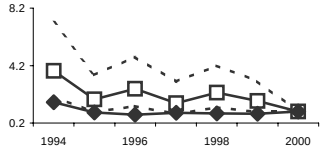
Magpie



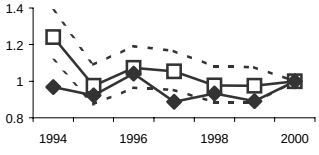
Long-tailed Tit



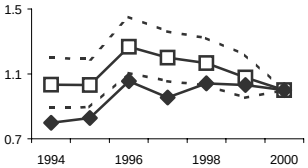
Lesser Spotted Woodpecker



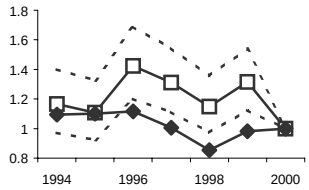
Jay



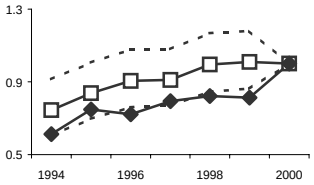
Nuthatch



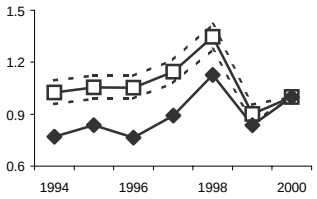
Treecreeper



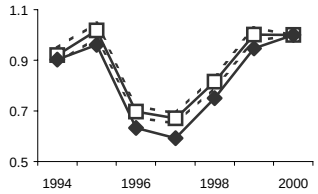
Reed Warbler



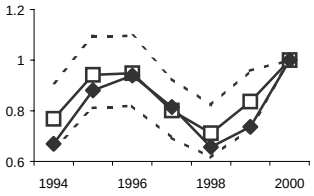
Chiffchaff



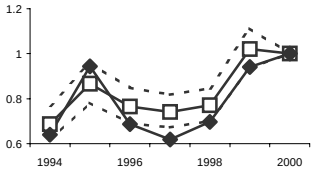
Wren



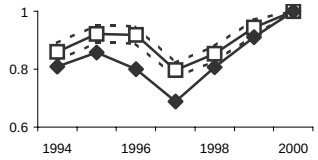
Sedge Warbler



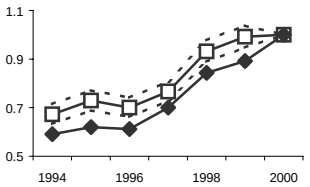
Goldcrest



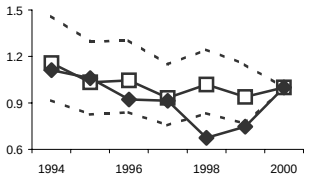
Robin



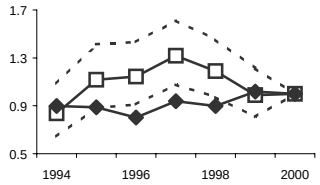
Blackcap



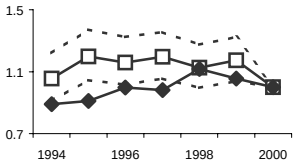
Spotted Flycatcher



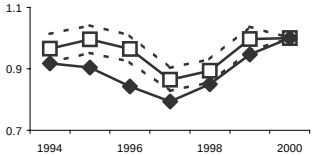
Redstart



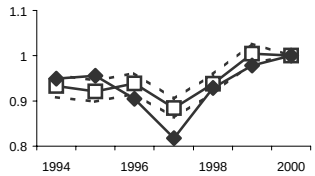
Garden Warbler



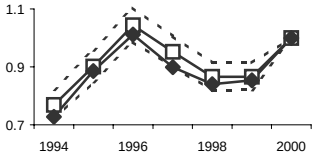
Dunnock



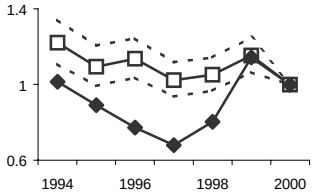
Blackbird



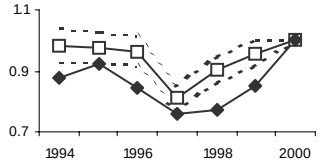
Whitethroat



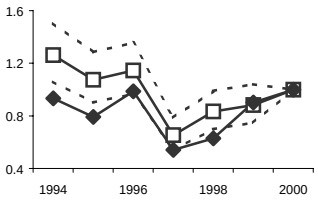
Meadow Pipit



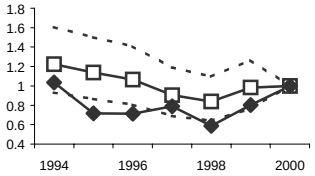
Song Thrush



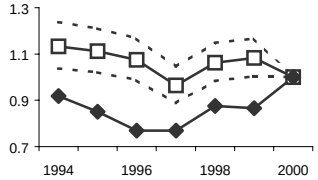
Lesser Whitethroat



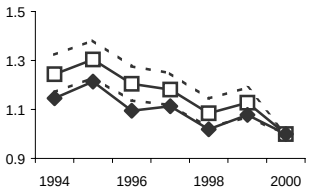
Tree Pipit



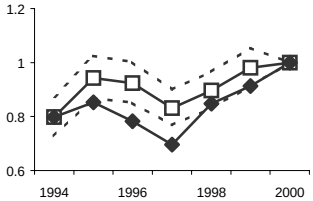
Mistle Thrush



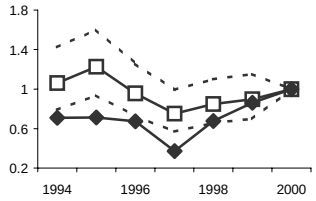
Willow Warbler



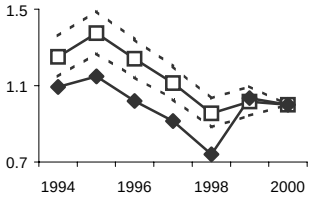
Pied Wagtail



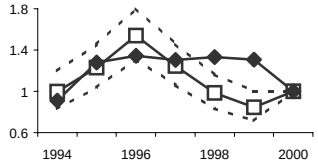
Grey Wagtail



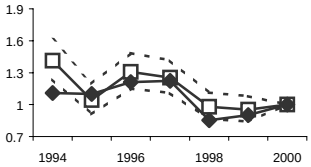
Linnet



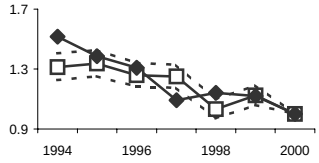
Yellow Wagtail



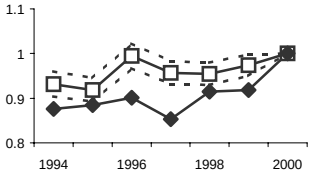
Bullfinch



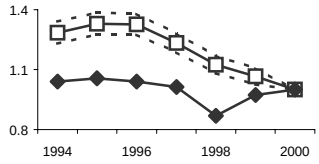
Starling



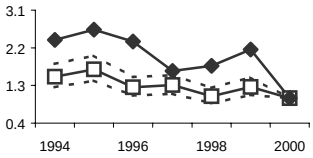
Chaffinch



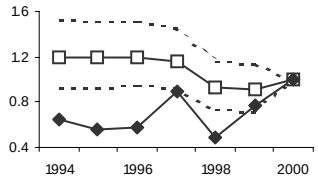
House Sparrow



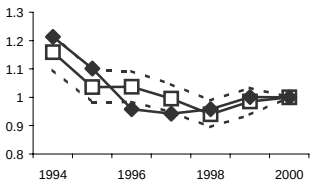
Corn Bunting



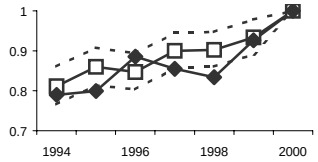
Tree Sparrow



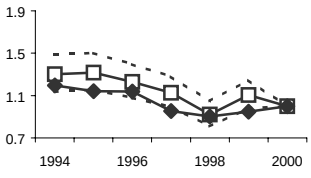
Yellowhammer



Greenfinch



Reed Bunting



Goldfinch

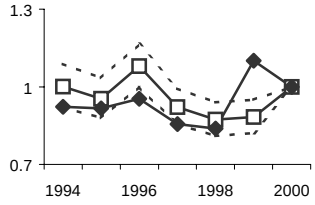
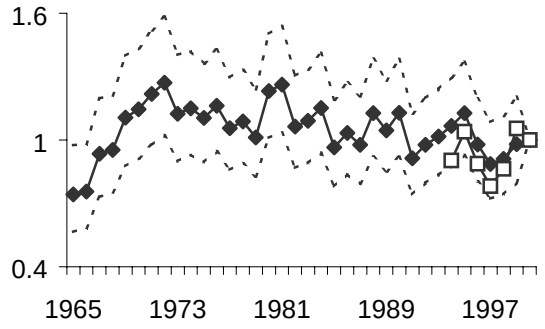
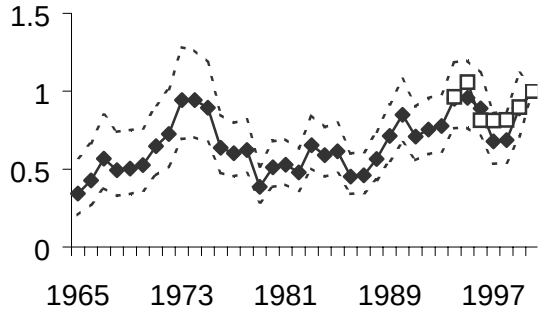


Figure 3. Comparison between BBS (□) for the period 1994 to 2000 and CBC indices (♦) for the period 1965-2000 for Southern Britain for four example species (Moorhen, Great Spotted Woodpecker, Coal Tit, Long-tailed Tit) routinely indexed by both surveys. The dashed lines represent upper and lower 95% confidence intervals of the CBC indices. Indices are measured relative to the year 2000, which is set to 1.

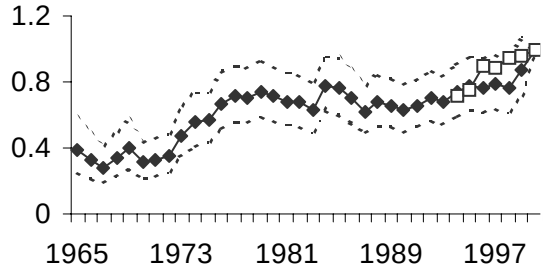
Moorhen



Long-tailed Tit



Great Spotted Woodpecker



Coal Tit

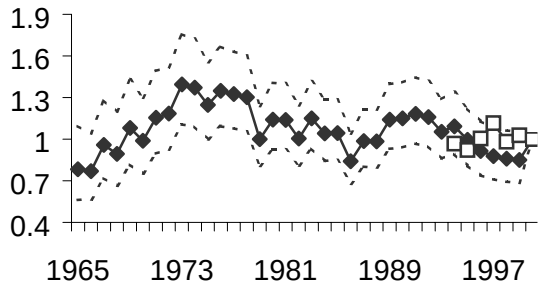
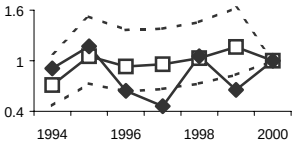
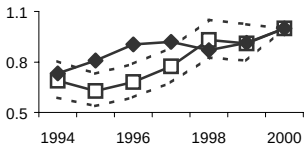


Figure 4. Comparison between BBS indices within Southern Britain (□) and BBS indices outside Southern Britain (♦) for 73 species routinely indexed by the BBS for the period 1994 to 2000. The dashed lines represent upper and lower 95% confidence intervals of the BBS indices. Indices are measured relative to the year 2000, which is set to 1.

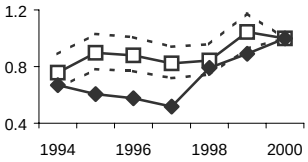
Little Grebe



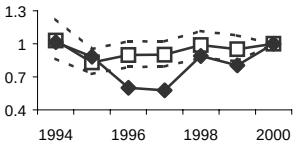
Buzzard



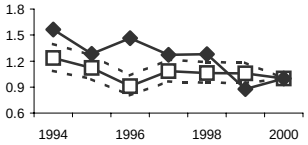
Coot



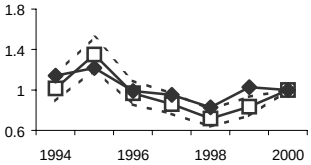
Mute Swan



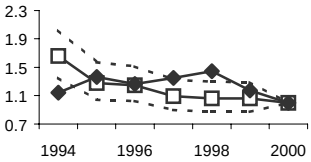
Kestrel



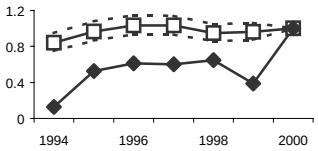
Lapwing



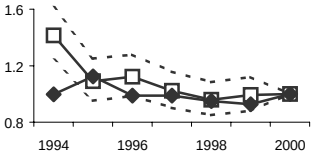
Shelduck



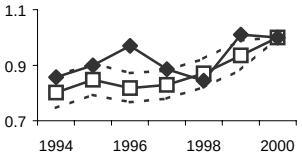
Red-legged Partridge



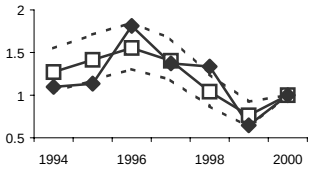
Curlew



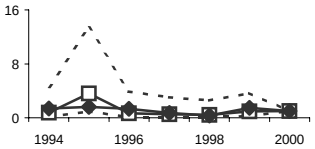
Mallard



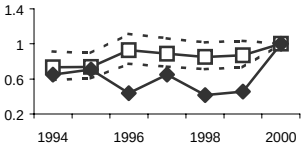
Grey Partridge



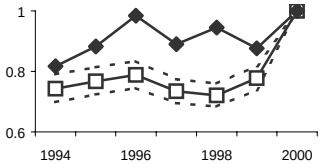
Woodcock



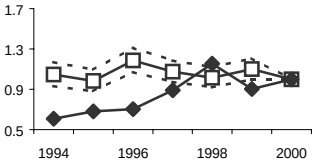
Tufted Duck



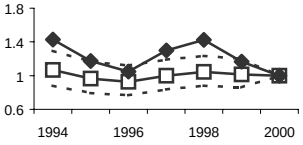
Pheasant



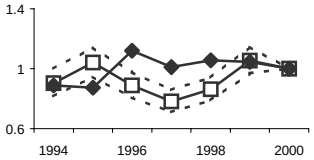
Stock Dove



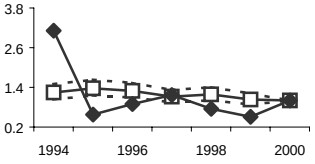
Sparrowhawk



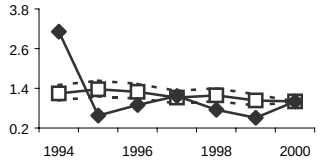
Moorhen



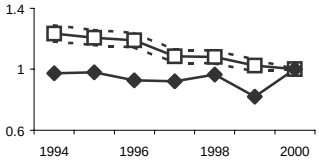
Woodpigeon



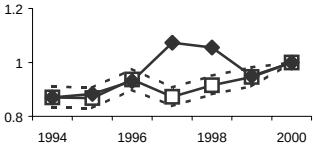
Turtle Dove



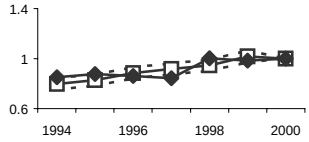
Skylark



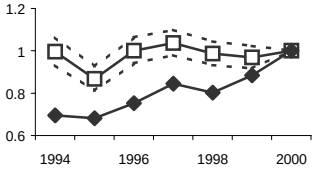
Great Tit



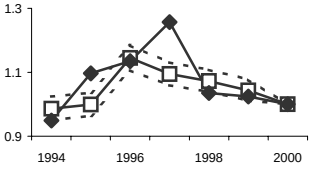
Collared Dove



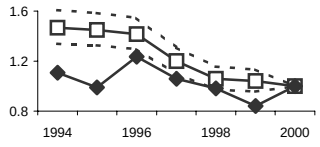
Swallow



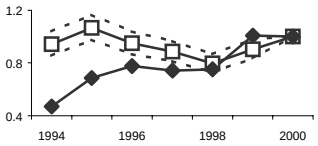
Blue Tit



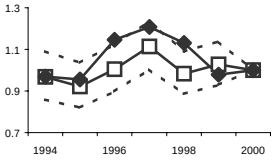
Cuckoo



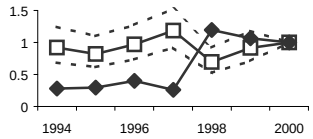
House Martin



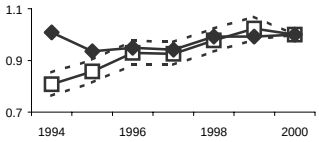
Coal Tit



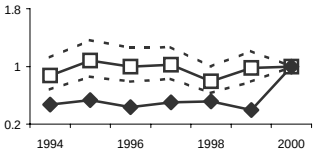
Little Owl



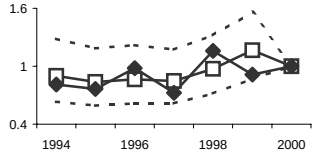
Crow



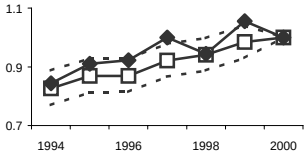
Marsh Tit



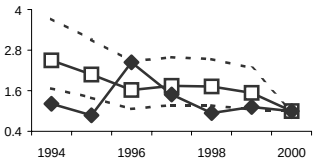
Tawny Owl



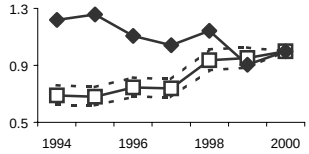
Jackdaw



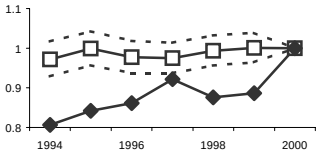
Willow Tit



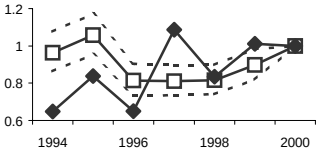
Green Woodpecker



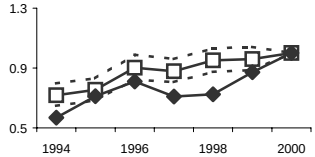
Magpie



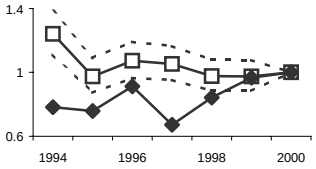
Long-tailed Tit



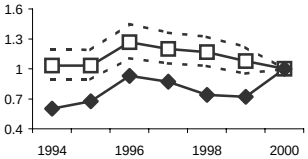
Great Spotted Woodpecker



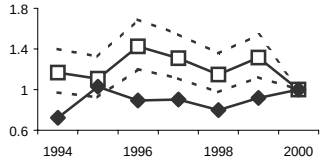
Jay



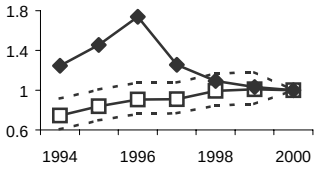
Nuthatch



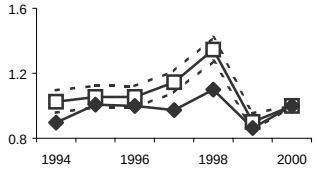
Treecreeper



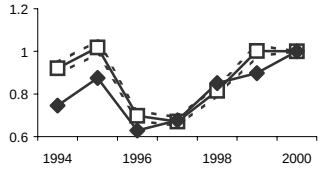
Reed Warbler



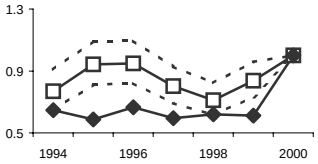
Chiffchaff



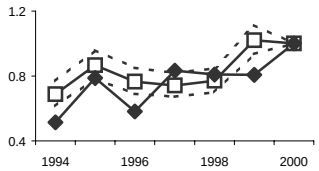
Wren



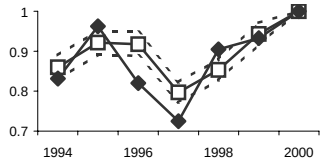
Sedge Warbler



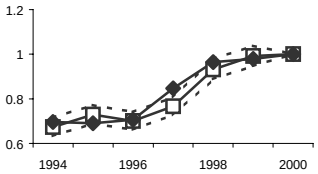
Goldcrest



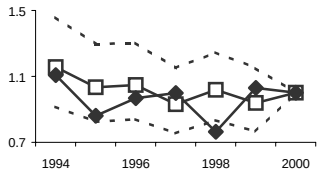
Robin



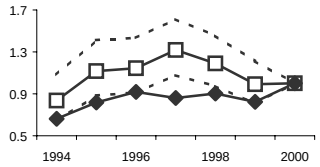
Blackcap



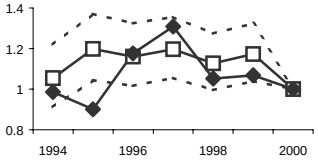
Spotted Flycatcher



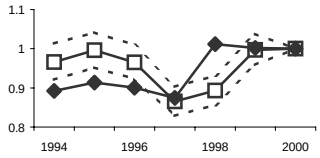
Redstart



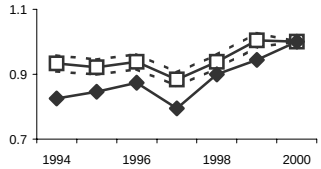
Garden Warbler



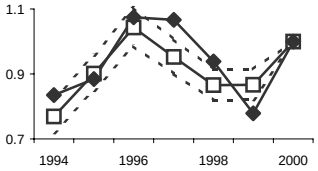
Dunnock



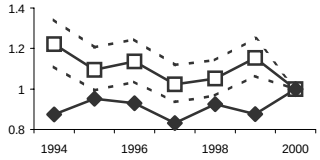
Blackbird



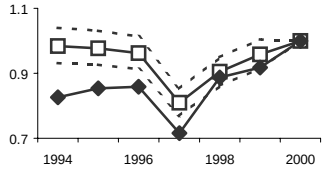
Whitethroat



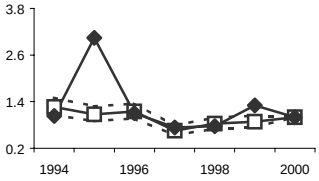
Meadow Pipit



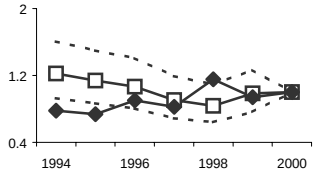
Song Thrush



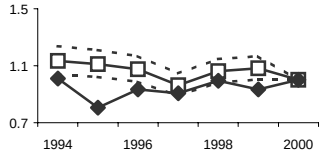
Lesser Whitethroat



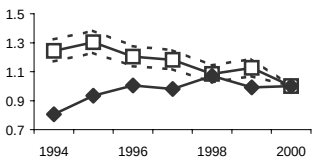
Tree Pipit



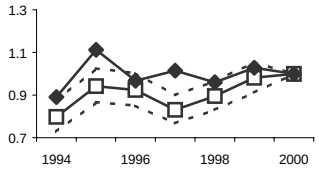
Mistle Thrush



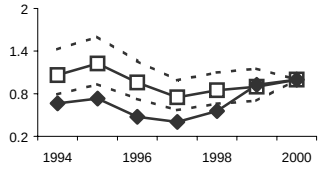
Willow Warbler



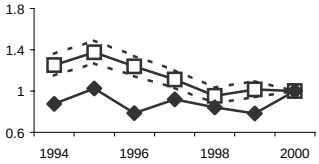
Pied Wagtail



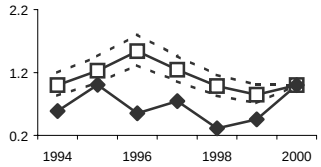
Grey Wagtail



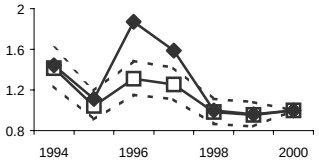
Linnet



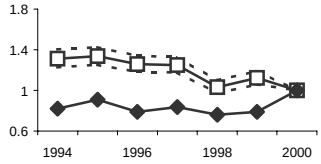
Yellow Wagtail



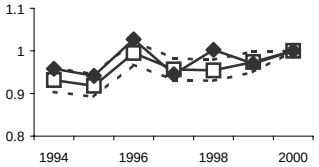
Bullfinch



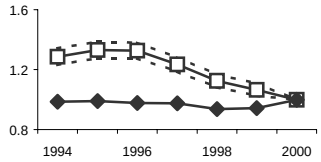
Starling



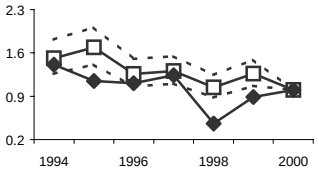
Chaffinch



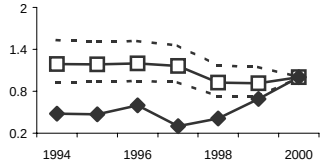
House Sparrow



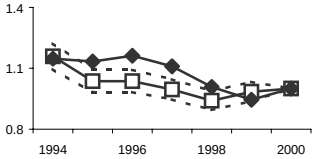
Corn Bunting



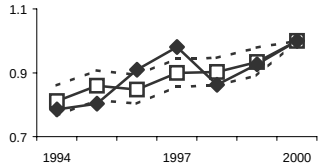
Tree Sparrow



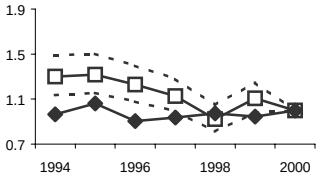
Yellowhammer



Greenfinch



Reed Bunting



Goldfinch

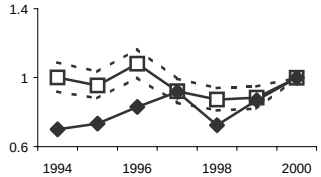
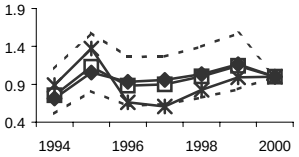
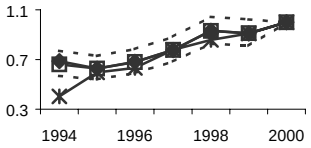


Figure 5. Comparison between BBS indices (♦) and CBC indices (*) within Southern Britain with joint BBS/CBC indices (□) for the period 1994 to 2000. The dashed lines represent upper and lower 95% confidence intervals of the joint indices. Indices are measured relative to the year 2000, which is set to 1.

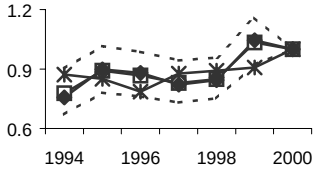
Little Grebe



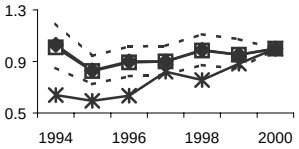
Buzzard



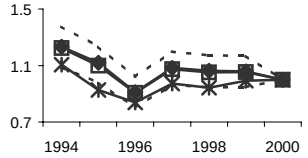
Coot



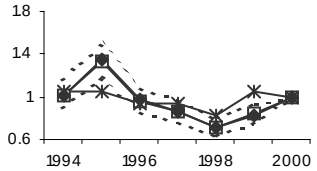
Mute Swan



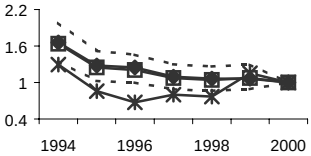
Kestrel



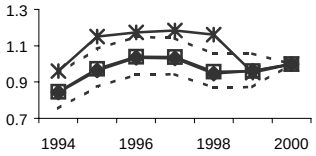
Lapwing



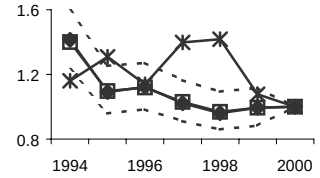
Shelduck



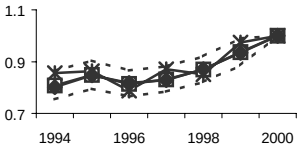
Red-legged Partridge



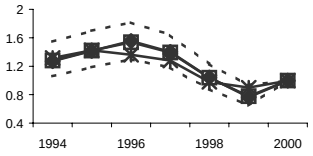
Curlew



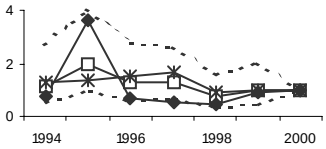
Mallard



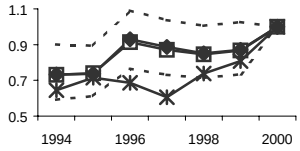
Grey Partridge



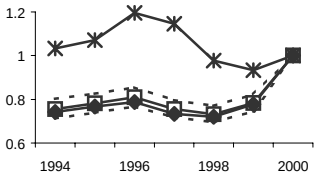
Woodcock



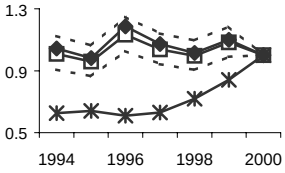
Tufted Duck



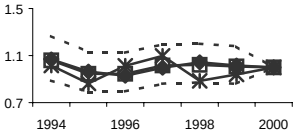
Pheasant



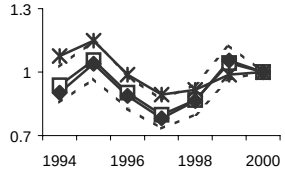
Stock Dove



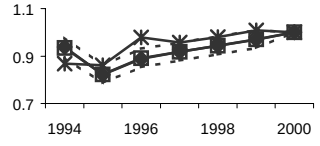
Sparrowhawk



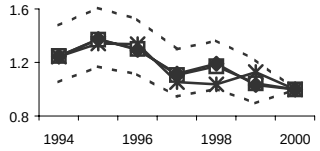
Moorhen



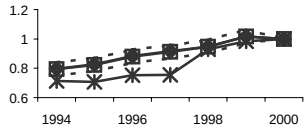
Woodpigeon



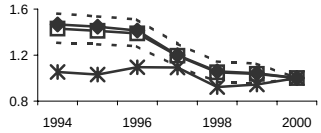
Turtle Dove



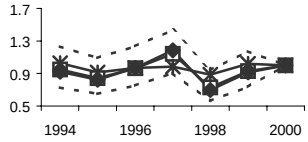
Collared Dove



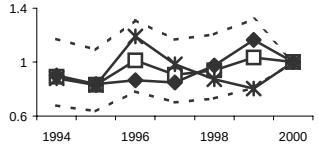
Cuckoo



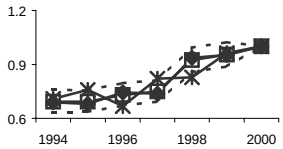
Little Owl



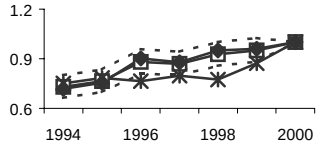
Tawny Owl



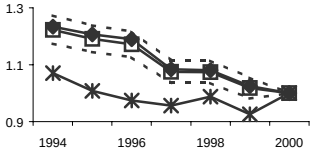
Green Woodpecker



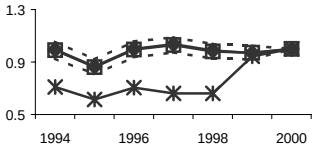
Great Spotted Woodpecker



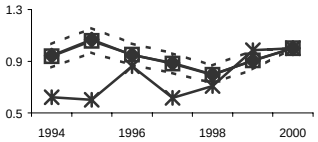
Skylark



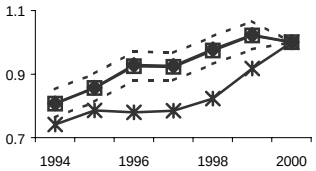
Swallow



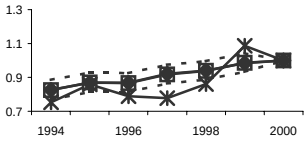
House Martin



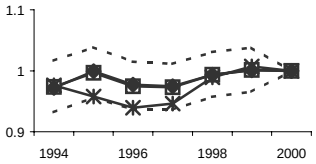
Crow



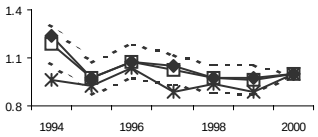
Jackdaw



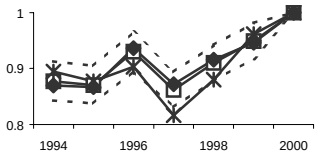
Magpie



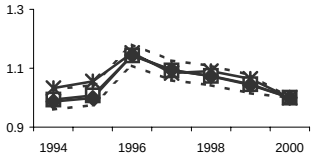
Jay



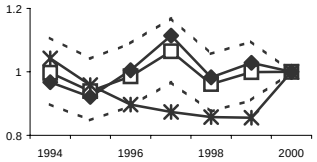
Great Tit



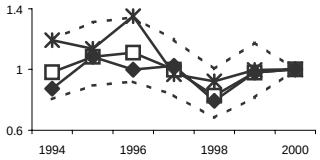
Blue Tit



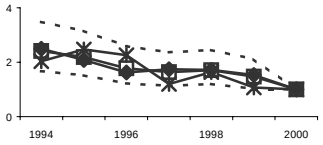
Coal Tit



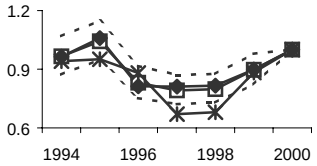
Marsh Tit



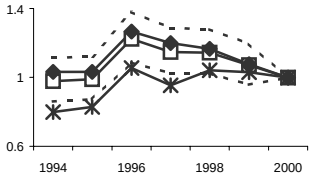
Willow Tit



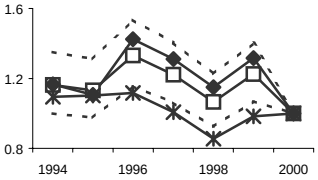
Long-tailed Tit



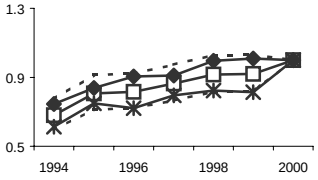
Nuthatch



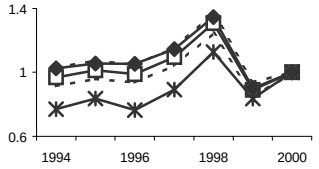
Treecreeper



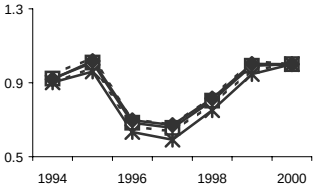
Reed Warbler



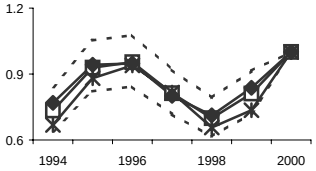
Chiffchaff



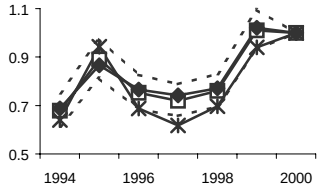
Wren



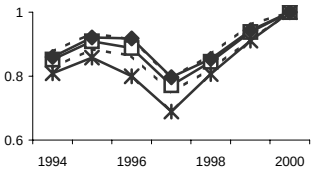
Sedge Warbler



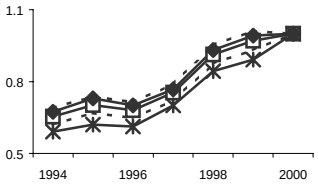
Goldcrest



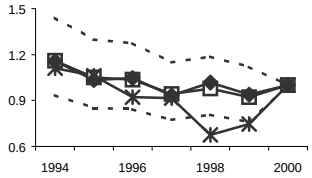
Robin



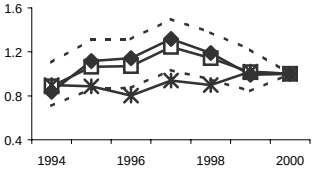
Blackcap



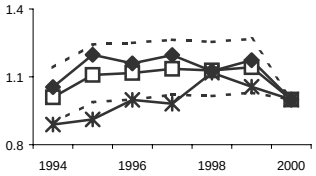
Spotted Flycatcher



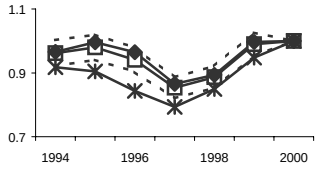
Redstart



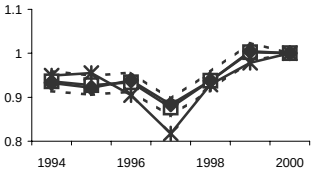
Garden Warbler



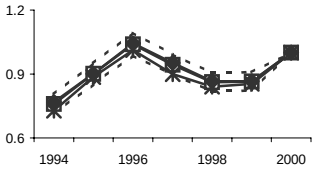
Dunnock



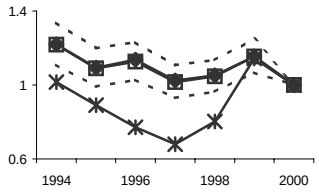
Blackbird



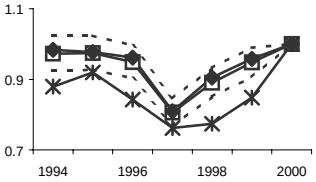
Whitethroat



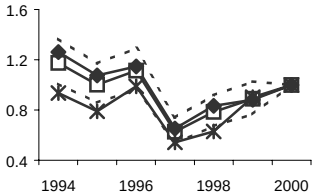
Meadow Pipit



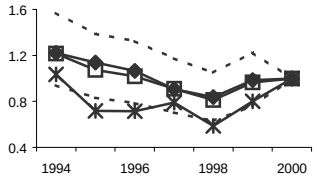
Song Thrush



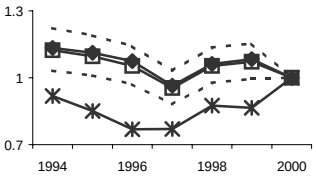
Lesser Whitethroat



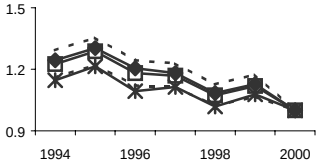
Tree Pipit



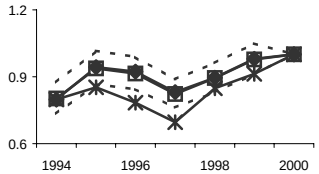
Mistle Thrush



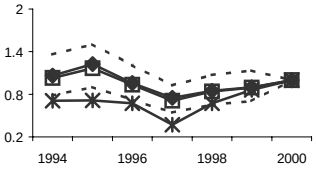
Willow Warbler



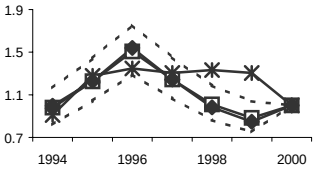
Pied Wagtail



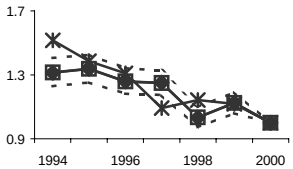
Grey Wagtail



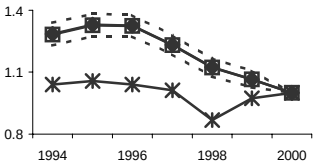
Yellow Wagtail



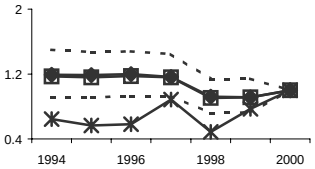
Starling



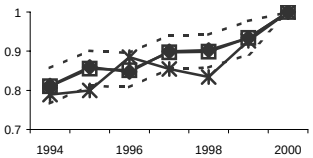
House Sparrow



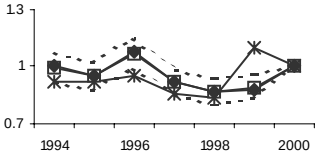
Tree Sparrow



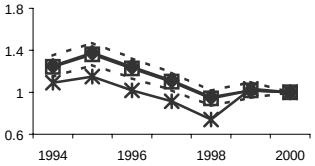
Greenfinch



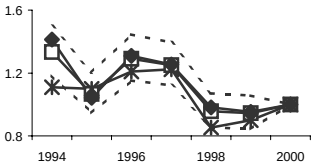
Goldfinch



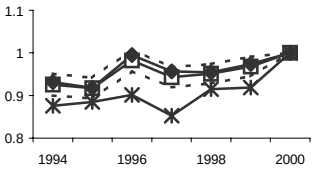
Linnet



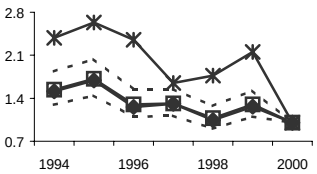
Bullfinch



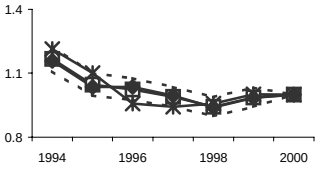
Chaffinch



Corn Bunting



Yellowhammer



Reed Bunting

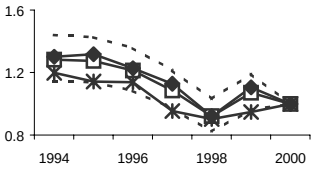
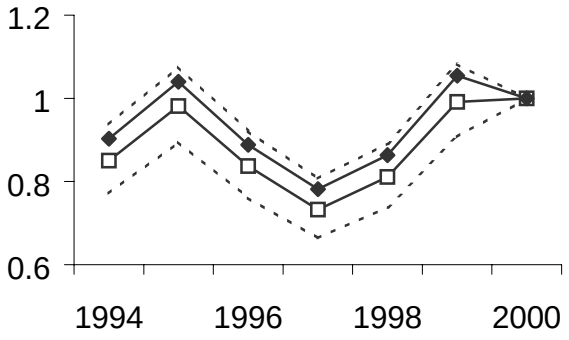
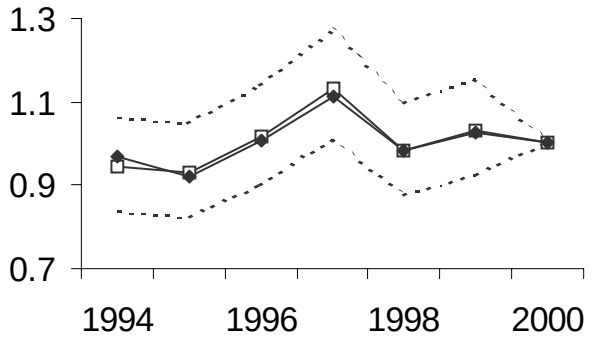


Figure 6. Comparison between unweighted BBS indices (♦) and weighted BBS indices (□) in Southern Britain for four example species (Moorhen, Great Spotted Woodpecker, Coal Tit, Long-tailed Tit) routinely indexed by the BBS for the period 1994 to 2000. The dashed lines represent upper and lower 95% confidence intervals of the weighted BBS indices. Indices are measured relative to the year 2000, which is set to 1..

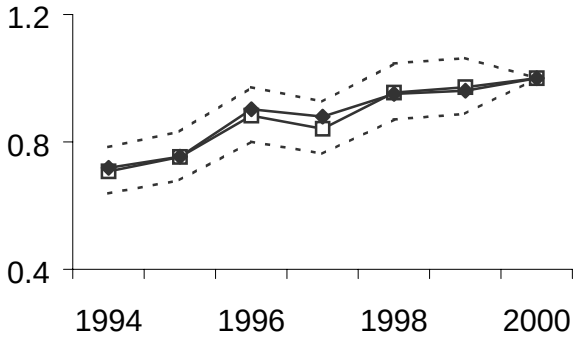
Moorhen



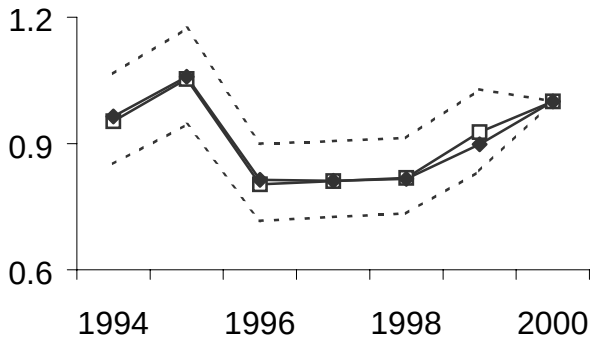
Coal Tit



Great Spotted Woodpecker



Long-tailed Tit



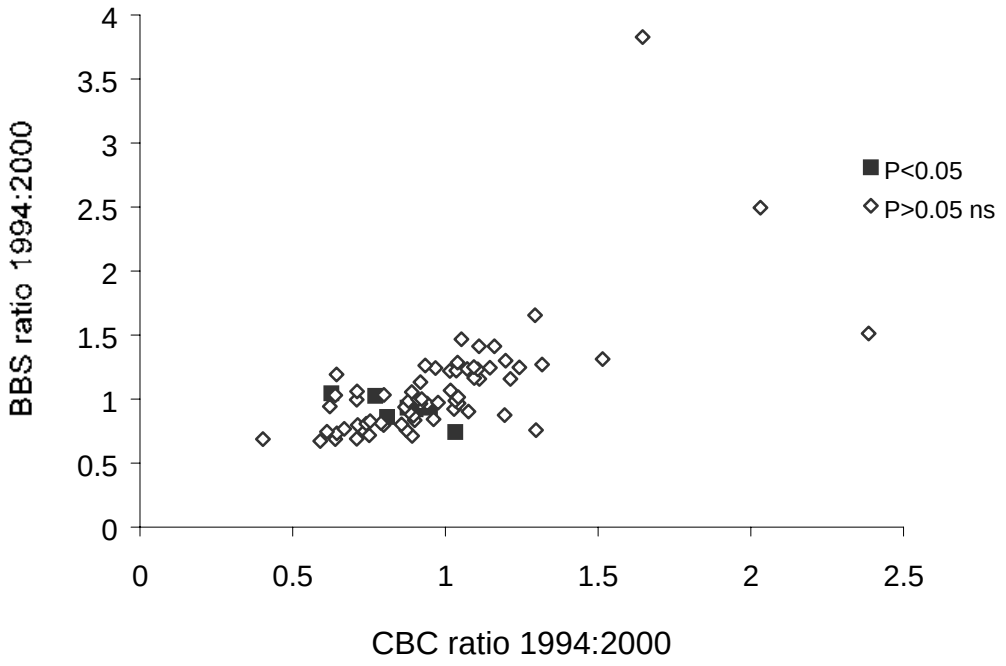


Figure 7. Comparison between BBS and CBC indices in 1994 for 73 species routinely indexed by both surveys, where change is measured relative to the year 2000 which is set to 1.

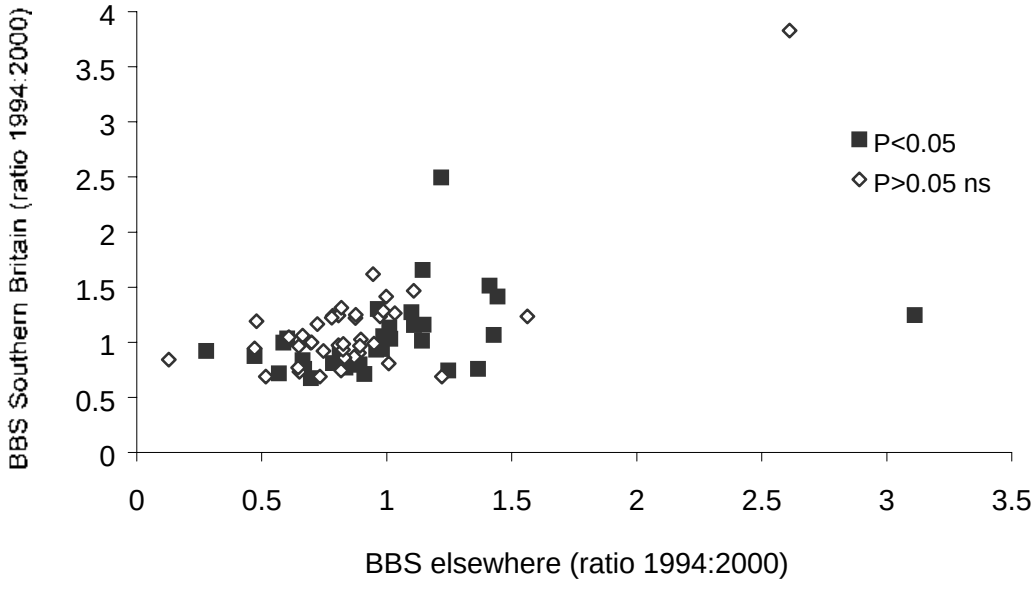


Figure 8. Comparison between BBS indices inside and outside Southern Britain in 1994 for 73 species routinely indexed by the BBS, where change is measured relative to the year 2000 which is set to 1.

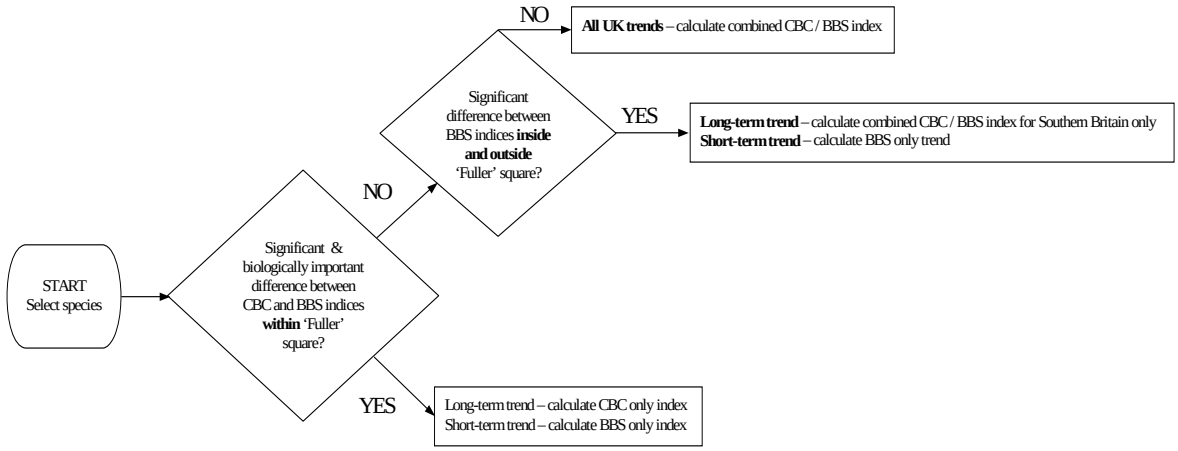


Figure 9. Flowchart showing the decisions made when choosing the most appropriate approach for calculating indices from CBC/BBS data under different scenarios.

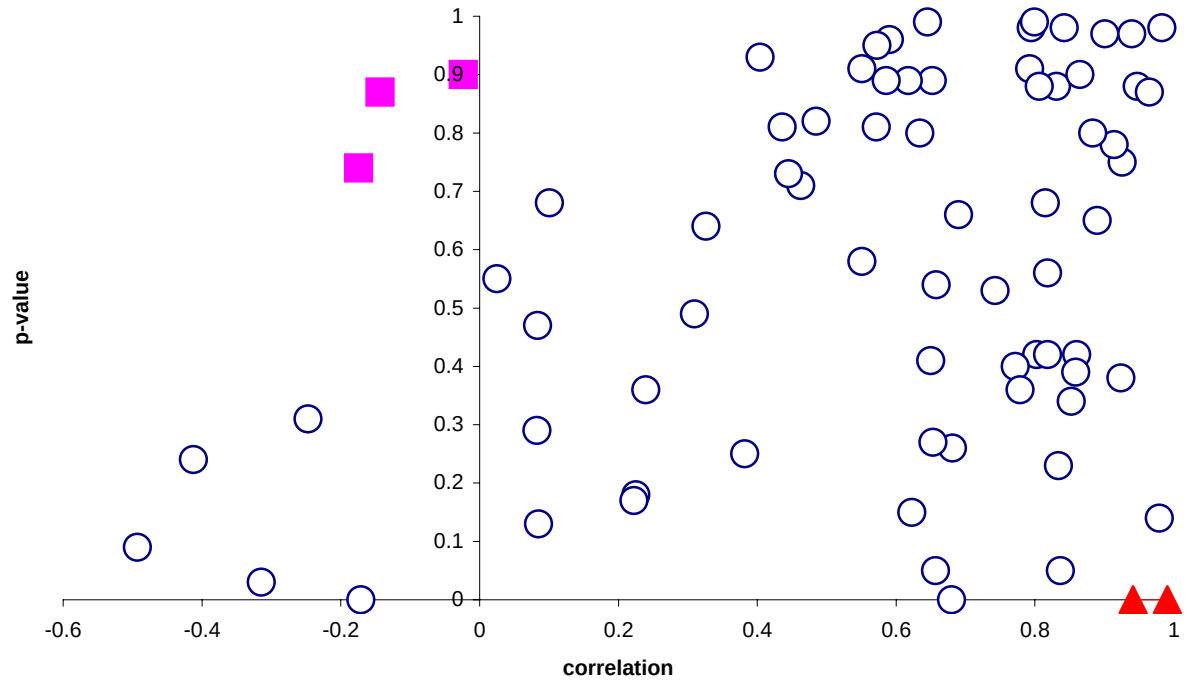


Figure 10. Correlation coefficients versus p-values from Table 1. Represented distinctly are Robin, Wren (filled triangles), Tree Sparrow, Sparrowhawk and Curlew (filled squares).

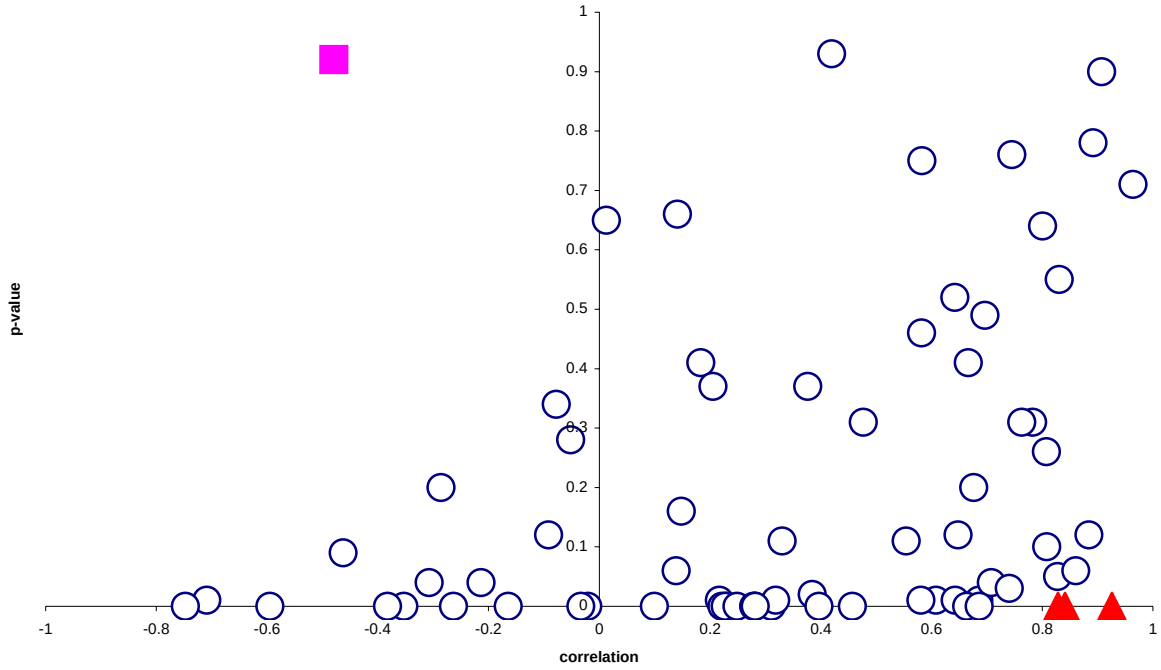
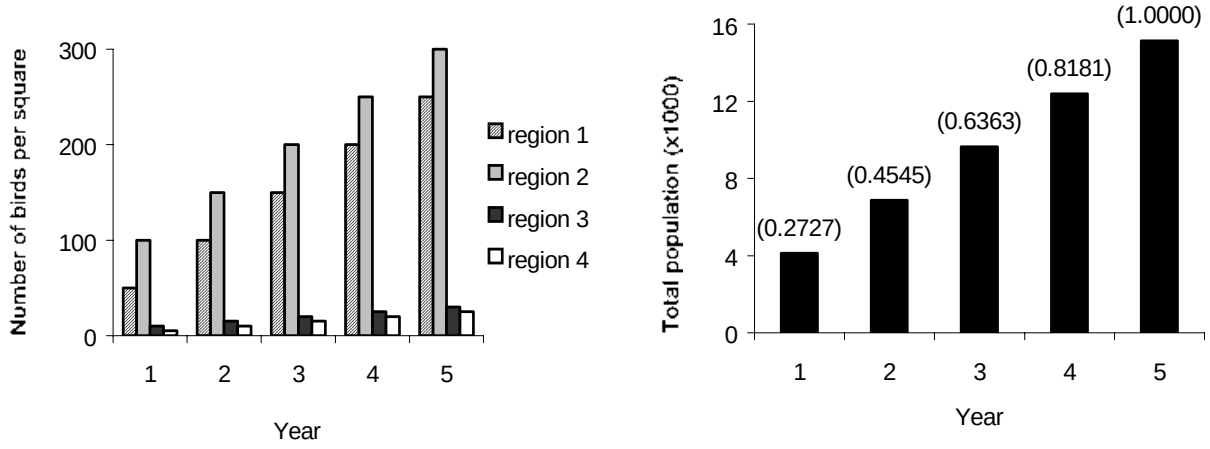


Figure 11. Correlation coefficients versus p-values from Table 2. Represented distinctly are Robin, Wren and Blackbird (filled triangles) and Reed Warbler (filled square).

APPENDIX 1

Regional weighting in BBS analyses – a simulation-based demonstration

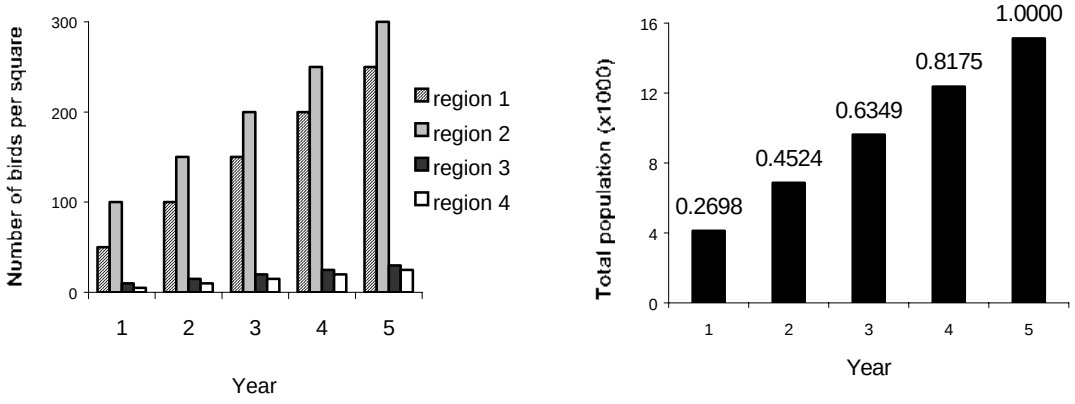
The following artificial simulation was performed to illustrate the importance of regional weighting in BBS analysis. The simulation assumes that the entire population of a hypothetical country (comprising 100 BBS-type squares) is surveyed over a period of five years (perfect coverage). We assume that this country contains four equally sized regions (each containing 25 squares), within each of which the general trends increase. However, the rate of population growth is different between regions varying from a three to five-fold increase and the number of birds observed in each year therefore is different between regions (Figure a). When a generalised linear model (GLM) is applied to these data without weightings, the resulting indices for each year, shown in parentheses are produced, accurately reflecting the relative annual numbers of birds.



(i) (ii)

Figure a. Simulation of population change within four regions of a hypothetical country comprising 100 BBS-type squares (i) over a period of five years and total population size (and relative index of population change) across regions over the five years (ii).

Now suppose instead we have a country of 125 squares; with the additional 25 squares added to region 4, with the same number of birds present on these additional squares as already present in the same year on the rest of region 4, so that region 4 now contains double the number of squares (Figure b).



(i) (ii)

Figure b. Simulation of population change within four regions of a hypothetical country comprising 125 BBS-type squares over a period of five years, where region 4 contains double the number of squares per year as in Figure a (i) and total population size (and relative index of population change across regions over the five years (ii).

Now if the additional squares were not surveyed and we use only squares 1-100 in the GLM we get biased estimates of the national population trend, because the population trend in the squares not surveyed is not the same as the population trend in the whole of the surveyed region. This simulation is a simple analogue of the BBS design, in that population trends are presumably different in different regions but observer coverage also differs.

The weighting method employed (SAS PROC GENMOD subcommand 'SCWGT') corrects for this discrepancy in assumed observer coverage, which occurs in the BBS because of the geographic variation in human population throughout the British Isles. If a weight value of 2.0 is associated with the region 4 in the fitting of the GLM, and one of 1.0 elsewhere, the resulting indices take values in proportion to the entire 125-square population of Figure b. The addition of these weightings leads to deterioration in the quality of the fit. The extent of this deterioration in real BBS analyses though is perhaps surprising, and requires closer examination.