Environment Agency

using science to create a better place

Waterways Breeding Bird Survey: progress and population trends 1998–2004

Science report: SC010012

BTO

SCHO1205BKCA-E-P

The Environment Agency is the leading public body protecting and improving the environment in England and Wales.

It's our job to make sure that air, land and water are looked after by everyone in today's society, so that tomorrow's generations inherit a cleaner, healthier world.

Our work includes tackling flooding and pollution incidents, reducing industry's impacts on the environment, cleaning up rivers, coastal waters and contaminated land, and improving wildlife habitats.

This report is the result of research commissioned and funded by the Environment Agency's Science Programme.

Published by:
Environment Agency, Rio House, Waterside Drive, Aztec West, Almondsbury, Bristol, BS32 4UD
Tel: 01454 624400 Fax: 01454 624409
www.environment-agency.gov.uk

ISBN: 1844325334

Further copies of this report are available from:
The Environment Agency's National Customer Contact Centre by emailing enquiries@environment-agency.gov.uk or by telephoning 08708 506506.

Authors:
John H Marchant, Andrew C Joys, David G Noble & Rachel H Coombes

Dissemination Status: Publicly available

Keywords: Birds; breeding; waterways; survey; monitoring; mammals; conservation, UK

Research Contractor:
British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU
Tel: 01842 750050 Fax: 01842 750030
Website: www.bto.org
Email: info@bto.org

Environment Agency's Project Manager:
Kevin Hall, Warrington Office

British Trust for Ornithology reference:
Research Report 412

Science Project reference: SC010012

Product code: SCHO1205BKCA-E-P

Science at the Environment Agency

Science underpins the work of the Environment Agency, by providing an up to date understanding of the world about us, and helping us to develop monitoring tools and techniques to manage our environment as efficiently as possible.

The work of the Science Group is a key ingredient in the partnership between research, policy and operations that enables the Agency to protect and restore our environment.

The Environment Agency's Science Group focuses on five main areas of activity:

- **Setting the agenda**: To identify the strategic science needs of the Agency to inform its advisory and regulatory roles.
- **Sponsoring science**: To fund people and projects in response to the needs identified by the agenda setting.
- **Managing science**: To ensure that each project we fund is fit for purpose and that it is executed according to international scientific standards.
- **Carrying out science**: To undertake the research itself, by those best placed to do it - either by in-house Agency scientists, or by contracting it out to universities, research institutes or consultancies.
- **Providing advice**: To ensure that the knowledge, tools and techniques generated by the science programme are taken up by relevant decision-makers, policy makers and operational staff.

Steve Killeen Head of Science

Executive Summary

1 Background

The Waterways Breeding Bird Survey (WBBS) was set up in 1998 by the British Trust for Ornithology (BTO), with funding from the Environment Agency. It was designed initially to complement the long-running Waterways Bird Survey (WBS), with a potential for replacing it in the long term. The WBBS uses random site selection, greater species coverage and simpler fieldwork, avoiding the need for territory mapping of individual birds. Its methods are closely modelled on those of the Breeding Bird Survey (BBS), which in 2000 replaced the Common Birds Census as a monitoring method for birds in the wider countryside. The WBBS aims to provide bird and bird–habitat data representative of British waterways, for use in population monitoring and nature conservation. It should supplement the BBS data, particularly for waterbirds, and provide crucial site-specific information on waterway habitats for organisations such as the Environment Agency, concerned with their conservation. Its methods make it directly comparable with the River Habitat Survey (RHS). It is already established as a valuable tool for appraisal of breeding birds along sections of waterway, for example in environmental impact assessment.

2 Aims

Development of the WBBS has been in three phases. Phases 1 and 2, during 1998–2000, established its value as a monitoring tool for breeding birds along waterways. This report concerns Phase 3, 2001–2004. It aims to demonstrate that the BTO can maintain a sample of WBBS surveys sufficient for long-term population monitoring. It also aims to evaluate WBBS data for this purpose and decide how best to analyse them.

The BTO WBS mapping surveys have continued alongside the new scheme, but support for the WBS fell with the inception of WBBS. Since 1999, WBS observers have been encouraged to conduct WBBS transects as well as their mapping surveys on their chosen stretches of waterway. This means there are WBBS data from non-random, self-selected sites, in addition to the random sample of WBBS sites. This report assesses whether it is acceptable and useful to include these sites in the WBBS data for waterways bird monitoring.

3 Results

Random WBBS surveys increased from 108 in 1998 to 217 in 2004. WBS-linked surveys numbered between 64 and 68 during 1999–2004. During 1998–2004, WBBS surveys were conducted on 446 stretches of waterway, comprising 2977 500-m sections (1488.5 km). Samples were greatly reduced during the Foot and Mouth Disease outbreak in 2001, and records from that year are not used in the analyses here.

113 bird species occurred on more than five stretches in at least one year. The five most abundant species in 2004 were Wood Pigeon, Mallard, Chaffinch, Wren and Blackbird, with the most abundant first. The most widespread species were Chaffinch, Wren, Blackbird, Mallard and Wood Pigeon.

Around 90% of WBBS observers record mammals. Rabbit and red deer were the most abundant mammal species recorded. In 2004, water voles were found on 6% of stretches, American mink on 10% and otter on 18%. WBBS samples are currently too small to allow useful assessments of mammal population change. The BTO is examining the scope for combining data from the WBBS and BBS, for waterside mammals, to maximise the monitoring samples.

The WBS plots showed statistically significant population changes for five species between 2003 and 2004. These were Grey and Pied Wagtails (up) and Sedge Warbler, Whitethroat and Reed Bunting (down).

Comparisons of trends between the WBBS and WBS were generally favourable but revealed major discrepancies for some species. These may be due to the short and interrupted run of years available for this comparison, or in some cases to differences in the units of counting. A longer run of years, and alternative treatment of large flocks on WBBS counts, might improve the agreement between WBS and WBBS trends.

Including non-random WBBS sites conducted by WBS observers increases both monitoring precision and the range of species that can be monitored, and has relatively little effect on the resulting population trends. The entire sample provides enough data to monitor more than 70 bird species, including at least 25 waterbird species.

Weighting the WBBS counts regionally during the analysis gives trends that are more representative of the UK, and allows for future regional stratification of the sample.

Population trends from WBBS counts were calculated by summing the maximum count from each section to obtain a count for each stretch. This method gives greater precision than that used routinely by the BBS, which sums counts from all sections for each visit and takes the maximum of the two visits.

4 Conclusions and recommendations

Where linear waterways are the major habitat of a species, the WBBS is likely to give a more reliable indicator of UK population change than the BBS, because the quantity of appropriate habitat being sampled is larger.

The BTO proposes that the WBBS and WBS continue in parallel for at least a further two breeding seasons, 2005 and 2006, to allow the calibration of WBBS and WBS trends to be improved, and to consolidate the WBBS sample. This may pave the way for the WBBS eventually to replace the WBS as the way of monitoring breeding birds of linear waterways.

Should the mapping census be terminated in favour of the WBBS, the report recommends including WBBS data from WBS-linked sites, to ensure that the goodwill and expertise of the current WBS volunteers are retained.

The position of an ongoing WBBS in the UK’s breeding bird monitoring strategy needs to be more clearly established among interested parties.

Contents

1 Introduction

Monitoring the populations of breeding birds along linear waters is important because rivers and canals are components of the countryside that are rich in birds and not covered well by general monitoring programmes. Detailed data collection for birds, alongside habitat recording, can help towards the conservation of wildlife along rivers and canals. The British Trust for Ornithology (BTO) currently runs two separate schemes that have these aims: the Waterways Bird Survey (WBS) and the Waterways Breeding Bird Survey (WBBS).

1.1 The Waterways Bird Survey (WBS)

In the Waterways Bird Survey (WBS), which began in 1974, BTO volunteers conduct mapping censuses alongside linear waters, both rivers and canals, throughout the United Kingdom. The primary role of the WBS has been to record population changes among species poorly represented in the BTO's other monitoring schemes, principally the Common Birds Census (CBC). Carter (1989), Marchant *et al.* (1990), Marchant & Balmer (1994) and Newson *et al.* (2003) have provided overviews of the WBS and its results.

The territory-mapping method, used by both the CBC and the WBS, produces high-quality maps of the activity recorded for each bird species during the breeding season. These data can also be used to investigate, at a variety of spatial and temporal scales, the ways in which breeding birds use the habitats available to them. Since observers can choose their own survey sites, however, the resulting distribution of sites is non-random and potentially biased. Because the mapping method is labour-intensive, surveys are relatively few in number. These problems were addressed by the introduction of a new scheme, the Breeding Bird Survey (BBS), run jointly by the BTO, the Joint Nature Conservancy Council (JNCC) and the Royal Society for the Protection of Birds (RSPB).

The BBS was introduced in 1994, specifically to take over from the CBC as the main way of measuring bird population changes in the wider countryside. After 39 years of operation, and a seven-year overlap period between the BBS and the CBC, the CBC ceased in 2000. Population trends of common birds are now monitored by the BBS index series, beginning in 1994, and by joint CBC/BBS trends, most of which date from 1966 (Baillie *et al.* 2006).The WBS continues, alongside the BBS, supplying valuable extra data on a small number of specialist waterside bird species (Baillie *et al.* 2006).

The WBS suffers the same disadvantages for bird population monitoring as the CBC. In addition, the WBS covers only a set list of waterside bird families and species, and so provides no information on more widespread bird species as they occur in the waterside environment. These drawbacks are all addressed by applying BBS-style transect methods to waterside surveys (Marchant *et al.* 1996).

1.2 Origins and development of the Waterways Breeding Bird Survey (WBBS)

With this background, the BTO has been developing a Waterways Breeding Bird Survey (WBBS) since 1998, in conjunction with the Environment Agency. The overall aims of the project are to:

- develop a transect method suitable for collecting breeding bird survey data from random waterway sites;

- test its implementation;

- use the method to supplement long-term monitoring data from the BBS and WBS, and to provide bird and bird–habitat data relevant to nature conservation along waterways.

In Phase 1 of the survey in 1998, methods of field survey and plot selection were tested (Marchant & Gregory 1999), and breeding bird numbers along canals were studied in relation to the timing of the coarse fishing season (Marchant *et al.* 1999).

In Phase 2, 1999–2000, the non-random canal sample was dropped, and WBBS coverage was extended to include WBS observers, who were invited to contribute to the WBBS as well as to the WBS on their (self-selected) sites. Also in Phase 2, WBBS bird data from randomly selected sites were compared with River Habitat Survey (RHS) habitat data collected from the same sites by the Environment Agency (Marchant & Noble 2000, Marchant *et al.* 2002). A major innovation of the WBBS is that it is linked to the RHS, with data for both schemes collected for 500-metre sections of waterway (Marchant & Gregory. 1999).

It was clear from Phases 1 and 2 of the WBBS that the method is valuable as a quick and easy way to assess bird populations in river sections. The data can be used at local or catchment scales, for example for pre- or post-project site appraisals, or to identify river or canal sections of special conservation value. Use of the method by the BTO's UK-wide network of volunteers allows large samples to be surveyed nationwide and enables us to assess changes in breeding bird numbers in the waterside habitat.

1.3 Phase 3 of the WBBS, 2001–04

Phase 3 of WBBS development, the subject of this report, continued the same protocol as Phase 2 but increased the size of the annual sample. It aims to demonstrate that the BTO can maintain a sample of WBBS surveys sufficient for long-term population monitoring, and to evaluate the WBBS data for this purpose. We have continued collecting WBS data from our observers, to enable comparisons between census samples.

The 2001 breeding season was expected to mark the beginning of Phase 3. Unfortunately, this was prevented by the outbreak of Foot & Mouth Disease (FMD) in February 2001, which imposed severe restrictions on access to most of the UK countryside. No additional fieldwork was requested from BTO volunteers in 2001. Many observers were prevented from repeating surveys made in earlier years; others were able to make only one of the two survey visits, after access restrictions to their stretches were lifted mid-season (Marchant, Noble and Beavan 2002). Active promotion of the WBBS to increase the sample size was postponed until 2002, and fieldwork, originally planned to finish in 2003, was extended, with support from the Environment Agency, to include 2004. Marchant & Noble (2003) and Marchant & Coombes (2004) provide progress reports on the first two full field seasons of Phase 3. Fieldwork in spring 2004 brought Phase 3 to a close.

This is the final Phase 3 report. It describes all the WBBS data from 1998–2004 and evaluates their use for monitoring waterside breeding bird populations.

The following questions are addressed here:

- *What is the effect of taking maximum counts by section rather than by stretch?*

- *To what extent does weighting the results of each survey, according to the regional take-up of randomly selected sites, affect the estimation of population trends?*

- *How do the estimates produced from randomly selected and from WBS-linked WBBS data compare?*

- *What is the most effective way to use WBBS data to estimate population trends?*

- *For which species are WBBS data adequate to estimate population trends for 1998–2004?*

- *How do WBBS trends compare with those produced from WBS and from BBS data for the same period?*

- *How could waterside breeding birds best be monitored in future?*

Since the conclusion of Phase 3, fieldwork for a further season of WBBS counts has continued in 2005, using the same protocol as in 2004. Environment Agency support expired with the production of this final Phase 3 report, so other funding was required for the 2005 fieldwork. This has been supplied by the BTO. The extent of coverage in 2005 has yet to be determined but is expected to be similar to that in 2004. A number of randomly selected sites were surveyed in 2005 for the first time. It is anticipated that the 2005 data can become part of the monitoring series, although additional funding will be required for processing and analysing the results.

2 Methods

2.1 Methods of the Waterways Bird Survey (WBS)

2.1.1 Fieldwork

Taylor (1982) and Marchant (1994) describe WBS procedures in full. Territory mapping is used, which produces an estimate of breeding numbers and a map of breeding territories for each species, stretch and year (see Figure 1). Details of the habitats available are also mapped. Plots are chosen by the observers, under guidance from BTO staff, and are stretches typically 4–5 kilometres long with easy access and at least one bank that can be walked. Observers are asked to make nine visits to their site each breeding season. Coverage is restricted to waterside specialist birds such as grebes, ducks, geese, swans, waders, and reedbed passerines.

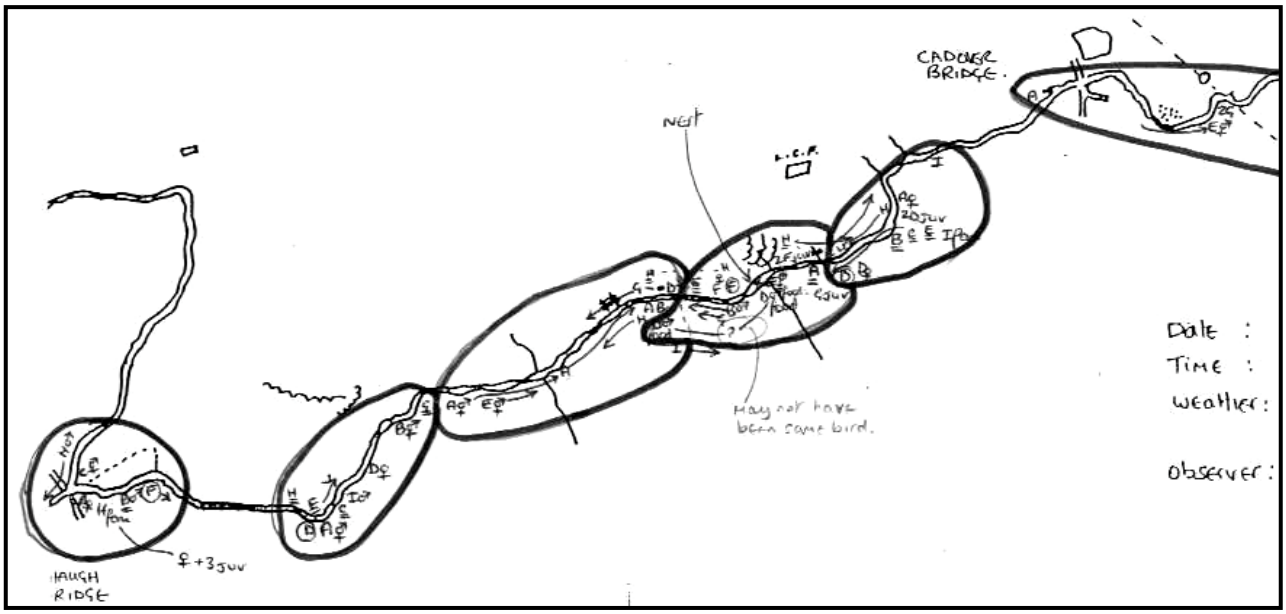


Figure 1. Example species map from the Waterways Bird Survey. The species is Grey Wagtail *Motacilla cinerea*.

By 2004, the WBS had completed 31 seasons of mapping fieldwork and recorded very valuable information on population change and relationships between birds and habitat (e.g. Rushton *et al.* 1994, Baillie *et al.* 2006). WBS mapping surveys continued as usual in spring 2005.

Table 1. Numbers of WBS mapping plots surveyed during 1998–2004. 'Slow' rivers have a gradient of <5 m/km and generally lie in a broad valley, and 'fast' rivers have a gradient of >5 m/km.

WBS plot types	1998	1999	2000	2001	2002	2003	2004
Fast rivers	22	18	20	5	24	21	21
Slow rivers	53	49	42	5	38	37	41
Canals	39	31	30	12	26	24	26
Other or mixed types	7	6	6	2	4	3	3
Total	121	104	98	24	92	85	91

The number of WBS mapping plots began to fall with the inception of the WBBS in 1998 (Table 1). A very low total was achieved in 2001 because of FMD but, apart from this, the low point was 2003, when only 85 surveys were completed. Special efforts to reverse this downward trend began to be successful in 2004, when the number of surveys rose substantially.

2.1.2 Calculation of population change

The units of WBS mapping results are 'apparently occupied territories', whereas for the WBBS and BBS they are numbers of birds counted. Long-term monitoring from WBS data is possible for around 24 species that occur typically on at least 15 plots in each year, where number of territories can be modelled as a function of year and site (e.g. Newson *et al.* 2003).

As opposed to long-term trends, year-to-year changes from the WBS are typically presented using a chain-index method that pairs the year-1 and year-2 data for those plots that were surveyed in both years (e.g. Marchant and Coombes 2003). This approach is used here to consider population change between 2003 and 2004. Only WBS plots where coverage was similar in 2003 and 2004 contributed to the calculations, and individual counts that were not comparable between the two years were excluded.

2.2 Methods of the Waterways Breeding Bird Survey (WBBS)

2.2.1 Selection of sites

The WBBS uses random waterway sites for bird surveys. This sampling strategy allows the results to be treated as representative of waterways throughout the United Kingdom.

The following procedure was used to select waterways randomly. First, we made a list of all 2 x 2-km national grid squares in the UK (omitting only those where the south-western 1-km square held no land), and ranked them in random order. Next, beginning at the top of the list, we examined each tetrad on the Ordnance Survey (OS) 1:25,000 map, discarding those without a waterway running through them, until the required number of tetrads with waterways was identified. The number of tetrads selected initially was 201; this figure was set higher than the target sample size of surveys, to allow for sites that proved inaccessible, for example, or did not attract a volunteer. Third, we assigned each selected tetrad to its BTO region and gave it a regional priority ranking based on the original random numbering. When it was necessary during the development of the WBBS, we identified additional waterway tetrads by returning to the original ranked list of tetrads, and comparing further batches of tetrads with the OS maps.

The 2 x 2-km tetrad was chosen as the most appropriate grid-square size because, in trial runs, too many 1-km squares held no waterway, while larger squares (5 x 5 or 10 x 10 km) frequently held more than one waterway, and raised questions about which to select from within the square. The River Habitat Survey uses 10-km squares and always takes the stretch of river closest to a predetermined point within the square.

We needed a clear definition of the water bodies to be included. Should ditches and drains be included, for example? What about headwaters, and broad or tidal stretches of rivers? We defined a waterway as any double blue line, with shaded in-fill, on the OS 1:25,000 Pathfinder/Explorer/Outdoor Leisure map series. OS informed us that this is any feature 6.5m wide or more (W. Debeugny, personal communication, 1998). Single blue lines, typically minor headwaters and drainage ditches, were ignored, as were all non-linear water features, or linear

features less than 500 metres long. Rivers were considered to finish at the normal tidal limit as marked 'NTL' on the OS maps; no upper width limit was applied.

No stratification was employed in creating the sample, since it was not required to meet the aims of the survey's initial phases. Stratification could be applied to the WBBS in the future, for example on the basis of waterway type, RHS data, water quality, waterbird density or observer density. It could be used to reduce the variance of the results or make more efficient use of available manpower.

For each selected random waterway, an A4-sized map was prepared showing the boundaries of the random tetrad (positioned centrally) and the selected waterway. The waterway was picked out with a highlighter pen, typically for several kilometres in both directions beyond the tetrad boundary. These maps were sorted by BTO region and sent to the relevant BTO Regional Representative (RR), who matched each site with an observer. Sites were referred to by the grid reference of the south-western 1-km square of the selected tetrad.

Observers were asked to set start and end points of the actual survey stretch within the highlighted length of waterway, taking account of the following:

- *the tetrad location;*
- *the requirement for a whole number of complete 500-m transect sections;*
- *convenience of access;*
- *the observer's preference for the number of sections to be covered (maximum ten).*

This method was designed to ensure that access problems could be overcome in a large majority of cases, and a survey route set up that could be used on a long-term basis.

Aside from the random stretches, the WBBS sample has also, since 1999, included a substantial number of non-random stretches chosen because there are WBS mapping data available for the same sites. These are referred to in this report as 'WBS-linked' or 'non-random' stretches and are treated separately in most analyses. They differ from the random stretches in their geographical distribution, and may be biased towards places that are richer in breeding birds.

Surveys at sites falling into neither of these categories, such as the canal sites selected for their fishing seasons in 1998, are no longer requested.

2.2.2 Fieldwork methods

The BBS method has proved to be enjoyable, popular with observers, and well suited to its purpose. Modifications to BBS procedures were therefore kept to a minimum.

In the BBS, two visits are made to each transect, termed 'early' and 'late', one in the first and one in the second half of the breeding season, April–June (Raven *et al.* 2005). The transect route is divided into up to ten sections of fixed length. During each visit, all birds seen or heard are counted, section by section, in each of three distance bands from the transect line (0–25 metres, 25–100 metres, and >100 metres, summing counts from both sides of the transect line); birds seen only in flight are recorded separately.

WBBS instructions and recording forms are based heavily on those designed for the BBS. Some details of the forms were altered slightly between 1998 and 2000 but, once established, the field methods of the WBBS have been kept constant. Forms for 1998 and 1999 are appended to the reports from the WBBS for those seasons (Marchant and Gregory 1999, Marchant and Noble 2000). These contain full details of fieldwork methods and recording.

The methods for the WBBS differ from those of the BBS as follows:

- *routes within sites follow the waterway, rather than a predetermined pattern based on the national grid;*
- *the sections composing each transect stretch are each 500 m, to match the RHS's section length, whereas in BBS they are 200 m;*
- *transects are not fixed at 2 km, as BBS transects are, but are of variable length, with a maximum of 5 km (ten 500-m sections);*
- *habitat recording is extended from the BBS standard to allow extra information to be recorded about the waterway itself.*

Other aspects of fieldwork and analysis are identical. The WBBS follows the BBS in having a reference 1-km square for each survey site, even though the nominal reference may miss the actual survey by 2–3 km – especially in cases where the waterway runs through the opposite (northeast) corner of the selected tetrad, or where the observer has elected to survey a stretch that runs adjacent to rather than through the tetrad.

As in the BBS, mammals and signs of mammals were noted on each counting visit. For each species of wild mammal detected, either presence or a pair of counts (one early in the season and one late) was recorded. Observers coded the main features of up to three habitat types per 500-m section of waterway, of which the first habitat was the waterway itself and the other one or two were those considered by the observer to be the most important adjoining habitats. The system of habitat coding used was that devised by Crick (1992) and now used for all BTO monitoring surveys.

The WBBS requires only two visits to count birds, compared to the WBS's nine, and so is much quicker and simpler for observers. The WBBS transect data require relatively little processing and so analysis is faster. Importantly, its random sampling design ensures that the results are representative of the waterway habitat.

2.2.3 Coverage achieved by the WBBS in 1998–2004

Figure 2 shows the wide geographical scatter of the randomly selected plots, but also the absence of stretches in some parts of the UK. The pattern of their distribution follows from the area-based method of selection, which is more likely to score a hit with random tetrads that lie in the upper reaches of a catchment, where the density of river courses is greatest. Few stretches were selected in coastal regions and there were concentrations in some areas of higher ground, for example the Grampians, Southern Uplands and Welsh Marches. Eastern East Anglia, where river courses are few and well scattered, was barely represented in the sample. Just two of the tetrads selected there contained a waterway.

Within each region, BTO RRs sought volunteer observers to cover as many of their selected sites as possible, beginning at priority 1 and working down the list. RRs distributed survey packs and collected completed forms for return to the BTO.

To promote the non-random, WBS-linked section of the sample in 2004, WBBS packs were distributed to all current WBS observers with a request to contribute to both surveys. Similar appeals had been made annually during 1999–2003.

In all, 1356 WBBS surveys were conducted between 1998 and 2004, on 446 different stretches of waterway. The numbers of stretches and sections surveyed each year are shown in Table 2. Totals of stretches for 1999, 2000 and 2003 are one higher than those given in the previous report, because they each include a return that was received well after the set deadlines. Any

late data still to be submitted for 2004 or earlier years will be included in future summaries and analyses.

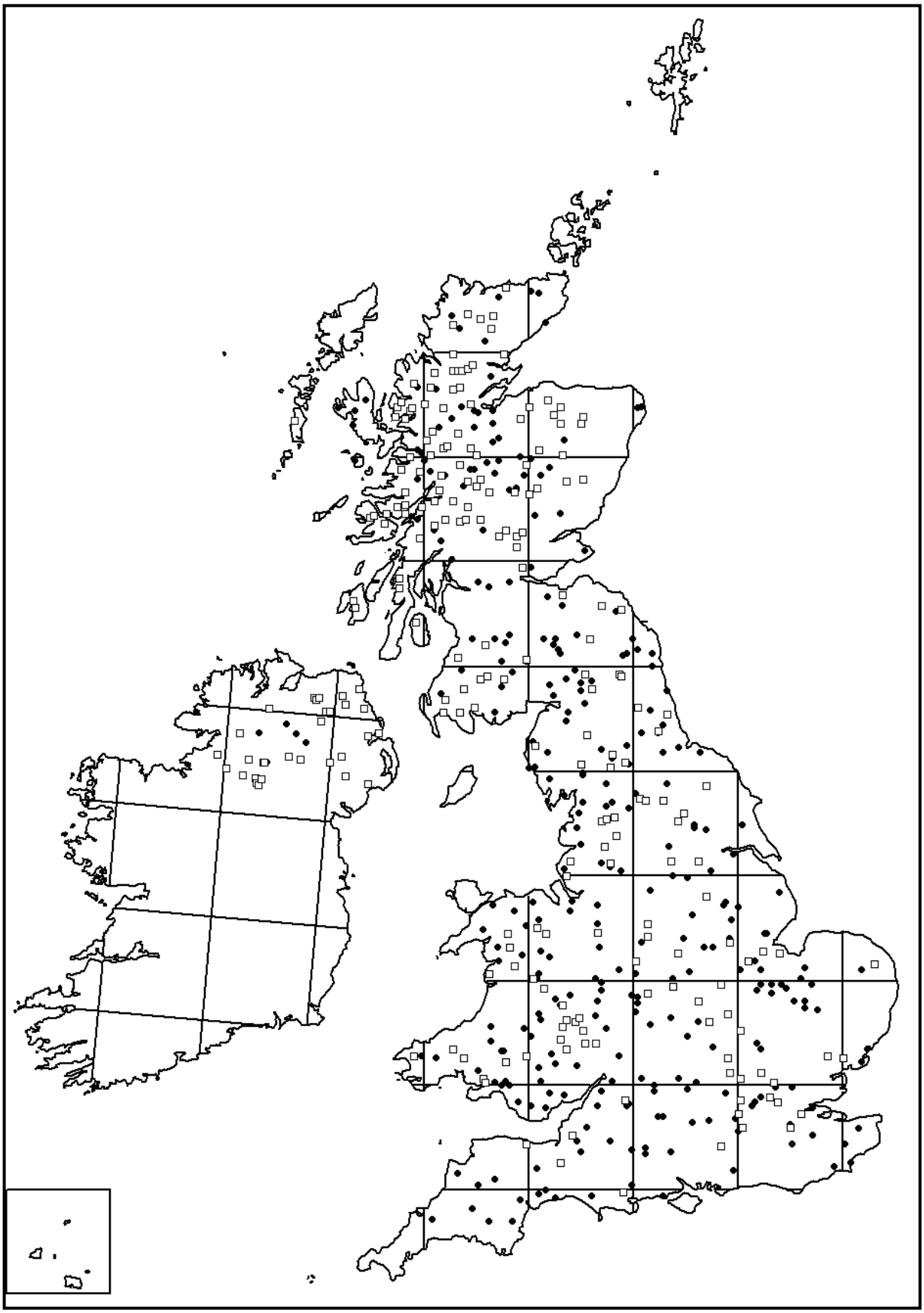


Figure 2. **Distribution of the 529 random WBBS stretches available for coverage in 2004. Those surveyed at least once during 1998–2004 are shown as black spots, and those not surveyed as open squares.**

Table 2. Numbers of WBBS stretches surveyed during 1998–2004, by class of survey.

Class of survey	1998	1999	2000	2001	2002	2003	2004	Surveyed at least once
Random stretches (% of those requested)	108 (54%)	117 (44%)	110 (42%)	24 (9%)	162 (32%)	198 (39%)	217 (41%)	301 (57%)
WBS-linked (non-random) stretches	19	68	65	27	66	64	68	103
Other non-random stretches	41	1	1	0	0	0	0	42
Total stretches	168	186	176	51	228	262	285	446
Total 500-m sections	1124	1261	1205	380	1515	1703	1847	2977
Mean sections per stretch	6.69	6.78	6.85	7.45	6.64	6.50	6.48	6.67

The 1998 sample included a total of 60 canal stretches that had been chosen non-randomly on the basis of the fishing seasons in operation there. Some of these were also WBS plots. The 41 plots that did not also fall into the WBS category were dropped from the survey in subsequent seasons.

WBS observers were asked to contribute WBBS data also from their stretches, beginning in 1999 with Phase 2 of WBBS development. As part of the study of fishing seasons, 19 WBS sites had also been covered for the WBBS in 1998, providing continuity in that part of the sample since 1998. Despite the fall in the WBS sample of mapping surveys (Table 1), the number of WBS-linked WBBS surveys has hardly changed since 1999 (Table 2).

Of the 201 stretches that had been selected randomly for the first year of WBBS, 108 were surveyed (54%; Table 2). Despite an extra 62 stretches being made available, totals for 1999 and 2000 were only marginally higher, and percentage coverage fell. The likely reason for this is that the extra stretches were mostly in areas where the BTO RR had initially indicated unwillingness to take part. Only 24 random stretches were surveyed in 2001, when FMD imposed severe restrictions on access to the countryside. A further 249 waterway stretches were added to the random sample before the 2002 field season, bringing the total number of sites available for coverage to 512. Of these, 162 were surveyed in 2002, 198 in 2003, and 217 in 2004, by far the largest total achieved by the WBBS so far.

In 2001, just 51 sites were surveyed in all, representing only 29% of the coverage in the previous year. These sites were concentrated in the English Midlands and the north of Scotland, areas where access was less restricted than elsewhere (Marchant, Noble and Beaven 2002). The 2001 WBBS sample is thus rather different in character from the samples in other years.

The final column of Table 2 indicates the numbers of different stretches in each category that contribute to the overall totals. Most surveys since 1999 have been repeat surveys at stretches already covered, and can therefore contribute to models of population change.

In 2004, 26 stretches in the random selection were covered for the first time, providing a further substantial boost to the WBBS sample. In addition, five WBS plots provided WBBS data for the first time. The grand total of 285 WBBS surveys in 2004 comprises 1847 500-m sections of river and canal, at an average of 6.5 sections per stretch (Table 2). The mean length of WBBS stretches has tended to fall slightly as the sample size has increased.

Numbers of WBBS stretches of all classes by UK country are shown in Table 3. WBBS observers surveyed more than 300 different waterway stretches in England during the seven-year period. Coverage in Northern Ireland was intermittent and at a very low level.

Table 3. Numbers of WBBS stretches surveyed during 1998–2004, by UK country.

UK country	1998	1999	2000	2001	2002	2003	2004	Surveyed at least once
England	135	135	131	38	152	179	191	306
Scotland	26	35	31	12	49	53	59	93
Wales	7	13	13	1	25	29	35	42
Northern Ireland	0	3	1	0	2	1	0	5
TOTAL	168	186	176	51	228	262	285	446

A full list of stretches covered since the inception of WBBS, with the number of 500-m sections surveyed each year, is given in Appendix 1.

2.2.4 Application of WBBS methods in 2004

Random sites designated for coverage in 2004 included the 512 sites that had been randomly selected for Phase 3 of the WBBS. These random stretches comprise the original selection of 201 sites in 1998, 62 added in 1999, and 249 sites added to the sample for Phase 3 in 2002. Eighteen additional sites were designated for coverage in 2004, from ten BTO regions where the RR was calling for more opportunities for volunteers interested in helping with WBBS. Of the 18 new sites added in 2004, only two were actually surveyed.

The extra sites designated in 2004 represented a move towards regional stratification of the WBBS's random sites, according to observer availability. Since only two such sites were covered as part of the Phase 3 surveys, they were not considered to make a significant change to the nature of the sample. The sample of selected sites for 2004 was taken as 529 (Figure 2), and the minor regional bias introduced by the selection process was ignored. New sites begun in 2004 did not contribute to any calculations of population trend, but may do so in future if surveys are continued there. Sample sizes for working out regional weightings during population trend calculations were therefore based on a UK total of 512.

The stretches covered in 2004 are mapped in Figure 3. Surveys in 2004 were well distributed around the UK but, compared with the overall distribution of random sites (Figure 2), it is notable that there were few surveys in western Scotland, and none in Northern Ireland.

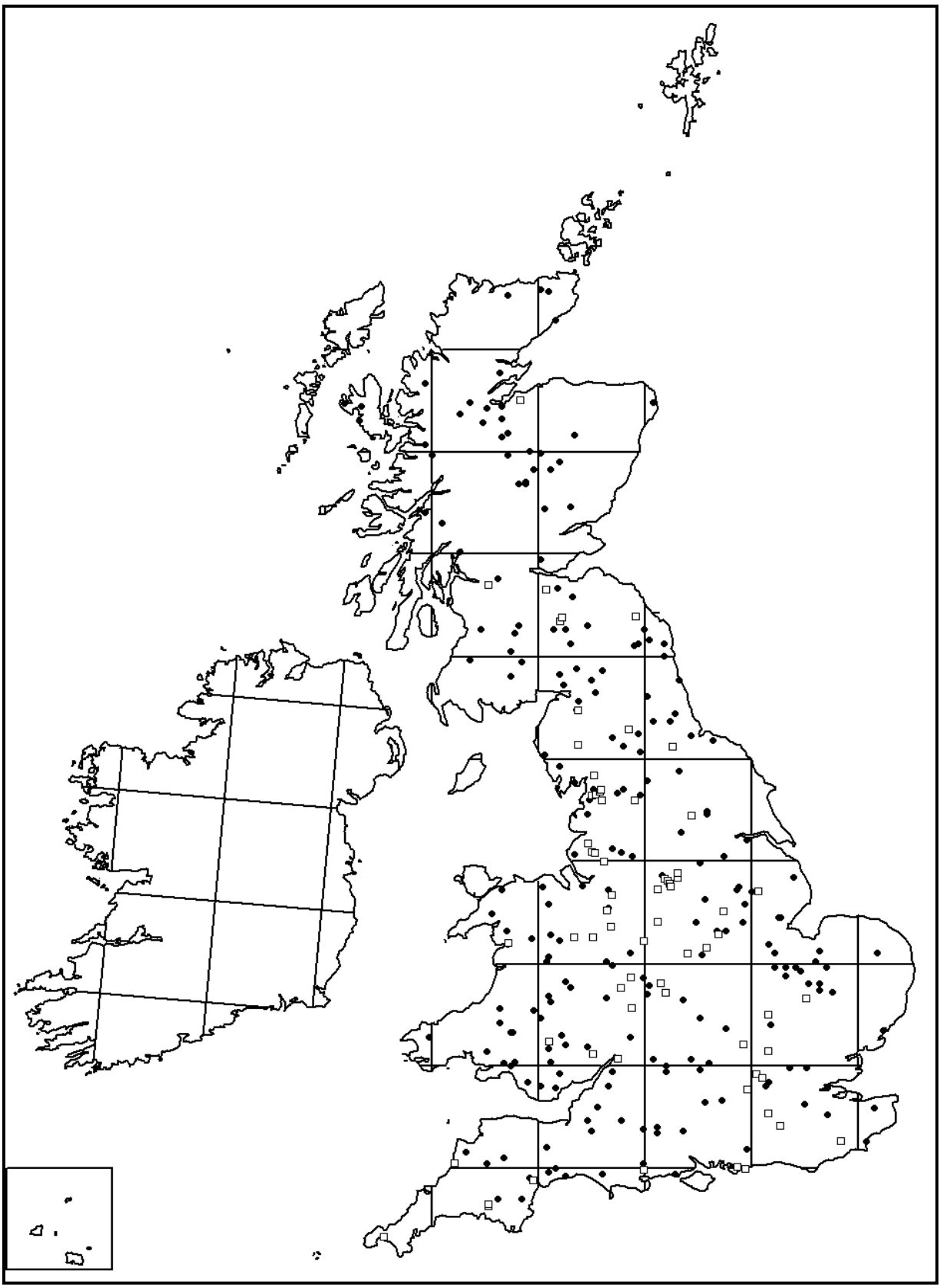


Figure 3. **Distribution of the 285 sites at which WBBS fieldwork was conducted in 2004. Surveys at randomly chosen locations are shown as black spots, and those conducted at non-random WBS plots as open squares.**

2.2.5 Calculation of population change from WBBS data

This report compares population change measures between different elements of the BTO's monitoring samples. The two main parts of the WBBS sample – the random stretches and the WBS-linked ones – were treated separately in this analysis. Because the nature of WBBS coverage in 2001 had been so different from the other six years (Tables 2 and 3), 2001 data were not used at all in these calculations.

The sum of the counts from all sections of each stretch of waterway was used for the analysis. These counts included birds seen in all three distance bands and in flight. For each transect section, the higher count of the two visits was used. Summing these maximum counts across the transect sections to obtain a single count for each stretch of the waterway is necessary, as each individual transect section cannot be treated as an independent stretch of waterway in its own right.

Annual population changes were produced using a full site-by-year log-linear Generalised Linear Model (GLM) with Poisson-distributed error terms. Only waterway stretches that were surveyed in two or more of the six years of interest are included in the analysis. Waterway stretches with zero counts for a species in all years were not included in the model. This does not affect the model's estimates of annual effects, but more conservative estimates of standard errors are obtained. Adjustments to the standard errors are made within the model to correct over-dispersion.

To account for the varying number of transect sections for each stretch of waterway, the log of the number of transect sections within each waterway stretch was used as an offset variable in the model (Stokes *et al.* 2003). In this case, the offset variable serves to normalise the fitted means to a per-section basis, since it is the total count of birds across the whole stretch, not the individual transect section counts, that are used in the model.

Weighting system employed in the model

Originally the random WBBS sites were selected to obtain a representative sample of the waterways in the UK. However, since only 57% of the random stretches were surveyed (Table 2), and some only in a single year, the intended random representation of waterways cannot be relied upon.

To ensure that bias in uptake by observers did not affect coverage of the UK, a weighting system was tested, in which counts were weighted to allow for differences in sampling effort among Government Office Regions (GORs). This was based on the proportion of randomly selected sites that were actually surveyed by observers in each of the regions. GORs were chosen as the regional level to ensure there was a sufficient sample size in each of the regions to work out a weighting factor: BTO regions produced sample sizes that were too small. We hope that, after correcting the bias in observer coverage using the weights, the population trends more accurately reflect the true picture in the UK.

Table 4 lists the total number of WBBS sites randomly selected in the UK by GOR. The weighting value was calculated for each GOR as the inverse of the proportion of all sites that were actually surveyed. Weights were calculated for each year separately as the numbers of WBBS sites surveyed varies from year to year, but a mean value calculated across years gives a useful indicator of likely values and is used to calculate indicative weights here (Table 5). A region with high observer coverage relative to the total number of sites available receives a low weighting value. The higher the weighting value, the greater the influence these sites have in the GLM relative to those with lower weights. In the GLM framework it is the relative differences in weights

between GORs, not the absolute weights, that are important. The GORs rank in the following order from low to high weights for random WBBS sites: South West, South East, North East, East of England, London, Wales, Yorkshire and The Humber, East Midlands, North West, West Midlands, Scotland and Northern Ireland (Table 5). Generally, WBBS sites in the south and east of England are down-weighted in the GLM relative to sites in the north, especially Scotland.

Table 4. Numbers of random and non-random WBBS sites, by Government Office Region.

Government Office Region	Total number of randomly selected WBBS sites (*random*)	Number of *random* WBBS sites surveyed (mean across years)	Ideal number of *non-random* WBBS sites	Number of *non-random* WBBS sites surveyed (mean across years)
North West	41	10.7	7.2	13.3
North East	23	10.3	4.1	1.6
Yorkshire & The Humber	25	8.0	4.4	5.6
East Midlands	23	7.3	4.1	7.5
East of England	28	11.2	4.9	5.5
West Midlands	35	7.8	6.2	7.2
South East	27	14.0	4.7	4.2
South West	33	17.8	5.8	5.5
London	7	2.5	1.2	1.8
Scotland	188	34.7	33.0	4.2
Wales	47	16.0	8.3	2.6
Northern Ireland	35	1.0	6.2	0

Table 5. Indicative weight values for random and non-random WBBS sites (using the mean number of sites surveyed across years).

Government Office Region	Random WBBS sites weighting	Non-random WBBS sites weighting
North West	3.83	0.54
North East	2.23	2.56
Yorkshire & The Humber	3.13	0.79
East Midlands	3.15	0.55
East of England	2.5	0.89
West Midlands	4.49	0.86
South East	1.93	1.12
South West	1.85	1.05
London	2.8	0.67
Scotland	5.42	7.86
Wales	2.94	3.19
Northern Ireland	35	–

The weights for the non-random WBBS sites were calculated in the following manner. We began by assuming, as for the weighting of random sites, that the regional distribution of the 512 randomly selected sites was a good representation of the UK distribution of waterways. If this were the case, the ideal regional distribution of the 90 WBS-linked sites would be in exact proportion to that of the 512 random sites. 'Ideal' figures, given in the third column of Table 4, were therefore calculated by applying the ratio 90:512 to the numbers of random sites selected, in the first column.

Comparing these 'ideal' figures to the real values, in the fourth column, it is clear that some regions, such as North West, were over-represented in the actual data while others, most notably Scotland, were under-represented. Indicative figures for the likely weightings within the model (Table 5), were calculated as the ratio of the 'ideal' and the observed distribution of non-random

sites. These are below unity for over-sampled regions and above unity in Scotland and other regions where waterways are plentiful but observers few.

For non-random WBBS sites, the GORs rank in the following order from low to high weights: North West, East Midlands, London, Yorkshire and The Humber, West Midlands, East of England, South West, South East, North East, Wales and Scotland. The relative weighting of regions varies between the random WBBS sites and the non-random WBBS sites, but Scotland has a high weighting under both schemes. For the actual production of the population trends, the weighting values were calculated for each year and so differ slightly from those provided in Table 5.

The impact of the weighting on population trends is greatest for those species that show regional differences in trends. Weighted trends were compared in detail with non-weighted ones, to assess the value of the weighting process.

3 Results

3.1 Annual results from the WBBS and WBS during 1998-2004

3.1.1 WBBS data collection for birds

Table 6 records the mean overall frequencies of bird species recorded on randomly selected WBBS stretches, for each year 1998–2004. The figures are the mean number of individuals recorded per 10 km of waterway. If a species was found on fewer than six stretches, the data are not included here. The sample sizes for each species and year indicate how the numbers of plots contributing data have increased during the period.

Zero values from stretches where the species was absent are included in the means, which are therefore comparable across species. Standard errors are not given but were larger than the means in almost all cases. Differences between years in the mean figures for particular species may be due to chance or the effects of plot turnover as well as population changes among the birds. They should not be read as indicating population trends.

The five most abundant species recorded on the random stretches in 2004 were Wood Pigeon (mean 82.9 birds per 10 km, standard error 110.7), Mallard (mean 54.2, s.e. 72.3), Chaffinch (mean 51.2, s.e. 47.2), Wren (mean 49.6, s.e. 44.4) and Blackbird (mean 42.5, s.e. 40.9). The most widespread species in 2004 on these stretches were Chaffinch (found on 198 random stretches, 91% of the total), Wren (196, 90%), Blackbird (192, 88%), Mallard (191, 88%) and Wood Pigeon (186, 86%). In all, 113 bird species occurred on more than five stretches in at least one year.

Table 6. Birds recorded on random WBBS stretches during 1998–2004. Numbers of birds per 10 km are the means from all random stretches covered, including those where the species was not found. The number of occupied stretches is given in brackets. Scientific names of bird species are given in Appendix 2. Species are listed in taxonomic order, with results for waterbirds (according to WBS definitions) presented in bold type.

Species	Birds per 10 km (number of stretches occupied)						
	1998 (n=108)	1999 (n=117)	2000 (n=110)	2001 (n=24)	2002 (n=162)	2003 (n=198)	2004 (n=217)
Mute Swan	**10.3 (41)**	**7.4 (45)**	**5.6 (38)**	**2.5 (8)**	**7.9 (49)**	**7.3 (66)**	**7.5 (72)**
Greylag Goose	**7.0 (14)**	**4.7 (11)**	**2.5 (12)**	**.**	**4.8 (19)**	**4.7 (26)**	**5.0 (36)**
Canada Goose	**7.6 (35)**	**7.9 (27)**	**10.0 (28)**	**.**	**9.1 (41)**	**10.9 (59)**	**9.1 (53)**
Shelduck	**13.4 (11)**	**9.2 (10)**	**15.2 (10)**	**.**	**6.2 (11)**	**5.5 (16)**	**4.6 (14)**
Mandarin	**.**	**.**	**.**	**.**	**0.2 (6)**	**0.5 (7)**	**0.3 (7)**
Wigeon	**.**	**.**	**.**	**.**	**.**	**0.4 (6)**	**.**
Gadwall	**1.3 (7)**	**0.9 (6)**	**1.5 (8)**	**.**	**1.1 (11)**	**1.3 (15)**	**0.8 (12)**
Teal	**0.5 (8)**	**0.4 (6)**	**0.8 (11)**	**.**	**0.5 (7)**	**1.2 (13)**	**1.0 (14)**
Mallard	**43.1 (92)**	**43.0 (99)**	**49.4 (92)**	**43.9 (17)**	**46.8 (135)**	**54.5 (173)**	**54.2 (191)**
Tufted Duck	**6.9 (17)**	**4.0 (17)**	**3.3 (17)**	**4.1 (6)**	**4.7 (29)**	**3.7 (30)**	**3.9 (36)**
Goosander	**1.4 (18)**	**1.2 (14)**	**1.0 (16)**	**.**	**1.9 (30)**	**1.7 (34)**	**2.3 (39)**
Red Grouse	.	.	0.3 (6)	.	0.4 (6)	.	0.3 (9)

Species	Birds per 10 km (number of stretches occupied)						
	1998 (n=108)	1999 (n=117)	2000 (n=110)	2001 (n=24)	2002 (n=162)	2003 (n=198)	2004 (n=217)
Red-legged Partridge	2.2 (16)	2.5 (15)	2.1 (17)	.	1.4 (17)	1.7 (29)	2.1 (36)
Grey Partridge	1.0 (13)	0.4 (9)	0.9 (12)	.	0.4 (8)	0.4 (10)	0.7 (19)
Pheasant	8.7 (60)	11.3 (68)	11.1 (65)	10.7 (12)	9.7 (93)	12.5 (123)	12.4 (138)
Little Grebe	**1.3 (12)**	**1.1 (12)**	**0.6 (8)**	**.**	**0.4 (9)**	**0.4 (9)**	**0.6 (13)**
Great Crested Grebe	**0.8 (6)**	**1.0 (9)**	**.**	**.**	**0.9 (14)**	**0.8 (14)**	**1.1 (17)**
Cormorant	**2.4 (27)**	**2.7 (29)**	**2.8 (25)**	**.**	**3.4 (36)**	**2.5 (47)**	**2.5 (53)**
Grey Heron	**5.3 (64)**	**4.8 (71)**	**5.4 (71)**	**4.1 (13)**	**5.2 (96)**	**5.7 (119)**	**6.7 (137)**
Red Kite	.	.	.	.	.	.	0.2 (6)
Sparrowhawk	0.9 (20)	0.5 (16)	0.6 (11)	.	0.9 (26)	1.0 (44)	0.5 (27)
Buzzard	2.3 (31)	2.4 (43)	2.8 (39)	.	3.5 (65)	3.6 (87)	3.5 (94)
Kestrel	1.7 (36)	1.3 (29)	1.9 (25)	.	1.4 (47)	1.5 (62)	1.8 (73)
Moorhen	**9.6 (63)**	**10.2 (63)**	**11.3 (61)**	**12.8 (13)**	**7.6 (71)**	**9.9 (96)**	**9.7 (103)**
Coot	**5.8 (30)**	**7.2 (24)**	**5.3 (22)**	**10.9 (10)**	**5.0 (30)**	**5.7 (43)**	**6.7 (53)**
Oystercatcher	**7.8 (27)**	**8.7 (32)**	**8.0 (27)**	**8.7 (6)**	**8.7 (45)**	**10.1 (64)**	**8.8 (64)**
Lapwing	**21.0 (36)**	**8.1 (39)**	**9.0 (37)**	**20.3 (6)**	**11.4 (53)**	**11.3 (66)**	**11.3 (68)**
Snipe	**0.7 (10)**	**0.6 (12)**	**0.6 (11)**	**.**	**1.7 (20)**	**1.9 (22)**	**1.6 (23)**
Curlew	**4.4 (26)**	**5.0 (30)**	**4.2 (29)**	**.**	**5.2 (47)**	**4.1 (49)**	**3.3 (53)**
Redshank	**1.7 (8)**	**1.5 (7)**	**2.0 (12)**	**.**	**2.1 (11)**	**1.7 (18)**	**1.2 (17)**
Common Sandpiper	**5.2 (35)**	**3.6 (30)**	**4.0 (35)**	**3.6 (6)**	**5.0 (54)**	**4.3 (53)**	**4.3 (65)**
Black-headed Gull	**32.7 (35)**	**11.3 (33)**	**16.6 (37)**	**14.7 (8)**	**15.9 (51)**	**19.0 (59)**	**15.0 (79)**
Common Gull	**4.7 (15)**	**4.4 (14)**	**13.4 (14)**	**.**	**3.5 (20)**	**3.3 (25)**	**6.4 (19)**
Lesser Black-backed Gull	**8.8 (23)**	**5.1 (28)**	**5.6 (27)**	**5.8 (8)**	**3.9 (30)**	**3.9 (44)**	**5.0 (54)**
Herring Gull	**18.5 (28)**	**8.4 (29)**	**10.2 (27)**	**.**	**7.2 (37)**	**9.1 (47)**	**7.1 (54)**
Great Black-backed Gull	**.**	**.**	**0.9 (6)**	**.**	**0.6 (6)**	**0.5 (16)**	**3.0 (13)**
Common Tern	**1.0 (12)**	**1.1 (13)**	**.**	**.**	**1.5 (17)**	**1.6 (23)**	**1.5 (24)**
Feral Pigeon	14.6 (23)	13.8 (21)	15.3 (25)	44.0 (7)	11.3 (36)	9.2 (39)	14.9 (47)
Stock Dove	5.4 (31)	8.4 (39)	6.2 (37)	4.4 (7)	3.8 (53)	3.6 (66)	4.7 (74)
Wood Pigeon	63.9 (90)	76 (95)	80.5 (95)	64.6 (17)	74.4 (137)	75.7 (170)	82.9 (186)
Collared Dove	5.4 (44)	5.9 (46)	7.3 (48)	5.7 (12)	7.6 (64)	4.9 (79)	6.7 (83)
Turtle Dove	1.2 (9)	1.9 (15)	1.3 (11)	.	1.1 (14)	0.8 (11)	0.4 (12)
Cuckoo	2.3 (41)	2.4 (37)	2.3 (45)	1.7 (6)	1.5 (44)	1.8 (56)	2.1 (65)
Barn Owl	.	.	.	.	.	0.2 (7)	0.1 (6)
Little Owl	0.3 (6)	.	.	.	.	.	.
Tawny Owl	.	0.2 (7)	0.2 (6)	.	0.2 (10)	0.2 (11)	0.1 (9)
Swift	30.1 (62)	21.5 (60)	21.6 (56)	13.8 (10)	21.0 (86)	16.9 (90)	15.8 (105)
Kingfisher	**1.9 (30)**	**1.6 (37)**	**1.7 (30)**	**.**	**1.3 (43)**	**1.6 (52)**	**1.4 (52)**
Green Woodpecker	1.9 (29)	1.8 (31)	2.2 (35)	.	1.7 (45)	2.0 (55)	1.7 (53)
Great Spotted Woodpecker	2.5 (38)	1.4 (33)	1.7 (38)	.	2.8 (67)	2.8 (77)	2.9 (93)
Skylark	11.3 (57)	10.1 (54)	9.1 (53)	11.8 (12)	7.8 (66)	8.6 (77)	8.4 (80)
Sand Martin	**16.2 (29)**	**10.6 (32)**	**16.6 (31)**	**5.4 (6)**	**15.6 (48)**	**12.4 (58)**	**12.4 (63)**
Swallow	15.7 (74)	18.2 (87)	20.2 (84)	13.0 (17)	18.8 (117)	24.7 (146)	31.5 (173)
House Martin	14.8 (49)	18.6 (54)	16.2 (53)	7.6 (9)	10.6 (65)	13.5 (101)	24.6 (108)
Tree Pipit	0.2 (6)	0.7 (11)	0.4 (10)	.	0.3 (9)	0.4 (13)	0.6 (16)
Meadow Pipit	19.5 (38)	18.6 (42)	19.9 (43)	28.5 (10)	15.6 (61)	17.9 (70)	15.2 (80)
Yellow Wagtail	**2.3 (12)**	**1.6 (11)**	**1.9 (10)**	**.**	**1.1 (15)**	**0.9 (17)**	**0.7 (19)**
Grey Wagtail	**3.6 (42)**	**5.4 (64)**	**5.7 (58)**	**3.1 (8)**	**7.3 (95)**	**6.7 (114)**	**6.3 (110)**
Pied Wagtail	**6.2 (64)**	**6.4 (63)**	**6.3 (70)**	**4.8 (14)**	**6.4 (100)**	**7.8 (122)**	**7.9 (136)**
Dipper	**3.3 (39)**	**2.8 (43)**	**3.1 (45)**	**.**	**4.8 (66)**	**4.8 (82)**	**3.8 (77)**
Wren	37.8 (88)	44.7 (102)	47.3 (96)	25.1 (18)	49.0 (142)	49.0 (178)	49.6 (196)
Dunnock	8.2 (64)	6.9 (72)	7.5 (69)	6.5 (13)	8.4 (94)	9.8 (130)	9.9 (130)
Robin	18.2 (78)	20.3 (94)	22.7 (94)	11.8 (18)	22.3 (134)	24.1 (172)	22.4 (183)

Species	Birds per 10 km (number of stretches occupied)						
	1998 (n=108)	1999 (n=117)	2000 (n=110)	2001 (n=24)	2002 (n=162)	2003 (n=198)	2004 (n=217)
Redstart	1.1 (11)	1.0 (12)	0.9 (13)	.	1.2 (20)	1.2 (28)	1.5 (28)
Whinchat	0.7 (11)	0.8 (11)	1.2 (11)	.	0.6 (11)	0.2 (8)	0.8 (11)
Stonechat	.	0.4 (6)	1.0 (10)	.	1.4 (15)	0.9 (15)	0.9 (18)
Wheatear	2.3 (16)	2.1 (21)	1.6 (10)	.	1.4 (23)	1.8 (27)	1.9 (34)
Ring Ouzel	.	.	.	.	0.3 (6)	0.2 (6)	.
Blackbird	32.8 (86)	32.5 (96)	41.2 (93)	25.7 (18)	38.6 (134)	43.3 (169)	42.5 (192)
Fieldfare	.	.	.	.	.	6.1 (12)	.
Song Thrush	10.5 (74)	11.3 (81)	12.3 (85)	6.1 (15)	15.5 (127)	14.7 (155)	14.4 (167)
Mistle Thrush	4.9 (50)	5.3 (58)	5.2 (58)	4.8 (8)	5.0 (81)	4.6 (99)	4.6 (105)
Grasshopper Warbler	**.**	**.**	**.**	**.**	**0.3 (10)**	**0.3 (11)**	**0.5 (10)**
Sedge Warbler	**6.6 (32)**	**7.3 (37)**	**9.7 (43)**	**13.5 (12)**	**8.8 (55)**	**7.7 (60)**	**8.3 (75)**
Reed Warbler	**7.3 (23)**	**8.7 (24)**	**8.9 (24)**	**12.9 (9)**	**6.2 (29)**	**5.9 (35)**	**6.6 (42)**
Blackcap	10.8 (61)	9.0 (67)	9.9 (68)	4.1 (7)	10.4 (90)	9.2 (116)	11.4 (136)
Garden Warbler	2.7 (35)	2.8 (39)	2.6 (33)	.	2.1 (47)	2.4 (60)	2.9 (66)
Lesser Whitethroat	0.9 (12)	0.4 (7)	0.5 (8)	.	0.5 (15)	0.4 (16)	0.5 (16)
Whitethroat	7.5 (50)	7.4 (44)	7.9 (53)	10.1 (11)	8.9 (72)	8.5 (79)	9.9 (88)
Wood Warbler	.	.	0.5 (7)	.	0.6 (10)	0.4 (13)	0.3 (10)
Chiffchaff	8.1 (56)	5.0 (54)	6.5 (49)	1.3 (6)	7.5 (78)	10.5 (112)	12.0 (130)
Willow Warbler	16.0 (79)	15.4 (89)	14.3 (73)	12.8 (14)	15.6 (103)	15.1 (128)	17.0 (146)
Goldcrest	2.2 (30)	3.5 (37)	4.7 (46)	.	3.7 (50)	4.0 (79)	4.6 (82)
Spotted Flycatcher	1.4 (21)	1.7 (29)	2.1 (29)	.	1.3 (24)	2.5 (50)	1.4 (44)
Pied Flycatcher	.	.	.	.	0.7 (10)	0.9 (11)	0.8 (12)
Long-tailed Tit	6.7 (53)	8.2 (57)	7.7 (52)	2.1 (7)	7.3 (78)	9.3 (103)	8.1 (99)
Marsh Tit	0.5 (9)	0.6 (12)	0.7 (11)	.	0.4 (15)	0.5 (13)	0.4 (14)
Willow Tit	0.5 (9)	0.2 (6)	.	.	0.2 (6)	0.2 (7)	0.2 (8)
Coal Tit	2.4 (25)	3.4 (33)	2.4 (32)	1.2 (6)	4.8 (64)	4.7 (75)	3.8 (75)
Blue Tit	30.8 (85)	23.7 (92)	27.3 (90)	11.8 (14)	30.2 (130)	35.3 (165)	35.3 (181)
Great Tit	18.2 (83)	13.3 (88)	14.7 (88)	4.8 (11)	16.7 (123)	18.8 (155)	20.5 (170)
Nuthatch	0.9 (18)	1.7 (24)	1.5 (21)	.	1.4 (29)	2.6 (43)	2 (50)
Treecreeper	1.6 (29)	2.2 (40)	1.9 (30)	.	2.0 (55)	2.1 (57)	1.4 (52)
Jay	2.0 (27)	2.0 (33)	1.8 (31)	.	1.7 (33)	1.8 (54)	1.3 (46)
Magpie	11.2 (67)	12.1 (75)	10.4 (68)	10.4 (12)	11.8 (93)	10.8 (113)	10.9 (138)
Jackdaw	23.4 (58)	26.5 (61)	24.6 (65)	21.1 (10)	27.1 (92)	31.9 (117)	30.0 (136)
Rook	57.4 (57)	70.4 (59)	49.5 (53)	.	40.6 (74)	38.8 (93)	38.1 (110)
Carrion Crow	32.2 (89)	30.9 (93)	32.9 (90)	16.3 (17)	37.2 (137)	36.6 (168)	41.8 (180)
Hooded Crow	0.6 (8)	0.9 (12)	0.6 (9)	.	0.4 (14)	1.0 (13)	1.2 (15)
Raven	0.5 (9)	0.8 (13)	0.7 (16)	.	1.3 (20)	0.8 (20)	1.0 (21)
Starling	64.8 (66)	60.3 (73)	55.5 (76)	60.9 (15)	51.7 (100)	35.4 (114)	40.5 (121)
House Sparrow	10.7 (46)	10.9 (47)	13.8 (50)	20.0 (11)	12.3 (59)	16.5 (89)	15.1 (99)
Tree Sparrow	.	.	1.0 (6)	.	1.4 (12)	1.0 (11)	0.7 (11)
Chaffinch	38.9 (94)	39.6 (102)	42.3 (100)	21.9 (18)	43.5 (148)	47.6 (178)	51.2 (198)
Greenfinch	9.0 (59)	8.6 (62)	9.8 (61)	10.1 (14)	10.6 (96)	12.9 (113)	13.9 (126)
Goldfinch	9.5 (56)	8.3 (62)	10.2 (69)	9.2 (14)	9.7 (94)	11.6 (113)	11.5 (124)
Siskin	0.8 (10)	1.1 (10)	1.0 (12)	.	1.3 (16)	0.9 (19)	1.3 (22)
Linnet	6.9 (28)	8.8 (39)	7.5 (32)	7.2 (13)	6.9 (51)	6.1 (55)	5.2 (64)
Lesser Redpoll	0.4 (7)	.	0.3 (6)	.	1.1 (11)	0.8 (13)	0.5 (12)
Bullfinch	1.6 (24)	1.1 (23)	0.9 (19)	.	2.6 (48)	2.8 (61)	2.1 (56)
Yellowhammer	3.8 (36)	4.1 (38)	3.7 (38)	2.2 (8)	3.7 (42)	3.2 (54)	3.1 (56)
Reed Bunting	**5.1 (45)**	**5.2 (42)**	**4.3 (41)**	**6.5 (11)**	**5.2 (53)**	**5.4 (66)**	**5.5 (80)**
Corn Bunting	0.8 (7)	.	1.0 (7)	.	0.4 (7)	0.4 (8)	0.3 (10)

3.1.2 WBBS data for mammals

Mammal data recorded by WBBS observers are always likely to be minimum figures, because mammal recording is secondary to the main tasks of recording birds and habitat, and in general is not systematic. Nevertheless, since mammals are generally an under-recorded group in the UK, any monitoring data, especially from random sites, may be valuable.

During 1998–2004, 34 mammal species were recorded by WBBS observers (Table 7). Those species found most frequently were diurnal ones, such as rabbit and grey squirrel, or ones that left obvious signs of presence, such as mole. By far the most numerous mammals seen were rabbit and red deer. Both the annual count totals and the percentages of occupied sites are roughly comparable across years, although subject to the same chance effects and effects of plot turnover as are the bird data. The sequences of counts or of occupancy suggest that decreases may have occurred among weasels and water voles, and perhaps other species, along WBBS stretches during 1998–2004. Deer, by contrast, appear to show general increases.

Across the 285 WBBS returns for 2004, mammal forms were completed and returned for 244 (86%). Mammal recording was therefore well supported by WBBS volunteers, as in 1998–2003. Of these 244 returns, 13 reported no mammals, leaving 231 sites on which mammals were observed. Half the sites recorded three or fewer species. Thirteen stretches recorded ten or more mammal species; the maximum was 14 at one site. Of specialist waterway mammals, water voles were found on 6% of stretches in 2004, American mink on 10%, and otter on 18%.

Newson *et al.* (2005) investigated the potential of the WBBS data for long-term monitoring of mammal populations and concluded that sample sizes would need to rise considerably to provide an appropriate level of power to detect change. Studies are continuing into the scope for combining mammal data from WBBS and BBS, for waterside species, to maximise the monitoring samples.

Table 7. Mammals recorded on all WBBS stretches reporting mammal data during 1998–2004. The number of animals is the sum of early and late counts across all occupied stretches. Occupancy rates include sites where presence was known but no animals were counted on WBBS visits.

Mammal species	Number of animals counted, and percentage occupancy of stretches surveyed						
	1998	1999	2000	2001	2002	2003	2004
Hedgehog *Erinaceus europaeus*	2 15%	2 21%	0 21%	0 17%	0 9%	3 14%	4 13%
Mole *Talpa europaea*	11 36%	26 57%	24 58%	2 41%	35 58%	4 49%	2 46%
Common shrew *Sorex araneus*	24 26%	12 24%	5 22%	0 22%	2 2%	2 2%	0 0%
Water shrew *Neomys fodiens*	–	–	–	–	–	0 1%	–
Daubenton's bat *Myotis daubentonii*	–	–	0 1%	–	–	–	–
Pipistrelle bat *Pipistrellus sp*.	1 1%	–	–	–	–	–	–
Brown long-eared bat *Plecotus auritus*	0 1%	–	–	–	–	–	–
Rabbit *Oryctolagus cuniculus*	1978 65%	2093 72%	2006 72%	528 65%	2349 69%	2355 68%	2314 66%
Brown hare *Lepus europaeus*	143 28%	96 33%	95 28%	34 37%	247 29%	162 28%	255 32%
Mountain hare *Lepus timidus*	44 6%	17 4%	19 3%	0 4%	9 4%	12 4%	10 2%
Red squirrel *Sciurus vulgaris*	3 3%	3 4%	2 3%	0 2%	6 4%	0 3%	8 4%
Grey squirrel *Sciurus carolinensis*	165 40%	104 43%	118 47%	16 46%	143 45%	198 45%	208 44%
Bank vole *Clethrionomys glareolus*	–	0 1%	1 1%	–	1 2%	–	–
Field vole *Microtus agrestis*	–	–	0 1%	–	0 1%	0 0%	–
Water vole *Arvicola terrestris*	14 12%	17 16%	12 12%	2 20%	16 12%	3 7%	7 6%
Wood mouse *Apodemus sylvaticus*	–	0 1%	0 1%	–	0 1%	1 1%	0 2%
House mouse *Mus domesticus*	–	1 1%	–	–	1 1%	–	–
Common rat *Rattus norvegicus*	8 12%	9 18%	6 18%	0 13%	4 10%	7 9%	3 12%
Common dormouse *Muscardinus avellanarius*	–	–	–	–	0 1%	–	0 0%
Fox *Vulpes vulpes*	22 37%	17 44%	12 50%	2 48%	45 43%	17 40%	32 34%
Pine marten *Martes martes*	0 1%	0 1%	1 1%	0 2%	0 1%	0 0%	–
Stoat *Mustela erminea*	3 14%	8 22%	3 16%	0 13%	4 11%	5 14%	2 9%
Weasel *Mustela nivalis*	3 11%	1 12%	2 10%	1 9%	6 8%	0 9%	0 8%
Mink *Mustela vison*	3 10%	4 21%	0 22%	0 13%	1 10%	0 15%	1 10%
Badger *Meles meles*	1 17%	1 18%	1 20%	0 15%	1 18%	0 18%	0 20%

Mammal species	Number of animals counted, and percentage occupancy of stretches surveyed						
	1998	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Otter *Lutra lutra*	8 12%	5 13%	2 13%	0 2%	5 16%	0 14%	9 18%
Wildcat *Felis silvestris*	–	–	–	–	0 1%	–	–
Feral or domestic cat *Felis catus*	–	–	36 22%	17 30%	49 18%	45 23%	58 18%
Red deer *Cervus elaphus*	381 8%	385 11%	565 9%	509 15%	1560 11%	891 9%	1337 9%
Sika deer *Cervus nippon*	–	–	–	–	0 1%	–	0 0%
Fallow deer *Dama dama*	2 3%	11 1%	1 1%	5 2%	1 2%	9 3%	7 2%
Roe deer *Capreolus capreolus*	27 18%	40 25%	59 23%	18 22%	98 30%	72 23%	148 25%
Muntjac *Muntiacus reevesi*	1 3%	1 7%	15 8%	0 4%	3 2%	1 4%	6 4%
Feral goat *Capra hircus*	14 1%	3 1%	2 1%	–	3 1%	22 1%	12 1%
% of WBBS mammal surveys on which no mammals were recorded	7%	6%	3%	4%	7%	9%	7%
Number of stretches on which mammal surveys were made (and as % of total WBBS surveys)	155 92%	174 94%	158 90%	46 90%	196 86%	222 85%	244 86%

3.1.3 WBS estimates of population change, 2003–04

Of the 91 WBS mapping surveys for which 2004 data were available, 80 plots had comparable data from 2003. The characteristics of these plots are broadly similar to those from previous year-to-year comparisons (Table 8). Data from these plots were used to estimate population change between 2003 and 2004 (Table 9).

Table 8. Summary of the 80 WBS plots providing data on population change for 2003–04. 'Slow' rivers have a gradient of <5 m/km and generally lie in a broad valley, and 'fast' rivers have a gradient of >5 m/km.

Category	No. of plots	Mean length (km)	Total length (km)
All paired plots	80	4.4	353.7
Changes since 2002–03 comparison			
Plots gained	5	3.7	18.7
Plots lost	1	4.0	4.0
Regional distribution			
Southern England	13	4.3	55.7
Eastern England	14	4.5	62.4
Western England	20	4.3	86.5
Northern England	21	4.6	95.9
Scotland	9	4.5	40.3
Wales	3	4.3	12.9
Distribution by waterway type			
Canal	24	4.2	101.8
Mixed canal/river	2	3.2	6.4
Slow river	32	4.4	140.7
Fast river	21	4.8	101.2
Other	1	3.6	3.6

Table 9. WBS estimates of population change for 2003–04, drawn from 80 plots in total for which comparable data were received for both years. No estimates are given where the number of contributing plots was less than 10. Scientific names of bird species are given in Appendix 2.

Species	Territory total 2003	Territory total 2004	% change	Number of contributing plots
Mute Swan	90	98	+9%	50
Greylag Goose	61	50	-18%	15
Canada Goose	166	184	+11%	41
Mallard	2085	1987	-5%	79
Tufted Duck	74	68	-8%	17
Goosander	59	64	+8%	24
Little Grebe	21	17	.	9
Moorhen	628	648	+3%	71
Coot	242	277	+14%	39
Oystercatcher	216	255	+18%	23
Lapwing	194	152	-22%	32
Curlew	52	54	+4%	17
Redshank	66	58	.	9
Common Sandpiper	90	96	+7%	18
Kingfisher	44	50	+14%	36
Sand Martin	1173	1343	+14%	18
Yellow Wagtail	8	12	.	8
Grey Wagtail	173	143	-17% *	53
Pied Wagtail	191	152	-20% *	53
Dipper	89	79	-11%	28
Sedge Warbler	306	389	+27% *	41
Reed Warbler	265	292	+10%	21
Whitethroat	203	252	+24% *	47
Reed Bunting	216	247	+14% *	44

* indicates statistical significance at the 95% level.

The 21 population changes presented in Table 9 include 14 increases and seven decreases. Five changes were statistically significant: Grey Wagtail and Pied Wagtail decreased, both after significant increases in 2003 (Marchant and Coombes 2004), and Sedge Warbler, Whitethroat and Reed Bunting increased.

3.2 Population trends for waterways breeding birds, 1998–2004

3.2.1 Comparison of trends between random and non-random WBBS sites and application of weighting factors

Table 10 details the population change between 1998 and 2004 for all those species that were seen on a mean annual number of 20 or more sites. Population changes are reported separately for random and non-random WBBS sites and also for weighted and non-weighted analyses in each case. Weighting was based on the inverse of the proportion of the total number of sites that were actually surveyed in each year at a regional level (section 2.2.5). Sample sizes were generally smaller on non-random than on random WBBS sites; for species which failed to reach the threshold size of 20 on non-random WBBS sites, population change is recorded only for random sites. Gulls, Red-legged Partridge, Pheasant, Feral Pigeon and Rook are excluded from the table, because for various reasons they were considered unlikely to be monitored under a WBBS scheme.

Statistically significant population changes are indicated. We would expect there to be more species with a significant population change on random than on non-random WBBS sites, because of the difference in sample size. This is the case, with a number of species showing a significant population change only in the random sample. For several of these species, however, this seems to be partly due to the higher magnitude of population change on the random sites. Encouragingly, for all but four species (Goosander, Kingfisher, Long-tailed Tit and Blue Tit), the population change is in the same direction for weighted and non-weighted analyses on random WBBS sites. For non-random WBBS sites, Swallow and Garden Warbler have population changes in the opposing direction between weighted and non-weighted analyses, although the magnitude of change in both cases is small.

Table 10. Population change measures for 1998–2004 for random and non-random WBBS sites, from weighted and non-weighted analyses. Change measures are reported for species with a mean annual sample size of 20 or more. Scientific names of bird species are given in Appendix 2.

Species	Population change measure for 1998–2004				Sample size (mean annual number of plots on which species was recorded)	
	Random WBBS sites		Non-random sites			
	Weighted	Non-weighted	Weighted	Non-weighted	Random WBBS	Non-random WBBS
Mute Swan	+59% *	+31% *	-37% *	-33% *	48	35
Canada Goose	+8%	+29% *	+7%	+10%	38	27
Mallard	+11% *	+10% *	+24% *	+22% *	122	56
Tufted Duck	+4%	+14%	–	–	23	–
Goosander	0%	-4%	–	–	23	–
Cormorant	+32% *	+33%	–	–	35	–
Grey Heron	-3%	-2%	-18%	-34% *	86	45
Sparrowhawk	-28%	-25%	–	–	22	–
Buzzard	+31% *	+14%	–	–	55	–
Kestrel	0%	+10%	–	–	43	–
Moorhen	+9%	+13%	-11%	-10%	71	47
Coot	+32% *	+34% *	-18%	-25%	32	27
Oystercatcher	-9% *	-9%	–	–	40	–
Lapwing	-36% *	-37% *	+53% *	+57% *	46	24

Species	Population change measure for 1998–2004				Sample size (mean annual number of plots on which species was recorded)	
	Random WBBS sites		Non-random sites		Random WBBS	Non-random WBBS
	Weighted	Non-weighted	Weighted	Non-weighted		
Curlew	-38% *	-39% *	–	–	36	–
Common Sandpiper	-21% *	-28% *	–	–	43	–
Stock Dove	-19% *	-16%	-16%	-2%	48	23
Wood Pigeon	+18% *	+28% *	+19% *	+23% *	120	55
Collared Dove	+16% *	+13%	+68% *	+26%	57	36
Cuckoo	-18%	-20%	–	–	45	–
Swift	-45% *	-32% *	-41% *	-45% *	72	35
Kingfisher	-13%	+3%	-59% *	-31%	38	22
Green Woodpecker	+43% *	+47% *	+234% *	+305% *	39	22
Gt Sp Woodpecker	+34% *	+41% *	+28%	+40%	54	30
Skylark	-10% *	-11%	-49% *	-35% *	61	27
Sand Martin	-44% *	-27% *	–	–	41	–
Swallow	+21% *	+36% *	-3%	+11%	106	48
House Martin	-9% *	-1%	+5%	+5%	67	29
Meadow Pipit	-1%	-1%	–	–	50	–
Grey Wagtail	+7%	+26%	+133% *	+113%	76	28
Pied Wagtail	-30% *	-20% *	-9%	-3%	87	37
Dipper	-25% *	-22%	–	–	56	–
Wren	+20% *	+24% *	+30% *	+31% *	123	55
Dunnock	+8%	+12%	+68% *	+41% *	88	49
Robin	+12% *	+13% *	+15%	+11%	117	54
Blackbird	+6% *	+6%	+6%	+11%	119	56
Song Thrush	+9% *	+10%	+45% *	+42% *	108	51
Mistle Thrush	-19% *	-12%	-20%	-11%	72	34
Sedge Warbler	-7%	-5%	-5%	-11%	47	30
Reed Warbler	+32% *	+28% *	–	–	29	–
Blackcap	+4%	+12%	+32% *	+37% *	85	47
Garden Warbler	-22% *	-15%	-1%	+4%	44	22
Whitethroat	+43% *	+41% *	+41% *	+19%	61	36
Chiffchaff	+18% *	+24% *	+119% *	+112% *	75	40
Willow Warbler	-15% *	-20% *	-19%	-23% *	96	46
Goldcrest	+38% *	+55% *	–	–	50	–
Spotted Flycatcher	-48% *	-42% *	–	–	31	–
Long-tailed Tit	-12% *	+5%	+54% *	+62% *	69	38
Coal Tit	-30% *	-7%	–	–	47	–
Blue Tit	+2%	-1%	+13%	+4%	115	55
Great Tit	+1%	+2%	+27% *	+41% *	109	53
Nuthatch	+85% *	+105% *	–	–	29	–
Treecreeper	+16%	+8%	–	–	41	–
Jay	-17%	-19%	-20%	-21%	36	21
Magpie	-5%	-7%	+11%	+3%	86	50
Jackdaw	+24% *	+30% *	+36% *	+39% *	83	46
Carrion Crow	-13% *	-6%	-10%	-14%	118	54
Starling	-36% *	-38% *	-12% *	-26% *	86	45
House Sparrow	+28% *	+26% *	+11%	+12%	62	37
Chaffinch	-9% *	-3%	+21% *	+20% *	127	55
Greenfinch	+40% *	+25% *	+57% *	+56% *	81	44
Goldfinch	+9%	+8%	+57% *	+49% *	82	42
Linnet	-41% *	-30% *	-46% *	-56% *	43	23
Bullfinch	-15%	-2%	–	–	37	–

Species	Population change measure for 1998–2004				Sample size (mean annual number of plots on which species was recorded)	
	Random WBBS sites		Non-random sites			
	Weighted	Non-weighted	Weighted	Non-weighted	Random WBBS	Non-random WBBS
Yellowhammer	-19% *	-15%	-45% *	-50% *	40	23
Reed Bunting	+27% *	+33% *	-22% *	-23% *	51	33

* indicates statistical significance at the 95% level.

To allow an easier comparison of the population change measures between the weighted and non-weighted analyses, a scatter plot is presented in Figure 4 for random WBBS sites and in Figure 5 for non-random sites. The close agreement between the weighted and non-weighted analyses for random sites for the majority of the species is evident from the very high correlation between the two sets of results (r = 0.944, P < 0.0001, n = 66). With the removal of the outlier for Green Woodpecker on non-random sites (Figure 5b), it is easier to see the other species in the plot. Again there is a strong correlation between the weighted and non-weighted population changes for the non-random WBBS sites (r = 0.962, P<0.0001, n = 46).

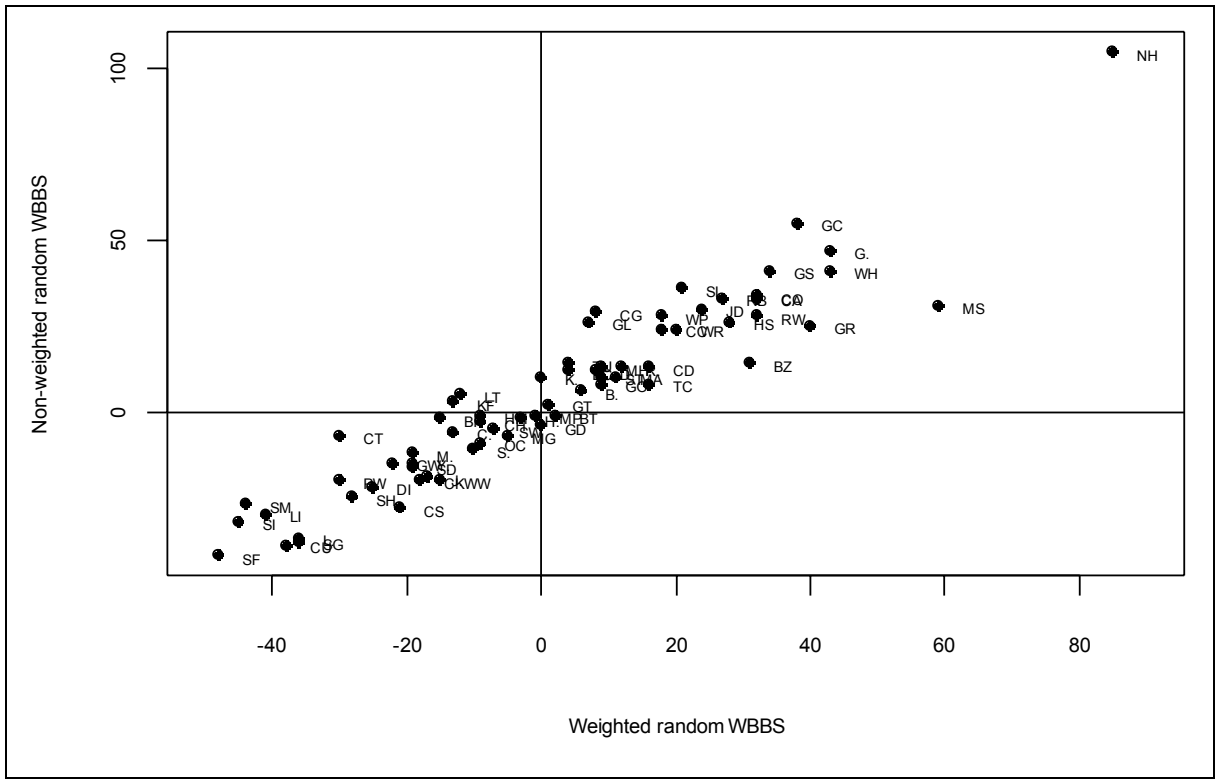
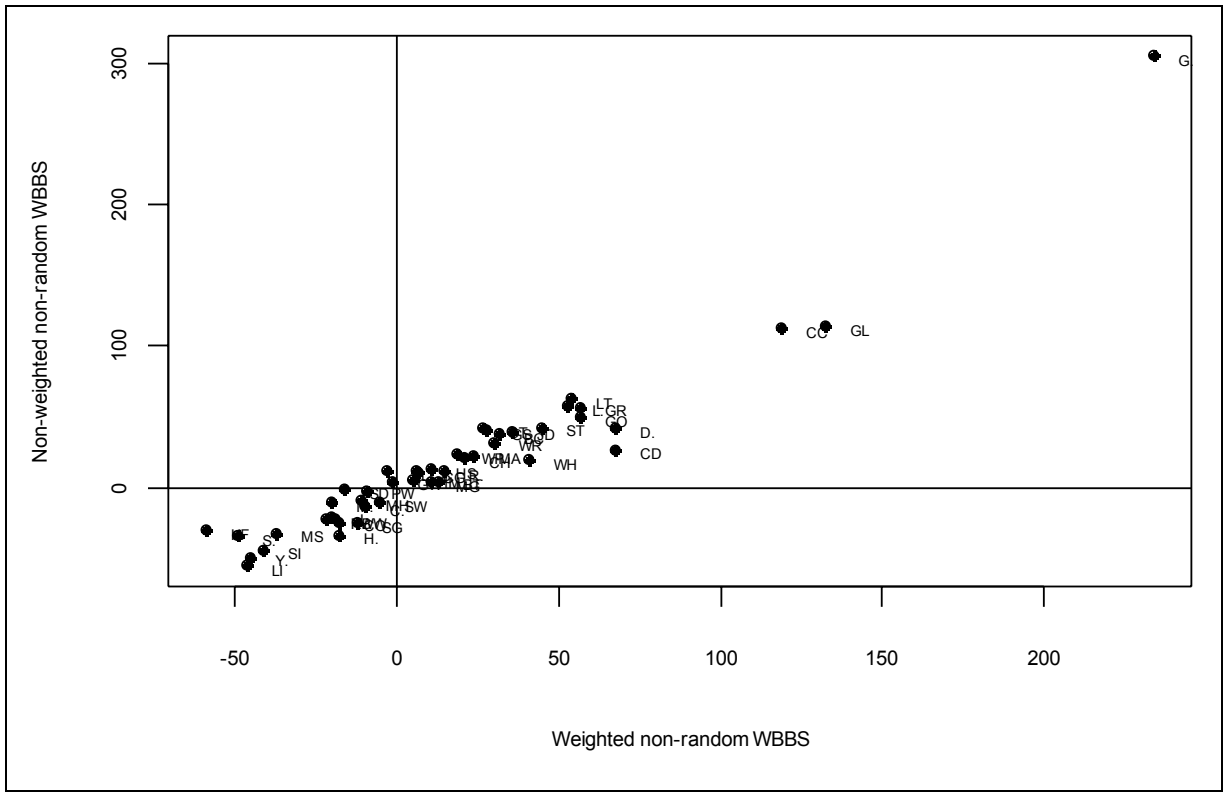
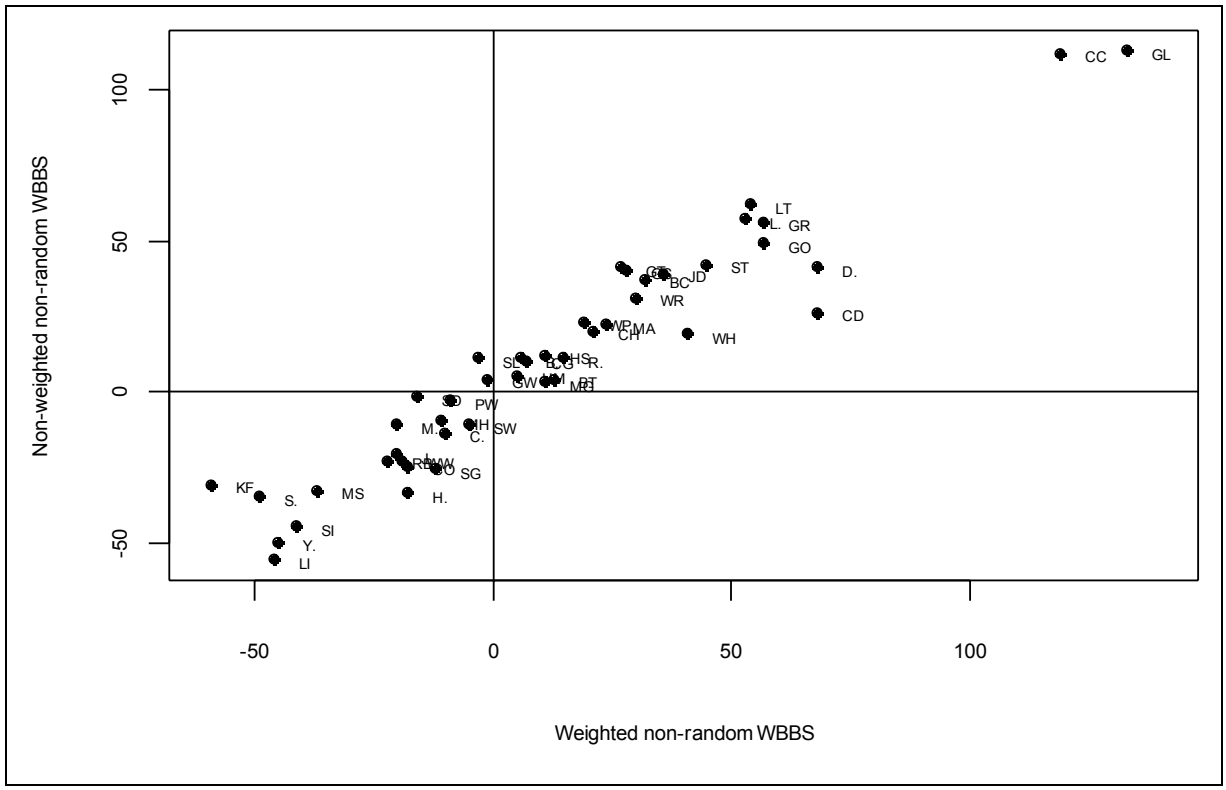


Figure 4. Comparison of population change measures for 1998–2004 for random WBBS sites between weighted and non-weighted analyses. A key to species codes is given in Appendix 2.



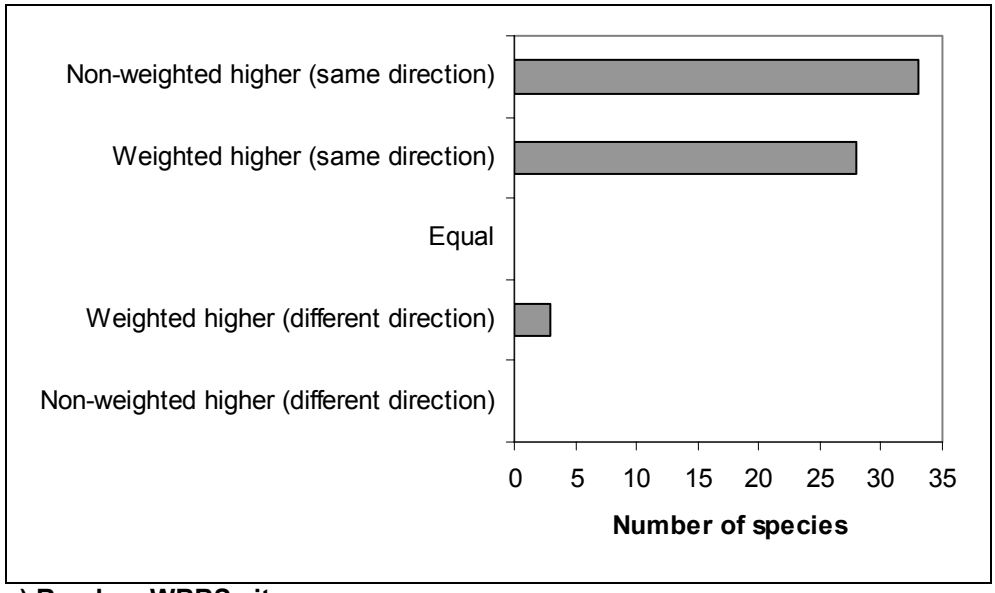
a) All 46 species



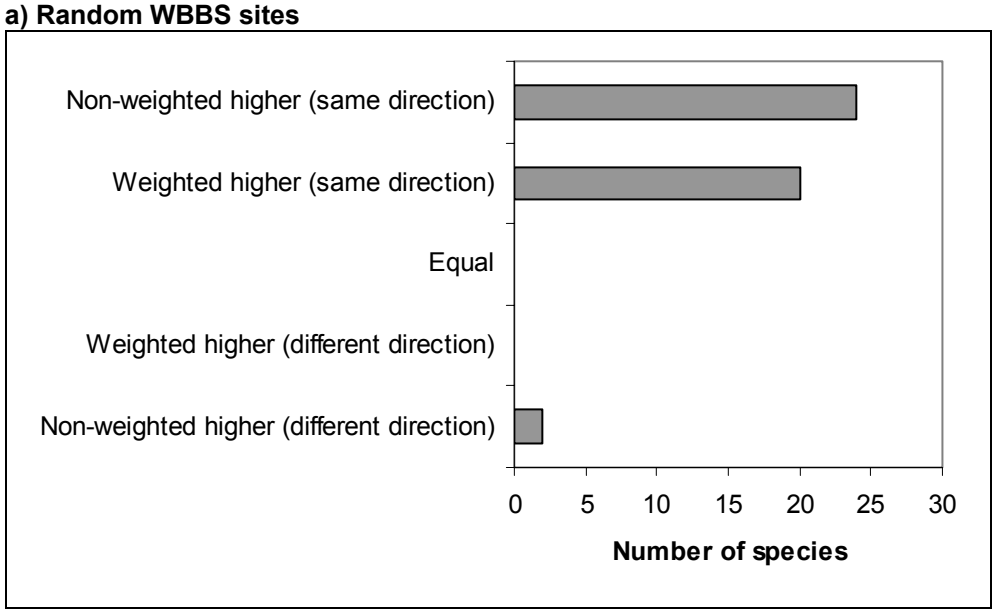
b) Green Woodpecker outlier removed

Figure 5. Comparison of population change measures for 1998–2004 for non-random WBBS sites between weighted and non-weighted analyses. A key to species codes is given in Appendix 2.

Figure 6 illustrates the ratio of population change between weighted and non-weighted analyses for random and non-random WBBS sites. For both these sample sets, the population changes tended to be slightly greater in magnitude for the non-weighted analyses. Directional agreement was very close.



a) Random WBBS sites

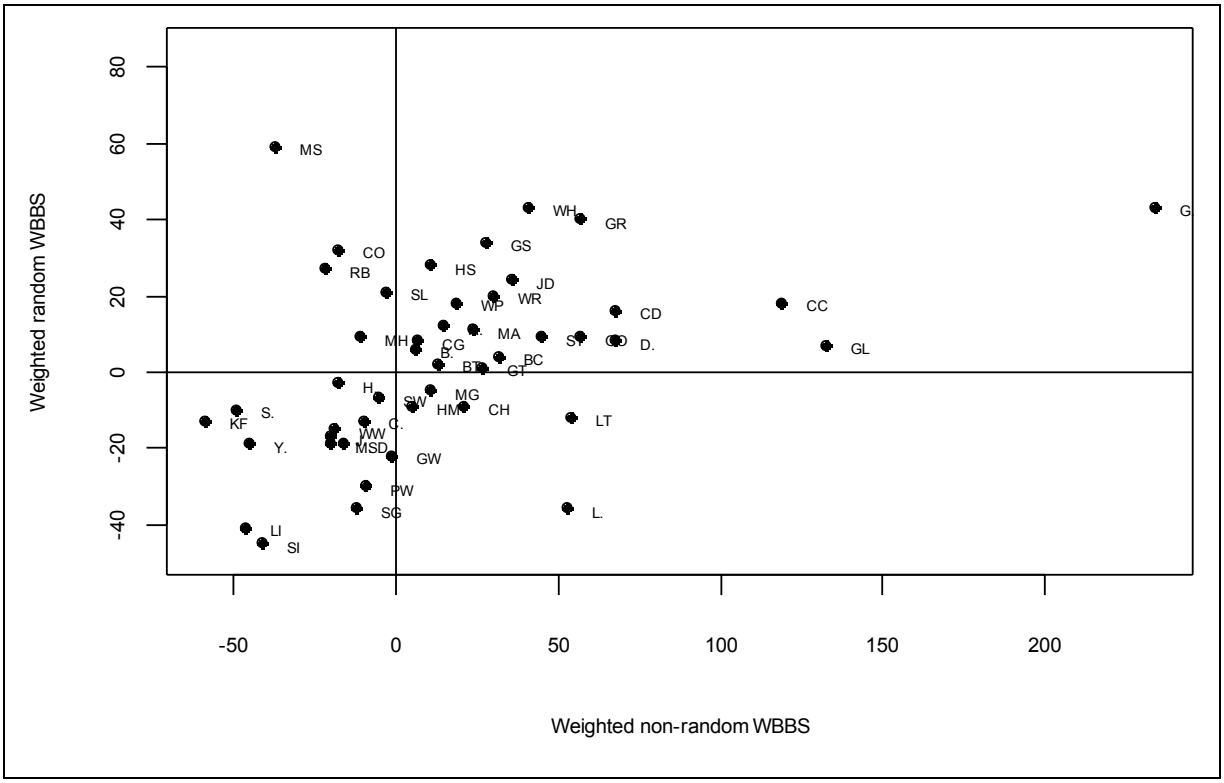


b) Non-random WBBS sites

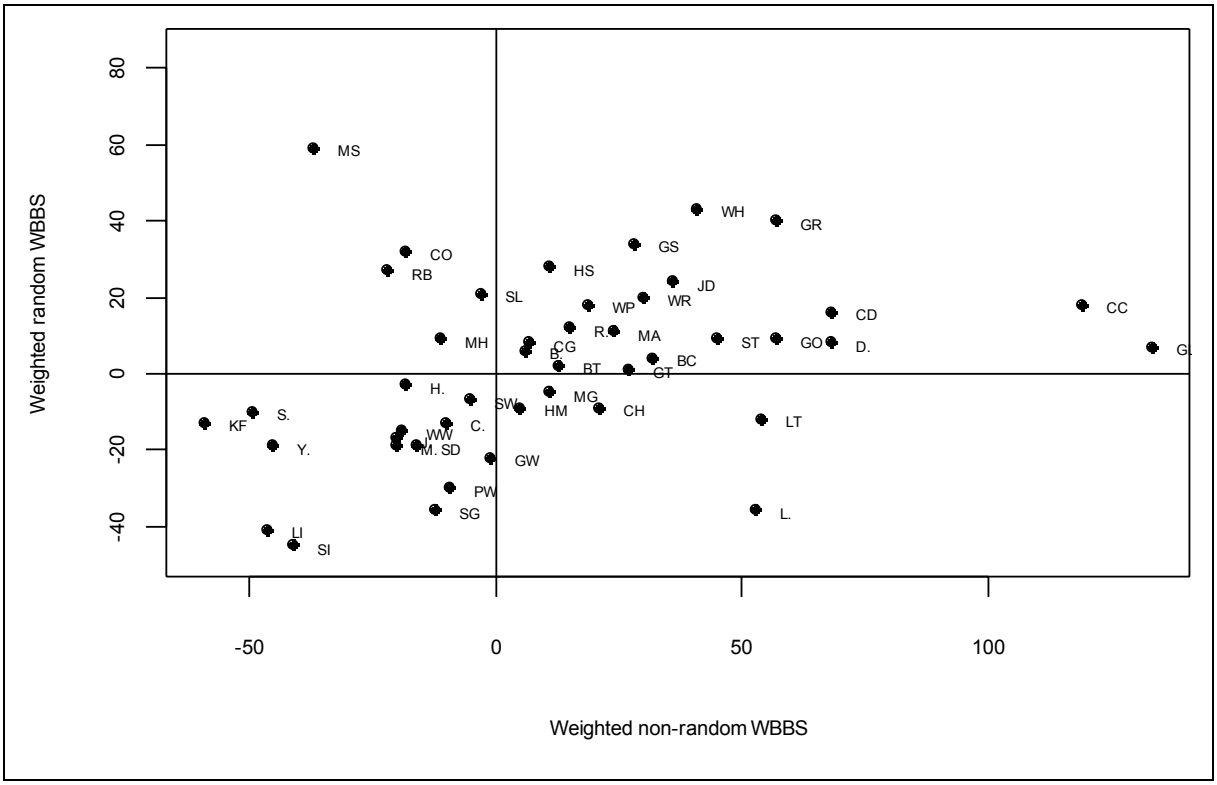
Figure 6. Summary of relative population change measures for 1998–2004 between weighted and non-weighted analyses.

Figure 7 illustrates the correlation in population changes between the weighted random WBBS sites and the weighted non-random WBBS sites, for 46 species. There is a wide range of scatter in the species (r = 0.416, p = 0.004, n = 46), with twelve species (Mute Swan, Moorhen, Coot, Lapwing, Stock Dove, Swift, Swallow, House Martin, Long-tailed Tit, Magpie, Chaffinch and Reed Bunting) showing population changes in opposing directions between the two sets of sites.

Generally the population changes appear to be of greater magnitude on non-random than on random WBBS sites (Figure 8). Long-term trends are mostly very similar, however, between analyses using all WBBS sites and those using random sites only (Appendix 3).



a) All 46 species



b) Green Woodpecker outlier removed

Figure 7. Comparison of population change measures for 1998–2004 between random and non-random WBBS sites. Weightings were applied throughout. A key to species codes is given in Appendix 2.

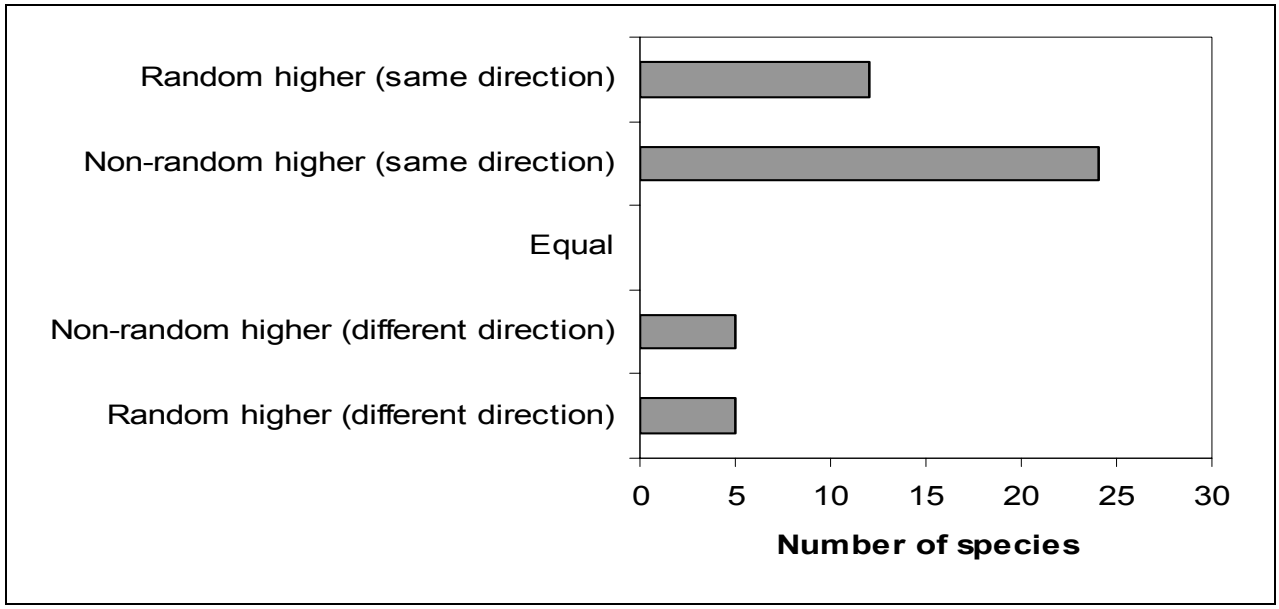


Figure 8. Summary of relative population change measures for 1998–2004 between random and non-random WBBS sites. Weightings applied throughout.

To allow a more formal statistical assessment of the differences in population trends between random and non-random sites, the significance of the interaction term between site type (random versus non-random) and year was tested in the GLM framework. This was performed for both annual year effects (allowing the population trend to vary from year to year) and also the overall long-term effect (linear relationship). Type 3 tests were used, which assess the significance of year while controlling for all other variables in the GLM. The significance of the year effects and linear change for the 49 species that were tested are detailed in Table 11. The analysis included all species that had a sample size of 20 or more on non-random WBBS sites. Five species had a significantly different annual population trend and a different overall long-term change between random sites and non-random WBBS sites: these were Mute Swan, Coot, Stock Dove, Swallow and Chaffinch. A significant difference may not necessarily imply a biological difference in population trend, however.

The findings of the comparison between the random and non-random sites would be greatly strengthened if a longer run of years were available. This would allow a degree of smoothing to be implemented in the population trend and remove the possible inaccuracies in making comparisons between the two groups of sites based on either annual fluctuations or the more rigid assumption of continuous long-term change.

Table 11. Comparison of trends between random and non-random WBBS sites. Significant findings at the 5% level for both annual effects and long-term change are highlighted in bold. Scientific names of bird species are given in Appendix 2.

Species	Annual effect of year			Long-term linear effect of year	
	χ^2 value	P value	No. of years significant[a]	χ^2 value	P value
Mute Swan	**27.958**	**< 0.0001**	**5**	**8.706**	**0.0032**
Canada Goose	5.31	0.3792		0.566	0.4519
Mallard	1.93	0.8587		0.044	0.8337

Species	Annual effect of year			Long-term linear effect of year	
	χ^2 value	P value	No. of years significant[a]	χ^2 value	P value
Pheasant	10.307	0.067		1.261	0.2614
Grey Heron	11.077	0.0499	1	1.394	0.2377
Moorhen	4.014	0.5474		1.708	0.1913
Coot	**11.541**	**0.0417**	**3**	**10.845**	**0.001**
Lapwing	5.821	0.3241	2	7.336	0.0068
Black-headed Gull	48.839	< 0.0001	3	0.408	0.5232
Stock Dove	**16.728**	**0.005**	**1**	**6.408**	**0.0114**
Wood Pigeon	0.403	0.9952		1.135	0.2868
Collared Dove	6.137	0.2931		1.359	0.2438
Swift	6.676	0.2459		1.487	0.2227
Kingfisher	5.512	0.3567		0.349	0.5546
Green Woodpecker	2.937	0.7096		0.87	0.351
Great Spotted Woodpecker	6.141	0.2927		0.286	0.5925
Skylark	11.216	0.0473	2	1.163	0.2809
Swallow	**13.584**	**0.0185**		**10.867**	**0.001**
House Martin	3.831	0.5741		1.655	0.1983
Grey Wagtail	15.134	0.0098		2.324	0.1274
Pied Wagtail	9.824	0.0804		0.197	0.6569
Wren	3.801	0.5784		0.002	0.9632
Dunnock	10.111	0.0722	2	0.082	0.7741
Robin	2.752	0.7381		0.02	0.887
Blackbird	1.816	0.874		0.09	0.7647
Song Thrush	3.656	0.5999		2.021	0.1552
Mistle Thrush	7.236	0.2036		0.326	0.5682
Sedge Warbler	2.892	0.7166		0.065	0.7987
Blackcap	8.99	0.1095		2.421	0.1197
Garden Warbler	7.749	0.1706		4.315	0.0378
Whitethroat	5.491	0.3589		0.429	0.5125
Chiffchaff	8.673	0.1228	4	9.091	0.0026
Willow Warbler	12.953	0.0238		3.55	0.0595
Long-tailed Tit	6.001	0.3061		1.058	0.3037
Blue Tit	10.858	0.0543		0.78	0.3773
Great Tit	16.137	0.0065	1	3.177	0.0747
Jay	2.1	0.8352		0.004	0.9473
Magpie	3.678	0.5966		1.147	0.2841
Jackdaw	5.71	0.3354		2.895	0.0889
Rook	43.815	< 0.0001	2	0.73	0.393
Carrion Crow	10.373	0.0653		0.092	0.7614
Starling	3.991	0.5508		0.781	0.377
House Sparrow	2.46	0.7825		1.411	0.2348
Chaffinch	**31.511**	**< 0.0001**	**1**	**16.526**	**< 0.0001**
Greenfinch	1.546	0.9078		1.078	0.299
Goldfinch	2.201	0.8207		0.106	0.745
Linnet	3.996	0.55		1.743	0.1867
Yellowhammer	4.711	0.4522		1.312	0.2521
Reed Bunting	8.504	0.1305	1	7.946	0.0048

[a] *= significance is based on χ^2 value for parameter estimates, type 1 tests (not controlling for order of variable entry)*

Table 12. Population change measures for 1998–2004 for all WBBS sites and for random WBBS sites only, from weighted analyses. Change measures are reported for species with a mean annual sample size of 20 or more. Gulls, Red-legged Partridge, Pheasant, Feral Pigeon and Rook are excluded. Scientific names of bird species are given in Appendix 2.

Species	Population change 1998–2004		Sample size (mean annual number of plots on which species recorded)	
	All WBBS	Random WBBS	All WBBS	Random WBBS
Mute Swan	+16% *	+59% *	83	48
Greylag Goose	+8%	–	29	–
Canada Goose	+6%	+8%	64	38
Shelduck	-39% *	–	21	–
Mallard	+13% *	+11% *	178	122
Tufted Duck	-3%	+4%	36	23
Goosander	-6%	0%	38	23
Cormorant	+46% *	+32% *	52	35
Grey Heron	-3%	-3%	131	86
Sparrowhawk	-22%	-28%	36	22
Buzzard	+31% *	+31% *	71	55
Kestrel	+7%	0%	62	43
Moorhen	+3%	+9%	118	71
Coot	+10%	+32% *	58	32
Oystercatcher	-5%	-9% *	55	40
Lapwing	-34% *	-36% *	70	46
Curlew	-37% *	-38% *	49	36
Common Sandpiper	-19% *	-21% *	57	43
Common Tern	+11%	–	25	–
Stock Dove	-13% *	-19% *	71	48
Wood Pigeon	+19% *	+18% *	174	120
Collared Dove	+27% *	+16% *	93	57
Cuckoo	-19% *	-18%	64	45
Swift	-46% *	-45% *	106	72
Kingfisher	-23% *	-13%	60	38
Green Woodpecker	+54% *	+43% *	61	39
Gt Spotted Woodpecker	+34% *	+34% *	84	54
Skylark	-15% *	-10% *	88	61
Sand Martin	-42% *	-44% *	58	41
Swallow	+17% *	+21% *	154	106
House Martin	-8% *	-9% *	96	67
Meadow Pipit	-2%	-1%	59	50
Grey Wagtail	+17% *	+7%	104	76
Pied Wagtail	-30% *	-30% *	124	87
Dipper	-26% *	-25% *	71	56
Wren	+22% *	+20% *	178	123
Dunnock	+17% *	+8%	136	88
Robin	+13% *	+12% *	171	117
Redstart	+11%	–	24	–
Wheatear	-22% *	–	23	–
Blackbird	+6% *	+6% *	174	119
Song Thrush	+14% *	+9% *	159	108
Mistle Thrush	-19% *	-19% *	106	72
Sedge Warbler	-8%	-7%	77	47
Reed Warbler	+12% *	+32% *	47	29
Blackcap	+12% *	+4%	132	85
Garden Warbler	-12%	-22% *	67	44
Whitethroat	+44% *	+43% *	98	61
Chiffchaff	+28% *	+18% *	115	75
Willow Warbler	-15% *	-15% *	141	96
Goldcrest	+53% *	+38% *	66	50

Species	Population change 1998–2004		Sample size (mean annual number of plots on which species recorded)	
	All WBBS	Random WBBS	All WBBS	Random WBBS
Spotted Flycatcher	-42% *	-48% *	41	31
Long-tailed Tit	-6%	-12% *	107	69
Coal Tit	-32% *	-30% *	62	47
Blue Tit	+5%	+2%	170	115
Great Tit	+4%	+1%	163	109
Nuthatch	+87% *	+85% *	45	29
Treecreeper	+30% *	+16%	59	41
Jay	-18% *	-17%	57	36
Magpie	-2%	-5%	136	86
Jackdaw	+23% *	+24% *	129	83
Carrion Crow	-11% *	-13% *	172	118
Starling	-33% *	-36% *	131	86
House Sparrow	+25% *	+28% *	99	62
Chaffinch	-3%	-9% *	182	127
Greenfinch	+43% *	+40% *	125	81
Goldfinch	+14% *	+9%	124	82
Linnet	-42% *	-41% *	65	43
Bullfinch	-12%	-15%	55	37
Yellowhammer	-22% *	-19% *	63	40
Reed Bunting	+13% *	+27% *	83	51

* indicates statistical significance at the 95% level.

By combining the random sites with the non-random WBBS sites it was possible to compare the trends and population changes from this combination with the smaller sample of random WBBS sites only (Table 12). The purpose of this analysis was to evaluate the effect on trend estimates of including the non-random sites. Weightings were used for both random and non-random sites, calculated as described in section 2.2.5. Because the random sites make up a large proportion of the combined sample of WBBS sites, the similarity between the population changes was expected to be high. Figure 9 indicates that this was the case ($r = 0.947$, $P < 0.0001$, $n = 66$). The population changes tend to be slightly greater in magnitude for all sites (random and non-random sites combined) than for random WBBS sites alone (Figure 10).

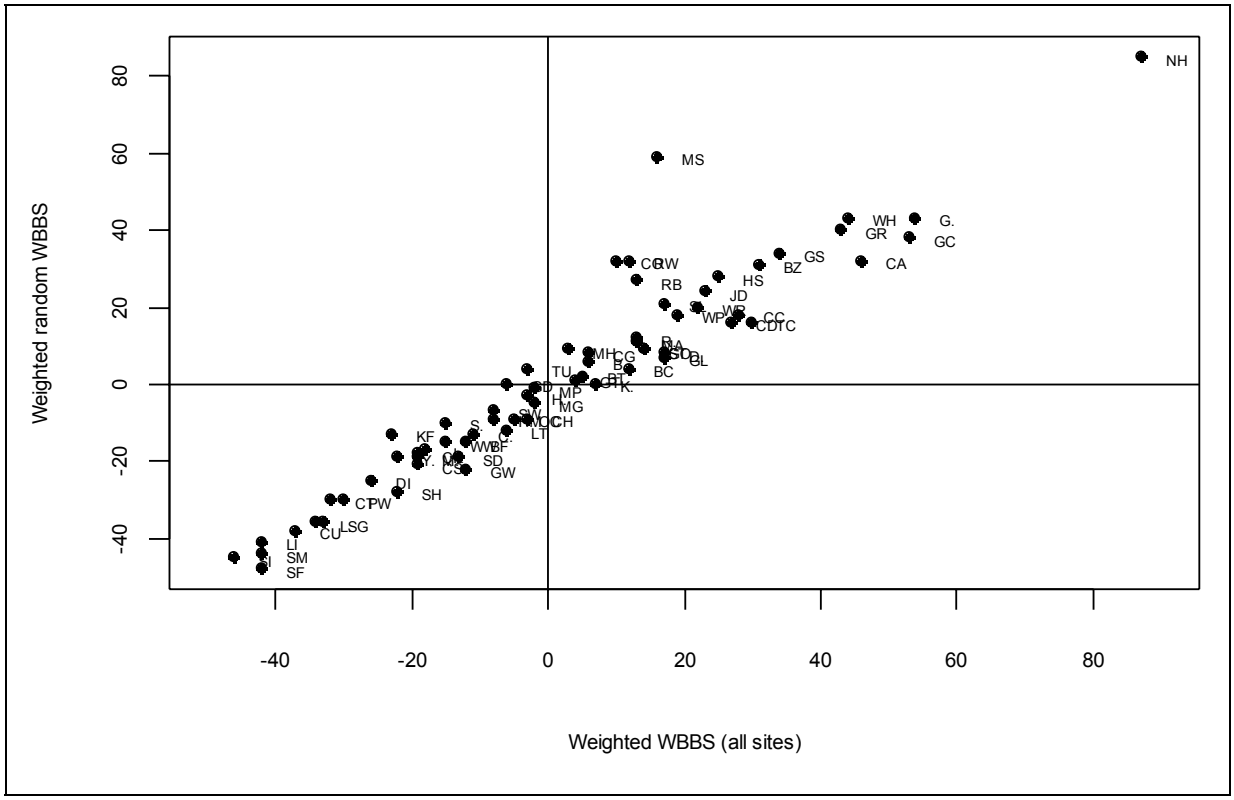


Figure 9. **Comparison of population change measures for 1998–2004 between all WBBS sites (combined random and non-random sites) and random WBBS sites only. Weightings were applied throughout. A key to species codes is given in Appendix 2.**

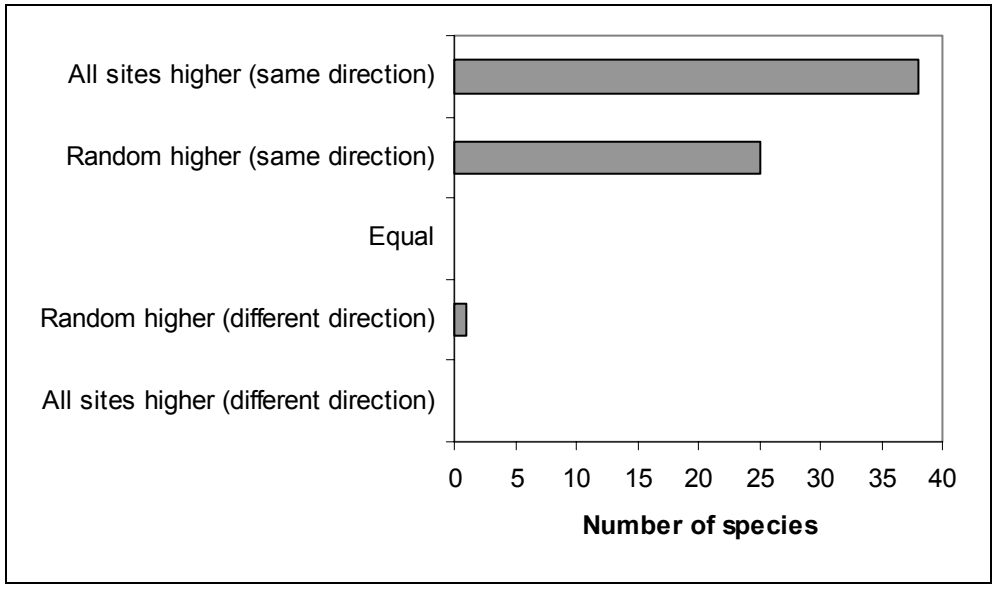


Figure 10. **Summary of relative population change measures for 1998–2004 between all WBBS sites (combined random and non-random sites) and random WBBS sites only. Weightings were applied throughout.**

3.2.2 Comparison of trends between WBBS transects and WBS mapping data

Table 13 shows the population changes for 1998–2004 for all WBBS sites combined as one data set, for non-random (WBS-linked) WBBS sites, and for WBS mapping data. Results are given for all 24 species routinely monitored under the WBS. Population trends for three species are missing for all WBBS sites, because they fail to reach the sample size threshold of 20 or more sites on a mean annual basis, whereas a lower threshold applies to WBS data. The population trends for the WBS sites are derived from the complete run of years for the WBS, starting from 1974 for most species, and then truncated. Annual effects were calculated relative to 1998, and the population changes are for 1998–2004, to match those of the WBBS. Again, data for 2001 have not been used.

Table 13. Comparison of population change measures for 1998–2004 for all WBBS sites, non-random WBBS sites only, and WBS mapping data. Scientific names of bird species are given in Appendix 2.

Species	Population change 1998–2004			Sample size (mean annual number of plots on which species recorded)		
	All WBBS sites	Non-random WBBS sites	WBS mapping results	All WBBS sites	Non-random WBBS sites	WBS mapping results
Mute Swan	+16% *	-37% *	0%	83	35	52
Greylag Goose	+8%	–	+136% *	29	–	11
Canada Goose	+6%	+7%	+83% *	64	27	36
Mallard	+13% *	+24% *	+1%	178	56	90
Tufted Duck	-3%	–	+10%	36	–	23
Goosander	-6%	–	+52% *	38	–	25
Little Grebe	–	–	-63% *	–	–	9
Moorhen	+3%	-11%	0%	118	47	76
Coot	+10%	-18%	-22% *	58	27	42
Oystercatcher	-5%	–	+9%	55	–	25
Lapwing	-34% *	+53% *	-1%	70	24	32
Curlew	-37% *	–	-7%	49	–	19
Redshank	–	–	-24%	–	–	11
Common Sandpiper	-19% *	–	-17%	57	–	20
Kingfisher	-23% *	-59% *	+38%	60	22	33
Sand Martin	-42% *	–	-31% *	58	–	21
Yellow Wagtail	–	–	-60% *	–	–	9
Grey Wagtail	+17% *	+133% *	+52% *	104	28	49
Pied Wagtail	-30% *	-9%	-8%	124	37	54
Dipper	-26% *	–	+8%	71	–	29
Sedge Warbler	-8%	-5%	+35% *	77	30	43
Reed Warbler	+12% *	–	+40% *	47	–	24
Whitethroat	+44% *	+41% *	+45% *	98	36	51
Reed Bunting	+13% *	-22% *	+20%	83	33	48

* indicates statistical significance

Sample sizes are consistently higher for all WBBS sites than for WBS plots. Seven species (Tufted Duck, Goosander, Coot, Oystercatcher, Kingfisher, Dipper and Sedge Warbler) have population trends in opposing directions under the two different schemes, although in some of these cases the magnitude of the estimated changes is quite small. Figure 11 shows the comparison between the two schemes in detail. The largest discrepancies in magnitude of population change are for Greylag and Canada Geese. Mallard, Moorhen, Common Sandpiper,

Sand Martin, Whitethroat and Reed Bunting show similar population changes on WBBS and WBS sites.

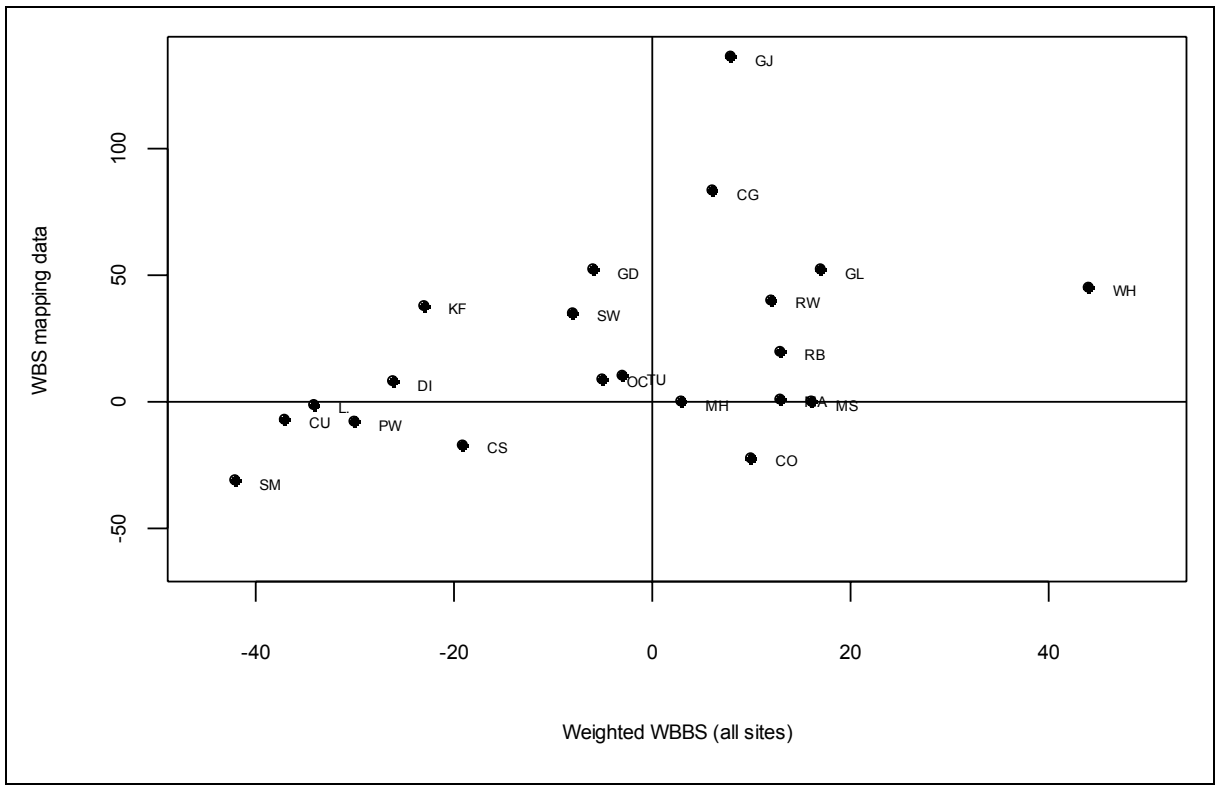


Figure 11. Comparison of population change measures for 1998–2004 between weighted WBBS sites (a combined data set of random and non-random sites) and WBS mapping data. A key to species codes is given in Appendix 2.

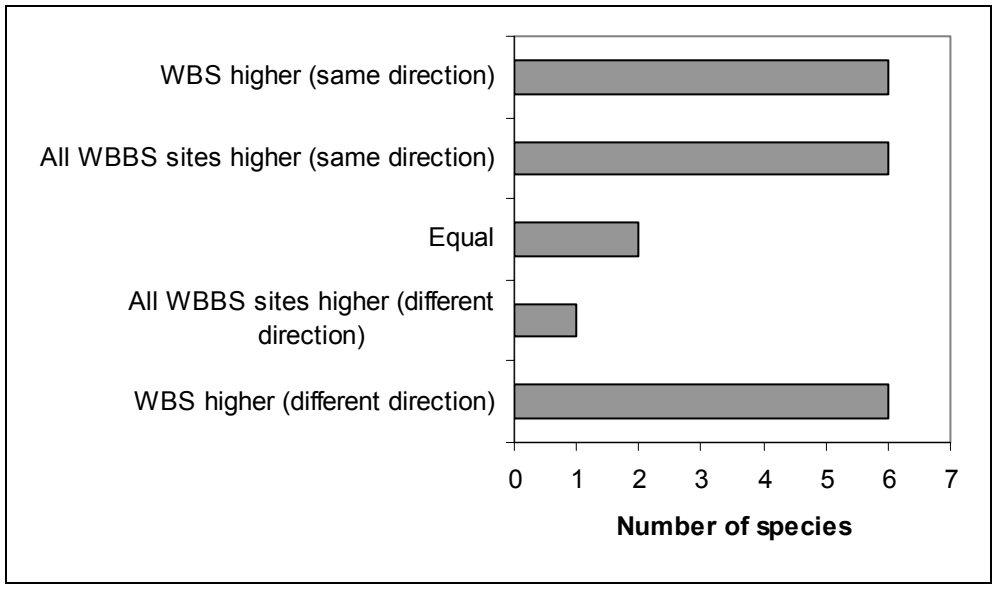


Figure 12. Summary of relative population change measures for 1998–2004 between weighted WBBS sites (a combined data set of random and non-random sites) and WBS mapping data.

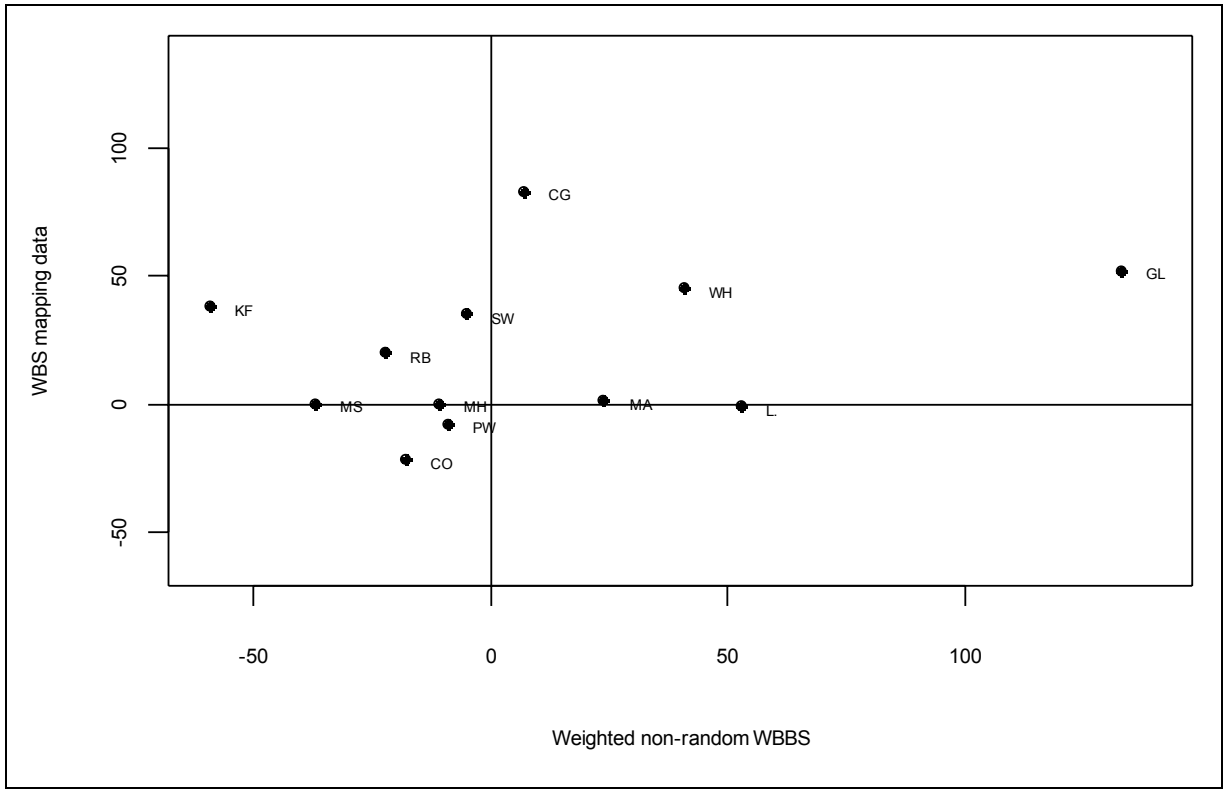


Figure 13. Comparison of population change measures for 1998–2004 between weighted non-random (WBS-linked) WBBS sites and WBS mapping data. A key to species codes is given in Appendix 2.

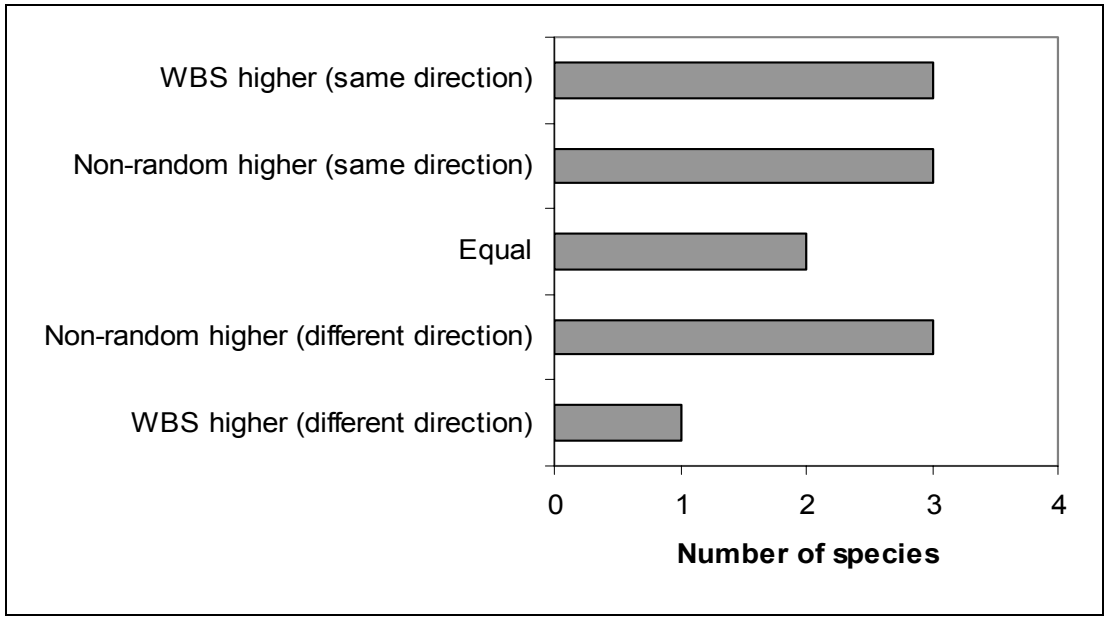


Figure 14. Summary of relative population change measures for 1998–2004 between weighted non-random WBBS sites and WBS mapping data.

Those species that show a trend in the same direction on both WBBS and WBS sites show no tendency for the magnitude of the population change to be greater or lesser on one particular site type (Figure 12). This is in contrast to those species that have population trends in opposing directions on WBBS and WBS sites, where the magnitude of the population change tends to be

greater on WBS sites. Long-term trends between WBBS and WBS show many encouraging similarities, despite the large degree of independence between the two data sets (Appendix 4).

A more restricted comparison is between the trends drawn from WBBS data for non-random sites and from WBS mapping data (Figures 13 and 14). To a large degree, these are the same stretches surveyed by the same observers, but with different methods of data collection. There are also, however, sites from which only WBS mapping or WBBS transect data were available. Only 12 species are covered by this subset of WBBS data, and the numbers of sites, except for Mallard and for Moorhen, are consistently small. There appears to be little indication of a systematic difference between the WBS sites and the WBBS as measured by the bar chart (Figure 14).

To facilitate a formal statistical comparison of the population trends between the WBBS and WBS sites, the significance of the interaction term between site type (WBBS versus WBS) and year was tested in the GLM framework. This was performed for both annual year effects (allowing the population trend to vary from year to year) and also the overall long-term effect (linear relationship). Type 3 tests were used which assess the significance of year while controlling for all other variables in the GLM. To ease comparison, the WBS data was restricted to 1998 onwards. To allow the use of the 'offset' command to account for the number of WBBS transect sections, the offset was set to one for WBS sites. This means there is no effect of 'offset' on WBS sites in the model. Sedge Warbler is the only species that has a significant difference between WBBS and WBS sites both for annual effects and for the overall long-term linear change. For this species, therefore, this result suggests that discrepancies in population trends between WBBS and WBS sites may become more apparent when comparing the longer and more complete time span of the WBS to the WBBS.

Table 14. Comparison of trends between all WBBS sites (a combined data set of random and non-random sites) and WBS mapping data. Significant findings at the 5% level for both annual effects and long-term change are highlighted in bold. Sample sizes are as in Table 13. Scientific names of bird species are given in Appendix 2.

Species	Annual effect of year			Long-term linear effect of year		Sample size (mean annual number of plots)	
	χ^2 value	P value	No. of years significant[a]	χ^2 value	P value	All WBBS sites	WBS mapping results
Mute Swan	1.793	0.8769		0.005	0.9436	83	52
Greylag Goose	2.393	0.7925		0.28	0.5967	29	11
Canada Goose	3.493	0.6245		2.874	0.09	64	36
Mallard	6.148	0.2921	2	1.952	0.1624	178	89
Tufted Duck	0.483	0.9927		0.011	0.9172	36	23
Goosander	3.143	0.6779		0.532	0.4657	38	25
Little Grebe	5.644	0.3424		1.223	0.2688	14	9
Moorhen	3.15	0.6769		1.468	0.2256	118	76
Coot	7.509	0.1855	1	2.036	0.1536	58	42
Oystercatcher	2.971	0.7044		0.116	0.7334	55	25
Lapwing	5.876	0.3185		0.039	0.8434	70	32
Curlew	3.008	0.6988		1.757	0.1849	49	19
Redshank	1.18	0.9467		0.095	0.7577	20	11
Common Sandpiper	1.111	0.9532		0.047	0.8285	57	20
Kingfisher	1.506	0.9124		0.348	0.555	60	33
Sand Martin	3.457	0.6299		1.981	0.1592	58	21
Yellow Wagtail	5.209	0.391		1.558	0.212	20	9
Grey Wagtail	2.669	0.7509		1.633	0.2013	104	49
Pied Wagtail	2.111	0.8336		0.089	0.7653	124	53

Species	Annual effect of year			Long-term linear effect of year		Sample size (mean annual number of plots)	
	χ^2 value	P value	No. of years significant[a]	χ^2 value	P value	All WBBS sites	WBS mapping results
Dipper	1.047	0.9586		1.066	0.3019	71	29
Sedge Warbler	**15.182**	**0.0096**	**1**	**13.196**	**0.0003**	**77**	**43**
Reed Warbler	6.08	0.2985		3.629	0.0568	47	23
Whitethroat	5.373	0.3721		0	0.999	98	51
Reed Bunting	2.892	0.7166		0.123	0.7263	83	48

[a] *= significance is based on χ^2 value for parameter estimates, type 1 tests (not controlling for order of variable entry)*

4 Discussion and recommendations

4.1 Review of methods for calculating WBBS trends

The 500-m sections that are the basic units of the WBBS recording provide data that are of value at this scale, for example for comparison with RHS information. Analyses need to recognise, however, that adjacent sections, surveyed on the same mornings by the same observers, are not independent. For monitoring, the sampling unit is effectively the whole stretch.

There are a number of ways of obtaining a count from a stretch, using data from the early and late bird-counting visits. For example, the maximum between early and late can be taken either across sections, with the resulting maxima being summed, or across the whole stretch, after summing the sections. The former method makes more biological sense, at least for species with territories likely to be confined within a single 500-m section, because presence even on just one of the two visits would always be reflected in the monitoring total. It does, however, increase the risk of double-counting the same individuals, if on the two visits they were seen in different sections. The BBS uses exclusively the latter method, taking the maxima after summing across all sections. Intermediates between the two, in which adjacent sections were first amalgamated, could also be devised; methods could be tailored to the territorial behaviour of each species.

The analyses presented here differ from the BBS example in using maxima taken first across transect sections. This often has the advantage that the monitoring totals are slightly larger, especially for species that are hard to detect. The precision of trend estimation is increased using this 'section' method, rather than the more usual 'stretch' method (Appendix 5).

The BBS sets maximum counts for six species of waders, above which the data are treated as relating to a non-breeding flock rather than to breeding birds and omitted from the totals (Raven *et al.* 2005). No such limits have been used for the WBBS data. These further options in the way the count is derived have not been examined in this report.

4.1.1 Value of a geographical weighting factor

Using geographical weightings made only minor differences to assessments of population trend (Table 10, Figures 4–6). It is likely that the changes that were introduced made the trends more representative of waterways. For this reason, therefore, subsequent analyses used weightings exclusively.

Weighting is also useful because it allows for a future geographical stratification of data collection. The present lack of stratification concentrates random stretches in regions of the UK where observers are hard to find, whereas in other regions there may be observers available but no vacant random stretches. With a regional stratification in place, random stretches could in future be selected at higher densities in areas with more observers, thus enabling an increase in overall sample size. Despite the relatively low weightings that would be applied to data from these new sites, monitoring precision should increase as a result.

The methods pioneered in this report could be used to apply weightings retrospectively to WBS mapping data, to make WBS trends more representative of UK waterways as a whole.

4.1.2 Should non-random (WBS-linked) sites be included in trend calculations?

Ideally, monitoring sites should be entirely random, with no room for observer choice that may be influenced, for example, by habitat quality or by levels of disturbance. Such choice may result in a biased sample. In practice, we have been able to find observers for a little over half the random sites selected, allowing observers in many regions room to select their survey sites from within the random list. Further, a second WBBS sample exists which is clearly self-selected, being sites at which observers have chosen to conduct mapping surveys.

Comparisons of population change estimates for 1998–2004 between random and non-random sites shows that the results are correlated (r = 0.416, P = 0.004, n = 46), but with quite wide scatter, and with twelve species showing population changes in opposing directions between the two sets of sites (Table 10, Figure 7, Appendix 3). The short run of years, with only 19 WBS-linked stretches in the first year, reduces the chance of a strong correlation between the two sets of results. Generally the population changes appear to be of greater magnitude on non-random than on random WBBS sites (Figure 8). Geographical weighting of both non-random and random sites is likely to reduce the effects of the somewhat different geographical distributions of the two samples.

Five species had a significantly different annual population trend and a different overall long-term change between random sites and non-random WBBS sites (Table 11). A significant difference may not necessarily imply a biological difference in population trend, however, and may result solely from comparing results that were each of low precision.

Table 15. Standard errors of the population change measure for 1998–2004 for all WBBS sites and for random WBBS sites only, from weighted analyses. Standard errors are reported for species with a mean annual sample size of 20 or more sites. Gulls, Red-legged Partridge, Pheasant, Feral Pigeon and Rook are excluded. Scientific names of bird species are given in Appendix 2.

Species	Standard error of population change measure for 1998–2004		Sample size (mean annual number of plots on which species recorded)	
	All WBBS	Random WBBS	All WBBS	Random WBBS
Mute Swan	1.0461	1.057	83	48
Greylag Goose	1.0603	–	29	18
Canada Goose	1.0424	1.0504	64	38
Shelduck	1.0526	–	21	12
Mallard	1.0174	1.0192	178	122
Tufted Duck	1.0722	1.0765	36	23
Goosander	1.0836	1.0893	38	23
Cormorant	1.0869	1.0994	52	35
Grey Heron	1.0528	1.0602	131	86
Sparrowhawk	1.1759	1.1988	36	22
Buzzard	1.0664	1.068	71	55
Kestrel	1.0994	1.1073	62	43
Moorhen	1.0394	1.047	118	71
Coot	1.0518	1.0637	58	32
Oystercatcher	1.0317	1.0334	55	40
Lapwing	1.0301	1.0318	70	46
Curlew	1.0498	1.0516	49	36
Common Sandpiper	1.0417	1.0445	57	43
Common Tern	1.116	–	25	15
Stock Dove	1.0595	1.0651	71	48
Wood Pigeon	1.0152	1.0166	174	120
Collared Dove	1.0559	1.0638	93	57

Species	Standard error of population change measure for 1998–2004		Sample size (mean annual number of plots on which species recorded)	
	All WBBS	Random WBBS	All WBBS	Random WBBS
Cuckoo	1.0976	1.1033	64	45
Swift	1.032	1.0345	106	72
Kingfisher	1.1114	1.1204	60	38
Green Woodpecker	1.1082	1.1147	61	39
Gt Spotted Woodpecker	1.0813	1.0878	84	54
Skylark	1.0436	1.0461	88	61
Sand Martin	1.0336	1.0358	58	41
Swallow	1.0276	1.0295	154	106
House Martin	1.0338	1.0353	96	67
Meadow Pipit	1.0249	1.025	59	50
Grey Wagtail	1.0569	1.0607	104	76
Pied Wagtail	1.0427	1.0448	124	87
Dipper	1.061	1.0646	71	56
Wren	1.0194	1.0212	178	123
Dunnock	1.0439	1.0492	136	88
Robin	1.0279	1.0305	171	117
Redstart	1.1028	–	24	18
Wheatear	1.0687	–	23	20
Blackbird	1.0207	1.0226	174	119
Song Thrush	1.0379	1.0408	159	108
Mistle Thrush	1.0603	1.0639	106	72
Sedge Warbler	1.051	1.0583	77	47
Reed Warbler	1.0543	1.0688	47	29
Blackcap	1.0402	1.0446	132	85
Garden Warbler	1.0808	1.0906	67	44
Whitethroat	1.0491	1.0538	98	61
Chiffchaff	1.0431	1.0465	115	75
Willow Warbler	1.0294	1.0313	141	96
Goldcrest	1.0728	1.0758	66	50
Spotted Flycatcher	1.1026	1.1116	41	31
Long-tailed Tit	1.0498	1.0542	107	69
Coal Tit	1.0675	1.0702	62	47
Blue Tit	1.022	1.024	170	115
Great Tit	1.0292	1.0318	163	109
Nuthatch	1.1105	1.1163	45	29
Treecreeper	1.0965	1.1057	59	41
Jay	1.1071	1.1167	57	36
Magpie	1.0372	1.0419	136	86
Jackdaw	1.024	1.0256	129	83
Carrion Crow	1.0209	1.023	172	118
Starling	1.0188	1.0204	131	86
House Sparrow	1.0341	1.0368	99	62
Chaffinch	1.0182	1.0196	182	127
Greenfinch	1.0393	1.0447	125	81
Goldfinch	1.0415	1.0446	124	82
Linnet	1.0542	1.0594	65	43
Bullfinch	1.0966	1.1045	55	37
Yellowhammer	1.0655	1.0707	63	40
Reed Bunting	1.0572	1.065	83	51

Adding the non-random (WBS-linked) stretches into the monitoring sample has relatively small and apparently non-systematic effects on the assessments of population trend (Table 12). Their inclusion allows greater monitoring precision, as measured by the standard errors of population change measures (Table 15), which are consistently lower for the larger, inclusive samples.

The larger samples resulting from the inclusion of non-random stretches also allow considerably more extensive species coverage (Table 16). A further five waterbird species have annual samples exceeding 100 plots when non-random sites are included, for example, and a further three have samples exceeding 40. BBS experience indicates that, as a general rule, a minimum of 40 sites is likely to provide an acceptable confidence interval for monitoring purposes (Joys *et al.* 2003). WBBS transects are on average about 63% greater in length than BBS transects, however, and run through a habitat generally richer in birds. Since Joys *et al.* (2003) found that an increase in the mean count of birds per site would increase the power for measuring change, it may be the case that fewer than 40 WBBS sites would provide adequate monitoring precision. Moreover, the fact that WBBS sites are all of similar habitat type should reduce the variance in the data, relative to BBS sites, and so increase the power to detect population change.

Including existing non-random WBBS data in population trend models therefore allows more species to be monitored, with greater precision. Ongoing data inclusion from these sites would also have the benefit of retaining the goodwill of existing WBS observers. Should we settle on WBBS as the sole future scheme for monitoring breeding birds along waterways, we could encourage non-random WBBS surveys from previous WBS sites to continue, and include the results in the trend calculations, perhaps until the eventual demise of these sites through natural wastage.

Table 16. Numbers of species in various categories of WBBS sample size in 2002, 2003 and 2004. Waterbirds are defined as those species included on WBS mapping surveys, including waterfowl, waders, gulls, Kingfisher, and various waterside passerines.

a) Random WBBS sites

Sample size (sites)	2002			2003			2004		
	Water-birds	Others	Total	Water-birds	Others	Total	Water-birds	Others	Total
26–40 sites	7	4	**11**	4	4	**8**	3	4	**7**
41–100 sites	17	31	**48**	18	24	**42**	18	22	**40**
>100 sites	1	11	**12**	4	22	**26**	5	24	**29**
Total species with >40 sites	18	42	**60**	22	46	**68**	23	46	**69**

b) All WBBS sites

Sample size (sites)	2002			2003			2004		
	Water-birds	Others	Total	Water-birds	Others	Total	Water-birds	Others	Total
26–40 sites	2	2	**4**	6	4	**10**	6	3	**9**
41–100 sites	19	20	**39**	16	17	**33**	16	18	**34**
>100 sites	6	26	**32**	9	30	**39**	10	31	**41**
Total species with >40 sites	25	46	**71**	25	47	**72**	26	49	**75**

4.2 Comparison of trend data from the WBS and WBBS

WBS trends have been valuable over the years, and continue to be so, in assessments of breeding bird trends and conservation priorities in the UK (Gregory *et al.* 2002, Baillie *et al.* 2006). They fill gaps in BBS coverage, as well as providing trend data from waterways for species already well covered by the BBS. The representative nature of the WBS data can be questioned, however, especially in comparison with the BBS, because observers choose their own sites to survey. Also, the intensive mapping method used by the WBS means that volunteers are few and sample sizes small. Observers collect data for waterbirds only.

WBBS trends, with a strong element of random sampling, are more representative. Large samples offset the relative high variability inherent in its quick, two-visit transect method. The data cover all species, and samples should be sufficient to monitor more than 70 species in the waterside habitat, as opposed to the WBS's 24. Units of counting for the WBBS are individual birds, whereas for the WBS they are breeding territories; the WBBS may thus include non-breeding birds, sometimes in flocks, that would not be represented in WBS data. Deciding whether or not birds are territorial adds a subjective element to WBS data processing, which is by-passed by the WBBS's all-inclusive approach. BBS has methods, not yet tested with the WBBS, designed to exclude non-breeding flocks of certain species.

Comparison of trends between WBS and WBBS suggests they are generally similar (Tables 13 and 14, Figures 11 and 12, Appendix 4). Trends over the period tended to be more positive from the mapping survey, however. Agreement was relatively poor for two of the species that may occur in large flocks (Canada Goose and Lapwing), and also for Kingfisher and Grey Wagtail.

4.3 Comparison of trend data from the BBS and WBBS

WBBS sample sizes are compared with the BBS in Table 17. There are three species where there are more WBBS than BBS plots in the long-term sample: these are Goosander, Kingfisher and Dipper. Among other waterbirds, Common Sandpiper, Common Tern, Sand Martin, Grey Wagtail and Reed Warbler have WBBS samples at least half as large as those for BBS over the same period.

These comparisons underestimate the true value of the WBBS, however. First, because of the strong recent increase in WBBS participation, current WBBS samples are considerably larger than the 1998–2004 average. Second, WBBS plots are likely to hold much larger numbers of waterbirds than BBS squares, and so provide greater monitoring precision. This is partly because they average 3–3.5 km in length and are often more than twice as long as a BBS transect (which is normally 2 km, but occasionally shorter), and partly because, for waterbirds, the whole length of the WBBS transect may contain suitable habitat. Thus, a WBBS sample half as large as the BBS one would often give a more precise estimation of population trend. It would be helpful to investigate and quantify these effects.

Population trends for 1998–2004 are given in Table 17. These are strikingly similar in many cases, for example Mallard, Cormorant, Sparrowhawk, Buzzard, Curlew, Common Sandpiper, Swallow, Meadow Pipit, Robin, Song Thrush, Reed Warbler, Blackcap, Chiffchaff, Willow Warbler, Magpie and Reed Bunting. If these similarities are more than chance, they indicate that trends in habitats by linear waterways are no different from the trends observed in the other habitats in which the species may occur.

For other species there are substantial discrepancies. There were significant trends in opposing directions for ten species: Mute Swan, Stock Dove, Kingfisher, Sand Martin, House Martin, Pied

Wagtail, Treecreeper, Jay, Chaffinch (although here the numerical difference between the estimates is very small), and Bullfinch. These differences suggest that different trends may have occurred in the ranges of habitat types covered by the two schemes. For non-waterbirds, the BBS trend is clearly of much greater interest, since WBBS coverage is only of a small section of the habitat used by each species. The WBBS trend could nevertheless help to shed light on the dynamics of population change. For waterbirds, however, WBBS figures are potentially closer to the overall trend of the UK population than are BBS ones, especially for species like Dipper for which linear waters are the primary habitat.

There are a number of scarce species not monitored by the BBS because of small sample sizes, for which the addition of WBBS data would produce a sufficient monitoring sample. Despite the statistical difficulties of this procedure, it may be preferable to produce a joint BBS–WBBS index than not to have one at all.

Table 17. Population change measures for 1998–2004 from weighted analyses for all WBBS sites and from BBS sites. Change measures are reported for species with a mean annual sample size of 20 or more WBBS sites. Gulls, Red-legged Partridge, Pheasant, Feral Pigeon and Rook are excluded. Scientific names of bird species are given in Appendix 2.

Species	Population change measure 1998–2004		Sample size (mean annual number of plots on which species recorded)		
	All WBBS	BBS	All WBBS	BBS	WBBS:BBS
Mute Swan	+16% *	-9% *	83	185	45%
Greylag Goose	+8%	+123% *	29	99	29%
Canada Goose	+6%	+31% *	64	331	19%
Shelduck	-39% *	-9% *	21	118	18%
Mallard	+13% *	+16% *	178	982	18%
Tufted Duck	-3%	+12% *	36	124	29%
Goosander	-6%	-31% *	38	33	115%
Cormorant	+46% *	+38% *	52	166	31%
Grey Heron	-3%	+19% *	131	513	26%
Sparrowhawk	-22%	-19% *	36	277	13%
Buzzard	+31% *	+22% *	71	544	13%
Kestrel	+7%	-4% *	62	528	12%
Moorhen	+3%	+25% *	118	526	22%
Coot	+10%	+46% *	58	205	28%
Oystercatcher	-5%	+10% *	55	244	23%
Lapwing	-34% *	+3% *	70	559	13%
Curlew	-37% *	-26% *	49	431	11%
Common Sandpiper	-19% *	-20% *	57	60	95%
Common Tern	+11%	+71% *	25	48	52%
Stock Dove	-13% *	+16% *	71	618	11%
Wood Pigeon	+19% *	+12% *	174	1913	9%
Collared Dove	+27% *	+20% *	93	1044	9%
Cuckoo	-19% *	-6% *	64	712	9%
Swift	-46% *	-15% *	106	870	12%
Kingfisher	-23% *	+39% *	60	43	140%
Green Woodpecker	+54% *	+15% *	61	592	10%
Gt Spotted Woodpecker	+34% *	+52% *	84	666	13%
Skylark	-15% *	-4% *	88	1407	6%
Sand Martin	-42% *	+129% *	58	99	59%
Swallow	+17% *	+16% *	154	1486	10%
House Martin	-8% *	+27% *	96	766	13%
Meadow Pipit	-2%	-4% *	59	640	9%
Grey Wagtail	+17% *	+29% *	104	167	62%
Pied Wagtail	-30% *	+7% *	124	1015	12%

Species	Population change measure 1998–2004		Sample size (mean annual number of plots on which species recorded)		
	All WBBS	BBS	All WBBS	BBS	WBBS:BBS
Dipper	-26% *	0%	71	46	154%
Wren	+22% *	+11% *	178	1879	9%
Dunnock	+17% *	+10% *	136	1568	9%
Robin	+13% *	+9% *	171	1813	9%
Redstart	+11%	-9% *	24	132	18%
Wheatear	-22% *	-27% *	23	243	9%
Blackbird	+6% *	+12% *	174	1896	9%
Song Thrush	+14% *	+15% *	159	1488	11%
Mistle Thrush	-19% *	-3% *	106	992	11%
Sedge Warbler	-8%	+15% *	77	248	31%
Reed Warbler	+12% *	+12% *	47	92	51%
Blackcap	+12% *	+10% *	132	1123	12%
Garden Warbler	-12%	-7% *	67	373	18%
Whitethroat	+44% *	+23% *	98	1024	10%
Chiffchaff	+28% *	+32% *	115	1040	11%
Willow Warbler	-15% *	-21% *	141	1205	12%
Goldcrest	+53% *	+8% *	66	582	11%
Spotted Flycatcher	-42% *	-13% *	41	194	21%
Long-tailed Tit	-6%	+15% *	107	677	16%
Coal Tit	-32% *	-6% *	62	585	11%
Blue Tit	+5%	+10% *	170	1772	10%
Great Tit	+4%	+16% *	163	1632	10%
Nuthatch	+87% *	+22% *	45	325	14%
Treecreeper	+30% *	-8% *	59	276	21%
Jay	-18% *	+19% *	57	553	10%
Magpie	-2%	-6% *	136	1470	9%
Jackdaw	+23% *	+7% *	129	1256	10%
Carrion Crow	-11% *	0%	172	1795	10%
Starling	-33% *	-20% *	131	1499	9%
House Sparrow	+25% *	+6% *	99	1275	8%
Chaffinch	-3%	+4% *	182	1898	10%
Greenfinch	+43% *	+21% *	125	1387	9%
Goldfinch	+14% *	+38% *	124	1104	11%
Linnet	-42% *	-4% *	65	1045	6%
Bullfinch	-12%	+22% *	55	463	12%
Yellowhammer	-22% *	-9% *	63	1008	6%
Reed Bunting	+13% *	+13% *	83	351	24%

* indicates statistical significance at the 95% level.

4.4 Conclusions and recommendations

4.4.1 Conclusions from Phases 1-3 of the WBBS

The first seven years of WBBS studies, concluding with the 2004 surveys, have established the WBBS method as a quick way to collect valuable data on breeding birds from 500-m sections of waterway. Sample surveys, for example, would assist the assessment of relative conservation value between waterway stretches or between catchments. Modelling alongside RHS data would allow such assessments to be made even for stretches lacking WBBS-style data. Surveys in breeding seasons before and after groundwork operations would help to quantify the biological effects of waterway management. The method has already been used to assess whether the presence or absence of a coarse-fishing close season affects breeding bird numbers.

This report shows the value of repeat surveys on a wide-scale and long-term basis for population monitoring. The BTO has been able to recruit sufficient volunteers for a WBBS sample large enough to monitor more than 70 bird species in the waterway habitat. For some species that are specialists in the waterway habitat, WBBS indices would be the most reliable indicator we have of overall change in population size. For others, such as woodland or farmland species for which waterways are not a major habitat, trends along waterways might, in comparison with trends for other habitat types derived from the BBS, help to reveal the dynamics of a population, even in the absence of overall change.

It was most unfortunate for this study that FMD occurred in the middle year of its seven-year run. The total lack of data for 2001 for calculating trends has undoubtedly been disruptive but was considered a better option than including the data that were collected, for which regional and habitat biases were clearly evident.

Despite this drawback, we have collected enough data to investigate how WBBS data should be used to produce population trend indices, and to compare these trends with those from the WBS and BBS.

4.4.2 Recommendations for future surveys

Discrepancies between the WBS and WBBS as shown in this report may stem in part from the availability of just four direct year-to-year comparisons in the period under study: 1998–99, 1999–2000, 2002–03 and 2003–04. A firmer comparison between these two schemes would be necessary to produce joint WBS/WBBS index trends that, like those of CBC/BBS, would allow continuity of population monitoring with WBBS to extend back to the start of the WBS in 1974.

It is therefore proposed that the WBBS and WBS continue in parallel, at least for a further two breeding seasons, 2005 and 2006, to allow the calibration of WBBS and WBS trends to be improved, and to consolidate the WBBS sample, after which the comparison would be re-assessed. The first of these two fieldwork seasons (2005) has already been completed.

The following aspects could usefully be addressed during a further, two-year phase of WBBS development:

- *stratification aimed at increasing the overall and some regional sample sizes*
- *development of online data entry like BBS-Online.*

This may pave the way for the WBBS eventually to replace WBS for monitoring breeding birds of linear waterways, with data linked between the two surveys to provide a continuous index series since 1974.

We also propose to establish the position of an ongoing WBBS in the UK breeding bird monitoring strategy more clearly, among interested parties, particularly those funding other bird monitoring schemes.

5 Acknowledgements

The launch of the WBBS was funded in collaboration with the Environment Agency's Science programme. We also acknowledge the financial support of Anglian Water, British Waterways, Northumbrian Water, Essex and Suffolk Water, Severn Trent Water, Thames Water and Welsh Water. BBS is funded jointly by the BTO, JNCC (on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland) and the RSPB.

The BTO's work relies heavily on volunteers. We are very grateful to all observers who have contributed WBBS or WBS data, and to the BTO's Regional Representatives and others who assisted with finding volunteers and forwarding paperwork.

We acknowledge the help of the following Environment Agency staff during the course of this project (since 1998): Geraldine Daly, Alastair Driver, Kevin Hall, Andrew Heaton, Marc Naura, Helena Parsons, Paul Raven, Martin Smalls, Adrian Taylor and Mark White. Steve Ormerod of the School of Biosciences at Cardiff University provided valuable advice and guidance. At BTO headquarters in Thetford, Peter Beaven, Nick Carter, the late Jackie Coker, Steve Freeman, Richard Gregory, Vivien Hiom, Maria Knight, Dave Leech, Angela Rickard, Sam Rider, Fiona Sanderson, Susan Waghorn and Jane Waters have all assisted at various stages of the project. Data Image Ltd input the bulk of the WBBS data from the observers' field sheets.

Figures 2 and 3 were produced using the program DMAP, with thanks to Alan Morton.

6 References and Bibliography

BAILLIE, S.R., MARCHANT, J.H., CRICK, H.Q.P., NOBLE, D.G., BALMER, D.E., BEAVEN, L.P., COOMBES, R.H., DOWNIE, I.S., FREEMAN, S.N., JOYS, A.C., LEECH, D.I., RAVEN, M.J., ROBINSON R.A., AND THEWLIS, R.M., 2006. *Breeding Birds in the Wider Countryside: their conservation status 2004.* Research report 385. Thetford: British Trust for Ornithology (www.bto.org/birdtrends).

CARTER, S.P., 1989. The Waterways Bird Survey of the British Trust for Ornithology: an overview. *Regulated Rivers: Research & Management* 4, 191–197.

CRICK, H.Q.P., 1992. A bird-habitat coding system for use in Britain and Ireland incorporating aspects of land-management and human activity. *Bird Study,* 39, 1–12.

GREGORY, R.D., WILKINSON, N.I., NOBLE, D.G., ROBINSON, J.A., BROWN, A.F., HUGHES, J., PROCTER, D., GIBBONS, D.W., AND GALBRAITH, C.A., 2002. The population status of birds in the United Kingdom, Channel Islands and Isle of Man: an analysis of conservation concern 2002-2007. *British Birds* 95, 410–448.

JOYS, A.C., NOBLE, D.G. AND BAILLIE. S.R., 2003. *Evaluation of species coverage and precision using the BBS indexing method.* Research report 317. Thetford: British Trust for Ornithology.

MARCHANT, J.H., 1994. *Guidelines for territory analysis on Waterways Bird Survey species maps*. Thetford: British Trust for Ornithology.

MARCHANT, J., AND BALMER, D., 1994. Waterways Bird Survey: 1992–1993 population changes. *BTO News,* 191, 8–10.

MARCHANT, J.H., AND COOMBES, R.H., 2003. Breeding birds on waterways. *BTO News,* 249: 22-23.

MARCHANT, J.H., AND COOMBES, R.H., 2004. *Waterways Breeding Bird Survey: progress report for 2002–03.* Research report 357. Thetford: British Trust for Ornithology.

MARCHANT, J.H., AND GREGORY, R.D., 1999. *Waterways Breeding Bird Survey pilot survey 1998: adaptation of BBS census methods to rivers and canals.* R&D technical report W205. Bristol: Environment Agency.

MARCHANT, J.H., GREGORY, R.D., BALMER, D.E., GOUGH, S.J., AND WILSON, A.M.,1999. *A comparison of breeding bird numbers along canals with and without a close season for fishing.* R&D technical report W193. Bristol: Environment Agency.

MARCHANT, J.H., HUDSON, R., CARTER, S.P., AND WHITTINGTON, P.A., 1990. *Population trends in British breeding birds.* Tring: British Trust for Ornithology.

MARCHANT, J.H., LANGSTON, R., AND GREGORY, R.D., 1996. *The Waterways Bird Survey: an evaluation and appraisal of its future role*. R&D technical report W22. Bristol: Environment Agency.

MARCHANT, J.H., AND NOBLE, D.G., 2000. *Waterways Breeding Bird Survey: progress report for 1998–99.* Research report 241. Thetford: British Trust for Ornithology.

MARCHANT, J.H., AND NOBLE, D.G., 2003. *Waterways Breeding Bird Survey: progress report for 2001–02.* Research report 322. Thetford: British Trust for Ornithology.

MARCHANT, J.H., NOBLE, D.G. AND BEAVEN, L.P., 2002. *Waterways Breeding Bird Survey: progress report for 2000–01*. Research report 292. Thetford: British Trust for Ornithology.

MARCHANT, J.H., NOBLE, D.G., LEECH, D.I., AND FREEMAN, S.N., 2002. *River Habitat Survey and Waterways Breeding Bird Survey 1998–2000: final report.* Research report 291. Thetford: British Trust for Ornithology.

NEWSON, S.E., NOBLE, D.G., AND MARCHANT, J.H., 2003. *Analysis of population trends for waterways birds: a comparison of Waterways Bird Survey indices.* Research report 337. Thetford: British Trust for Ornithology.

NEWSON, S.E., NOBLE, D.G., AND MARCHANT, J.H., 2005. *Waterways Breeding Bird Survey: preliminary analyses of mammal data 1998–2003.* Research report 405. Thetford: British Trust for Ornithology.

RAVEN, M.J., NOBLE, D.G., AND BAILLIE, S.R., 2005. *The Breeding Bird Survey 2004.* Research report 403. Thetford: British Trust for Ornithology.

RUSHTON, S.P., HILL, D., AND CARTER, S.P., 1994. The abundance of river corridor birds in relation to their habitats: a modelling approach. *Journal of Applied Ecology,* 31, 313–328.

STOKES, M.E., DAVIS, C.S., AND KOCH, G.G., 2003. *Categorical data analysis using the SAS system*. Second edition. Cary, North Carolina: SAS Institute Inc.

TAYLOR, K., 1982. *BTO Waterways Bird Survey instructions*. Tring: British Trust for Ornithology.

7 List of abbreviations

BBS Breeding Bird Survey
BTO British Trust for Ornithology
FMD Foot and Mouth Disease
GOR Government Office Region
JNCC Joint Nature Conservancy Council
RR Regional Representative (BTO)
RSPB Royal Society for the Protection of Birds
WBBS Waterways Breeding Bird Survey
WBS Waterways Bird Survey

8 Appendices

Appendix 1. Waterway stretches covered by the WBBS during 1998–2004. Stretches are ordered by class of survey (random, WBS-linked, or other) and by nominal 1-km grid square. For each stretch, the limiting grid references in the most recent survey are given, together with the number of 500-metre sections covered in each survey year.

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
1. Random sites										
H3078	Fairy Water	H304800	H325780	–	–	–	–	6	–	–
H4050	Many Burns River	H381495	H504513	–	6	–	–	–	–	–
H5688	Glenlark River	H574871	H592889	–	6	6	–	6	–	–
H6680	Ballinderry River	unknown	unknown	–	3	–	–	–	–	–
H7672	Rock River	H765724	unknown	–	–	–	–	–	5	–
NC2634	Maldie Burn	NC252352	NC239340	4	4	4	–	4	–	–
NC3422	River Cassley	NC344225	NC368203	6	6	–	–	6	–	–
NC5810	Allt Chaiseagail	NC572106	NC582105	–	–	–	–	2	–	–
NC7252	River Naver	NC722544	NC723518	–	–	–	–	–	–	6
ND0258	Forss Water	ND033613	ND036595	–	–	–	–	3	–	3
ND1056	River Thurso	ND107560	ND128580	–	–	–	–	7	4	7
ND1628	Dunbeath Water	ND163296	ND143308	–	–	–	5	5	5	5
NG1846	Hamra River	NG187480	NG199463	–	4	4	–	–	–	4
NG3230	River Talisker/Sleadale Burn	NG324302	NG315305	–	–	–	–	–	2	2
NG3444	Allt Ruairidh/River Ose	NG345428	NG344456	–	–	–	–	–	5	5
NG4454	River Romesdal	NG440543	NG455547	–	–	10	–	–	5	–
NG9406	Allt Coire Sgoireadail	NG952068	NG974088	–	8	8	8	8	8	8
NG9466	River Grudie	NG965684	NG959663	–	–	–	–	–	–	6
NG9804	Allt Coire nan Eiricheallach	NG998032	NG993055	5	5	5	5	5	5	–
NH1264	Abhainn Srath Chrombuill	NH142642	NH102642	–	–	–	8	–	–	–
NH1428	Allt a' Choire Dhomhain	NH144269	NH156302	6	–	–	–	–	–	–
NH2636	River Farrar	NH267376	NH239387	–	–	–	–	10	10	10
NH3648	Allt Cam Ban	NH363497	NH355502	2	1	1	–	1	2	2
NH4828	River Coiltie	NH524295	NH497282	–	–	–	–	–	–	6
NH4844	River Beauly	NH497442	NH468423	–	–	–	–	9	–	–
NH5242	River Beauly	NH517445	NH497442	–	–	–	–	9	9	9
NH6476	Strathrory River	NH660776	NH644783	–	–	–	–	–	4	4
NH6614	River Findhorn	NH705170	NH665140	10	10	10	–	10	10	10
NH6632	River Nairn	NH684340	NH674320	10	10	10	–	10	10	10
NH6644	River Ness (non-tidal part)	NH664444	NH642413	5	8	8	–	10	10	10
NH7218	River Findhorn	NH736200	NH705170	–	–	–	–	10	10	10
NH9200	Am Beanaidh	NH923039	NN917999	–	10	10	–	10	10	10
NJ3416	Water of Buchat	NJ323189	NJ393157	–	10	–	–	–	–	10
NK0446	South Ugie Water	NK015472	NK056485	–	9	–	–	–	–	–
NK0848	River Ugie	NK080499	NK093488	–	–	–	–	–	–	4
NM3496	Abhainn Rangail	NM342954	NM374964	–	–	–	–	–	7	–
NM9440	Dearg Abhainn	NM955420	NM967404	–	–	–	–	–	3	3
NM9478	Dubh Lighe	NM966787	NM932799	–	6	9	–	9	–	–
NN0096	River Kingie	NN042978	NN000964	10	10	10	10	10	10	10
NN0686	Allt a' Cham Dhoire	NN040863	NN064873	6	–	–	–	–	–	–
NN1030	Allt Coire Chreachainn/Allt Mhoille	NN109317	NN105304	–	–	–	–	–	10	10

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
NN1620	Allt an Stacain	NN153213	NN162218	–	4	–	–	–	–	–
NN2082	River Spean	NN183837	NN208814	9	9	–	–	–	–	–
NN2602	Croe Water	NN275020	NN242044	–	–	–	–	–	10	10
NN3872	Allt Feith Thuill	NN400731	NN372711	3	7	7	–	7	–	–
NN4488	Allt Coire Ardair	NN466887	NN440883	6	6	6	–	6	6	–
NN4888	Allt a' Chrannaig	NN484872	NN488885	3	3	3	–	3	3	–
NN5630	River Dochart	NN567321	NN537302	–	–	–	–	8	8	–
NN6094	River Spey	NN640941	NN596938	10	10	10	–	–	–	–
NN6884	Unnamed, feeds into aqueduct	NN687855	NN681870	3	–	–	–	–	–	–
NN7296	Milton Burn	NN719256	NN744988	10	10	10	–	10	10	10
NN8268	Bruar Water	NN821680	NN822696	–	–	–	–	–	–	3
NN8868	River Tilt	NN881685	NN881700	–	–	–	–	–	–	3
NN8870	River Tilt	NN881700	NN895716	–	–	–	–	–	–	4
NN9682	Bynack Burn	NN973839	NN960824	–	–	–	5	10	7	6
NO0298	Coire Etchachan Burn	NO034981	NO022999	–	–	–	6	6	3	7
NO0644	Buckny Burn/Lunan Burn	NO096455	NO060480	–	10	10	10	10	10	10
NO1282	Baddoch Burn	NO137834	NO129820	5	5	5	5	5	5	5
NO2090	River Dee	NO213920	NO201908	4	4	4	–	4	–	4
NO3046	Dean Water	NO339479	NO292458	–	7	7	–	7	7	7
NO5410	Kenly Water	NO538113	NO553122	4	4	–	–	–	–	–
NS4626	River Ayr	NS465261	NS454246	–	–	–	–	–	6	6
NS5280	Blane Water	NS518838	NS544804	–	–	–	–	–	10	–
NS6276	Glazert Water	NS610785	NS633771	–	–	–	–	–	10	6
NS6826	River Ayr	NS682263	NS715281	–	–	10	–	–	–	–
NS7404	Scar Water	NS766024	NS727040	–	–	–	–	10	10	10
NS7822	Duneaton Water	NS781226	NS814213	10	10	10	–	10	10	10
NS8230	Douglas Water	NS841319	NS828300	5	5	5	–	5	–	5
NS8280	Bonny Water	NS823803	NS793789	8	8	8	–	8	–	–
NS9804	Crook Burn	NS973063	NS984039	6	6	6	–	–	–	–
NT0294	Black Devon	NT031942	NT034944	–	–	–	–	1	2	1
NT1426	Stanhope Burn	NT120303	NT156283	–	–	–	–	3	–	8
NT1866	Water of Leith	NT199686	NT173672	–	–	–	–	3	3	3
NT2420	Crosscleuch Burn	NT240202	NT245200	–	–	–	–	2	2	–
NT2626	Douglas Burn	NT279272	NT269281	–	–	–	–	3	3	3
NT2816	Ettrick Water	NT299164	NT290160	–	–	–	–	2	2	–
NT3012	Rankle Burn	NT323130	NT320150	–	–	–	–	–	–	5
NT3258	River South Esk/Redside Burn	NT324600	NT320591	–	–	–	–	6	6	6
NT4630	Ettrick Water	NT474300	NT480314	–	–	–	–	3	–	3
NT8452	Blackadder Water	NT857543	NT825529	10	10	–	–	–	–	–
NT9010	River Alwin	NT923076	NT911107	7	–	–	–	7	6	7
NT9412	Shank Burn	NT973153	NT952137	6	6	6	–	6	6	6
NU0026	Wooler Water	NT995279	NT997248	–	–	–	–	–	10	7
NU0416	River Breamish	NU044168	NU017164	–	–	–	–	–	5	5
NU1800	River Coquet	NU185003	NU197009	–	–	–	–	–	3	3
NU1812	River Aln	NU186138	NU215125	9	9	9	–	9	9	9
NX1674	Cross Water of Luce	NX180772	NX192742	10	–	–	–	–	–	–
NX3696	River Stinchar	NX397956	NX371963	–	–	–	–	–	7	7
NX6856	Tarff Water	NX685579	NX682563	–	–	–	–	3	–	–
NX7480	Urr Water	NX756802	NX754803	–	–	–	–	–	2	1
NX8494	Scar Water	NX875925	NX835945	–	–	–	–	–	10	10
NY0002	River Ehen	NY022033	NY008075	–	–	–	–	–	10	–

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
NY0428	Lostrigg Beck/River Marron	NY056282	NY062281	–	–	–	–	–	3	–
NY0604	River Bleng	NY077032	NY103031	4	4	–	–	–	–	5
NY1818	Mill Beck	NY168172	NY190188	–	–	–	–	–	6	–
NY2082	Water of Milk	NY200826	NY230834	–	–	–	–	4	7	7
NY2472	Kirtle Water	NY242740	NY240724	–	–	–	–	–	1	1
NY3648	River Caldew	NY371488	NY366450	–	–	–	–	–	10	10
NY3688	Ewes Water	NY368880	NY370900	–	–	–	–	4	4	4
NY3856	River Eden	NY400565	NY376580	–	–	–	–	–	–	10
NY4496	Hermitage Water (major source)	NY450964	NY460969	–	–	–	–	–	2	–
NY5076	Black Lyne	NY496734	NY500757	6	–	–	–	–	6	6
NY5084	Kershope Burn	NY483828	NY521848	10	10	10	–	–	–	–
NY5464	King Water	NY554668	NY528633	3	–	–	–	–	5	10
NY6086	Lewis Burn	NY631887	NY623874	–	4	4	–	4	4	4
NY7020	Hilton Beck	NY710200	NY719207	–	–	3	–	3	3	3
NY8012	River Belah	NY800124	NY819123	–	–	6	–	6	6	6
NY9424	River Tees/Hudeshope Beck	NY976243	NY934257	–	–	–	–	–	10	10
NY9606	Arkle Beck	NY970064	NY955074	–	–	–	–	–	5	5
NZ0260	River Tyne	NZ030620	NZ040616	–	–	–	–	2	2	2
NZ0836	River Wear	NZ055369	NZ082368	–	–	–	–	10	6	6
NZ1658	River Derwent	NZ180599	NZ152572	–	–	–	–	10	10	–
NZ2436	River Wear	NZ243361	NZ259374	2	4	4	–	4	4	4
NZ2818	River Skerne	NZ302193	NZ291207	6	6	6	–	–	–	–
NZ2844	River Wear	NZ284438	NZ302456	–	7	7	–	7	7	7
NZ3276	Holywell Dene	NZ336768	NZ336761	–	–	–	–	2	2	2
NZ4422	Billingham Beck	NZ446235	NZ457216	–	–	–	–	–	6	6
NZ6418	Skelton Beck	NZ659201	NZ668215	5	5	5	–	5	5	5
SD2092	River Duddon	SD223962	SD200918	–	–	–	–	–	–	10
SD3406	Leeds & Liverpool Canal	SD365069	SD369092	–	–	6	6	6	6	6
SD3476	River Eea	SD361766	SD356765	–	–	–	–	–	1	1
SD4646	Lancaster Canal	SD481472	SD484453	10	–	–	–	–	6	6
SD4860	Lancaster Canal	SD474609	SD487635	–	–	–	–	–	7	7
SD5030	Lancaster Canal	unknown	unknown	–	–	–	–	2	–	–
SD5270	Lancaster Canal	SD521734	SD511707	–	–	–	–	–	10	10
SD5296	River Sprint	SD521977	SD521973	–	–	–	–	1	–	–
SD5298	River Sprint	SD522996	SD524992	–	–	–	–	1	–	–
SD7012	Eagley Brook	SD727123	SD712134	4	4	4	–	4	4	4
SD7466	River Wenning	SD746673	SD711677	8	8	8	–	8	8	8
SD7488	Clough River	SD764902	SD718906	–	–	10	–	–	10	–
SD7808	Manchester, Bolton & Bury Canal	SD793099	SD779073	–	–	–	–	6	6	6
SD8070	River Ribble	SD812696	SD807726	–	–	–	–	–	–	8
SD8804	Rochdale Canal	SD885079	SD893038	10	10	10	10	–	–	10
SD9664	River Wharfe	SE004633	SD981659	–	8	8	–	8	8	8
SE0278	River Cover	SE045808	SE023791	6	6	6	–	6	6	6
SE3288	River Swale	SE320895	SE337880	8	8	8	–	8	–	8
SE3428	Aire & Calder Navigation/R. Aire	SE383279	SE345301	–	–	–	–	10	10	10
SE3800	Dove & Dearne Navigation	SE411022	SE395012	4	4	4	–	–	–	–
SE5846	River Ouse	SE593445	SE600472	–	–	–	–	8	8	8
SE5848	River Ouse	SE602500	SE599467	–	–	–	–	8	8	8
SE7044	Pocklington Canal (The Beck)	unknown	unknown	–	–	–	–	–	10	–
SE7404	River Torne + un-named drain	SE757067	SE740040	–	–	–	–	7	7	7
SE9620	New River Ancholme	SE972164	SE974208	–	–	9	–	9	9	9

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
SH5648	Afon Colwyn	SH592480	SH583516	–	–	–	–	10	10	10
SH6672	Afon Aber	SH659725	SH669700	–	–	–	–	6	6	6
SH7032	Afon Eden	SH703321	SH700327	–	–	2	–	–	–	2
SH7218	Afon Wnion	SH720179	SH729179	–	–	–	–	–	–	2
SH8666	River Elwy (Afon Elwy)	SH877675	SH870670	–	–	–	–	3	2	–
SH9424	Afon Eiddew	SH950249	SH946250	4	4	4	–	4	4	1
SH9852	Afon Alwen	SH976528	SH987519	–	–	–	–	2	–	–
SJ0474	Afon Clwyd	SJ048745	SJ041748	–	–	–	–	–	2	2
SJ0802	Afon Rhiw	SJ093023	SJ085035	–	–	–	–	–	–	3
SJ1006	Afon Banwy neu Einion	SJ107068	SJ117078	3	–	–	–	–	3	3
SJ1058	Afon Clywedog	SJ087583	SJ107605	–	–	–	–	–	7	7
SJ1228	Afon Iwrch	SJ134266	SJ126300	7	7	7	–	7	7	7
SJ2022	Afon Tanat	SJ185240	SJ226240	10	10	10	–	10	10	10
SJ4066	Shropshire Union Canal	SJ415667	SJ399669	–	10	10	10	–	–	–
SJ4276	Manchester Ship Canal	SJ476777	SJ451773	5	5	5	–	5	5	5
SJ6402	River Severn	SJ672034	SJ634041	8	8	–	–	–	8	8
SJ6654	River Weaver	SJ650523	SJ662552	10	10	6	–	6	6	6
SJ6672	River Dane	SJ667720	SJ659738	–	–	–	–	–	10	10
SJ6832	Shropshire Union Canal	SJ691325	SJ682348	–	–	–	–	2	4	–
SJ8610	Shropshire Union Canal	SJ849142	SJ875102	10	10	10	–	10	10	10
SK0206	Cannock Extension Canal	SK021069	SK019045	5	–	–	–	–	–	–
SK0836	River Dove	SK102374	SK104346	–	–	10	–	10	–	–
SK1686	River Noe	SK168846	SK152865	7	7	7	–	7	7	7
SK3802	Ashby-de-la-Zouch Canal	SK384017	SK390037	–	–	–	–	–	4	–
SK4840	Nottingham Canal (disused)	SK484414	SK475440	–	–	–	–	–	–	5
SK5298	River Don	SK526400	SK522994	–	–	–	–	2	2	2
SK5408	Anstey	SK552083	SK546077	–	–	–	–	–	–	1
SK5662	River Maun	SK601649	SK569638	4	4	4	–	–	8	8
SK6832	Grantham Canal (disused)	SK676307	SK681331	–	–	–	–	7	7	7
SK7632	Grantham Canal (disused)	SK757333	SK776353	–	–	–	–	–	6	6
SK8672	Ox Pasture Drain	SK486370	SK487374	–	–	–	–	–	–	9
SK8874	Fossdyke Navigation	SK909750	SK880745	6	6	6	6	6	6	6
SK9240	River Witham	SK928414	SK930399	–	–	–	–	–	–	4
SK9458	River Brant	SK939583	SK942600	4	4	4	4	4	4	4
SM9828	Afon Anghof	SM971282	SM957263	–	–	–	–	–	4	4
SN1226	Eastern Cleddau (Cleddau-Ddu)	SN139278	SN127262	–	–	–	–	5	–	–
SN5214	Gwendraeth Fach	SN544164	SN533161	–	–	–	–	1	–	3
SN6442	Afon Twrch	SN652433	SN647414	–	–	–	–	4	4	4
SN6456	Afon Teifi	SN646561	SN660569	–	5	5	–	5	5	5
SN6802	Lower Clydach River	SN684026	SN687045	5	5	5	–	5	5	5
SN7400	River Clydach	SN738004	SS737981	9	9	9	–	10	–	7
SN7432	Afon Tywi	SN762352	SN752326	–	–	–	–	5	6	6
SN7632	Afon Gwydderig	SN753327	SN759331	–	–	–	–	–	3	3
SN7804	Dulais River	SN781041	SN792057	–	–	–	–	4	4	4
SN8200	Melin Court Brook	SN818022	SN838004	–	–	–	–	6	–	–
SN9654	Chwefri	SN973558	SN983542	–	–	–	–	–	4	4
SO0246	Duhonw	SO000472	SO045487	–	–	–	–	–	6	6
SO1016	Afon Crawnon	SO100162	SO138191	–	–	–	–	–	–	10
SO1068	Afon Ieithon	SO104660	SO104703	–	–	–	–	10	–	10
SO1204	Afon Rhymni	SO120059	SO138040	–	10	10	10	10	10	10
SO1262	Mithil Brook	SO115630	SO144628	–	–	–	–	8	–	8

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
SO2230	Grwyne Fawr	SO253285	SO233307	–	6	–	–	–	6	6
SO2620	Grwyne Fawr	SO280207	SO279201	–	–	–	–	–	5	5
SO2682	River Clun	SO282820	SO258826	–	–	–	–	–	–	5
SO3076	River Redlake	SO317763	SO294767	–	–	–	–	–	5	5
SO4086	River Onny	SO408867	SO409869	–	–	–	–	–	1	–
SO4618	Afon Mynwy	SO478168	SO469202	–	10	10	–	8	8	8
SO6466	River Teme	SO629686	SO656691	7	7	7	–	7	7	7
SO6680	River Rea	SO662821	SO668787	9	9	9	–	9	9	–
SO7090	Mor Brook	SO729888	SO707905	–	–	–	–	–	7	–
SO7098	River Severn	SO722975	SJ707004	8	8	8	–	8	8	8
SO7454	River Teme	SO746563	SO758544	6	6	6	–	–	–	–
SO8004	River Frome	SO784057	SO808046	7	6	–	–	7	7	–
SO8628	River Severn	SO867304	SO844279	6	–	–	–	10	9	9
SO9886	Un-named	SO970855	SO974851	–	–	–	–	–	–	1
SP0270	Worcester & Birmingham Canal	SP020739	SP016706	–	–	–	–	8	8	8
SP0478	Worcester & Birmingham Canal	SP051810	SP047779	–	–	–	–	–	7	7
SP0484	Worcester & Birmingham Canal	SP044827	SP059867	–	–	–	–	10	–	–
SP0806	River Coln	SP085094	SP124066	–	–	–	–	–	8	8
SP1658	Stratford-upon-Avon Canal	SP183565	SP167604	–	–	–	–	10	–	–
SP2000	River Leach	SP225009	SP209031	–	–	–	–	–	5	5
SP3664	Grand Union Canal	SP340649	SP380639	–	–	–	–	–	–	8
SP4406	River Thames or Isis	SP446068	SP439055	–	–	–	–	10	10	10
SP5246	River Cherwell	SP505483	SP490476	–	–	–	–	3	3	3
SP6002	River Thame	SP612027	SP605017	4	4	4	–	4	4	4
SP6260	Grand Union Canal	SP630601	SP625621	4	4	4	–	–	4	–
SP7636	River Great Ouse	SP760373	SP773380	–	–	–	–	–	4	4
SS3216	River Torridge	SS339172	SS325178	–	–	–	–	5	4	4
SS5204	River Lew	SS535059	SS539043	–	4	4	–	4	4	4
SS6810	River Taw	SS680116	SS693102	5	5	5	–	5	5	5
SS9084	Ogmore River/Afon Garw	SS902838	SS906858	–	–	–	–	–	4	4
ST0280	Afon Elai	ST039811	ST034824	6	6	6	–	6	5	5
ST0820	River Tone	ST078203	ST084221	5	5	5	–	5	5	5
ST1600	River Otter	ST160012	ST170018	3	3	3	–	3	3	3
ST1678	River Taff (Afon Taf)	ST171780	ST162783	–	–	–	–	2	2	2
ST2092	Afon Ebwy	ST218920	ST218930	–	–	–	–	–	2	2
ST3490	Afon Lwyd	ST336924	ST342913	–	–	–	–	–	3	–
ST4646	River Axe	ST475475	ST452490	–	–	7	–	7	7	7
ST5036	River Brue	ST494376	ST530360	–	–	–	–	–	–	4
ST5660	River Chew	ST572617	ST587635	5	5	5	–	–	5	5
ST6680	River Frome	ST645790	ST665844	–	–	–	–	–	7	10
ST7094	Little Avon River	ST728925	ST697947	–	–	–	–	9	9	9
ST7846	River Frome	ST784462	ST787476	5	5	–	–	5	5	5
ST9480	River Avon	ST953800	ST960805	2	2	–	–	–	–	–
ST9682	River Avon	ST960831	ST977820	6	6	–	–	–	–	–
ST9804	River Allen	ST996040	ST990060	4	4	4	–	4	2	3
ST9838	River Wylye	ST948399	ST972394	–	–	5	–	5	5	5
SU1234	River Avon	SU127354	SU129330	6	6	6	–	6	6	6
SU1240	River Avon	SU158408	SU124373	–	–	–	–	–	–	10
SU2094	River Cole	SU234935	SU209974	–	–	–	–	–	1	10
SU2470	River Kennet	SU240700	SU253703	–	3	–	–	–	–	–
SU2870	River Kennet	SU280715	SU299710	5	5	5	–	–	–	–

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
SU3636	River Test	SU382390	SU357364	–	–	–	–	–	–	9
SU5296	River Thames/Isis	SU539989	SU505971	10	10	10	10	10	10	10
SU5664	River Enborne	SU567648	SU557633	4	4	4	–	4	4	4
SU7266	River Loddon	SU743677	SU734663	4	–	4	–	4	4	4
SU8892	River Wye	SU882916	SU888991	–	–	–	–	–	4	–
SU9618	River Rother	SU961197	SU980190	–	6	6	–	6	6	6
SU9868	Virginia Water (outflow)	SU977686	SU987678	3	–	–	–	–	–	–
SX0872	River Camel	SX082742	SX065715	–	10	10	–	10	–	–
SX4682	River Lyd	SX478835	SX454834	5	5	5	–	–	–	–
SX6270	River Swincombe	SX632717	SX647732	–	–	–	–	5	5	5
SX8470	River Lemon	SX833711	SX850709	–	–	–	–	4	4	3
SX9290	Exeter Canal	SX923917	SX940894	–	–	–	–	6	6	6
SY1096	River Otter	SY088921	SY094948	7	6	6	–	5	5	5
SY2692	River Axe	SY263955	SY259924	5	5	5	–	5	5	5
SY6094	River Frome	SY617955	SY606960	–	–	3	–	–	–	3
SZ2894	Avon Water	SZ298953	SZ292959	–	–	–	–	–	2	2
TA0448	Watton Beck	TA037491	TA063473	–	–	–	–	–	7	–
TF0070	River Witham/South Delph	TF014709	TF058715	–	–	–	–	–	9	9
TF0210	River Gwash	TF040107	TF028106	–	–	2	–	–	–	–
TF1618	River Glen	TF153184	TF168200	–	–	–	–	5	5	5
TF2210	River Welland	TF230105	TF237136	–	–	–	–	6	6	6
TF2644	North Forty Foot Drain	TF280448	TF262460	–	–	–	–	5	–	5
TF2844	North Forty Foot Bank	TF295447	TF280448	–	–	–	–	4	–	4
TF4084	The Beck	TF538384	TF540385	–	–	–	–	–	–	5
TF6002	Relief Channel	TF602038	TF601032	1	1	–	–	–	–	1
TF6412	River Nar	TF640133	TF663136	5	5	–	–	–	–	5
TG1810	River Tud/River Wensum	TG155115	TG195107	–	–	–	–	–	–	5
TL1840	River Ivel	TL183428	TL183402	5	–	–	–	5	5	5
TL1890	Yaxley Lode (Drain)	TL189920	TL213912	–	–	–	–	–	4	–
TL2234	River Ivel	TL222369	TL223377	2	2	2	–	–	–	–
TL2296	King's Dike (Drain)	TL250965	TL227963	6	6	6	6	–	–	5
TL3288	Forty Foot or Vermuden's Drain	TL345879	TL315880	6	6	6	–	–	6	6
TL3296	Twenty Foot River (Drain)	TL324968	TL351989	8	7	7	7	7	–	7
TL4296	River Nene	TL421969	TL443985	–	–	–	–	6	6	6
TL4692	Sixteen Foot Drain	TL454924	TL468947	–	–	–	–	5	5	5
TL5480	River Great Ouse	TL544794	TL563807	–	–	–	–	–	5	5
TL6474	River Lark	TL666752	TL642764	–	–	–	–	6	6	6
TL6480	Mildenhall Drain	TL655813	TL650827	3	3	3	3	3	3	3
TL7096	Cut-off Channel	TL719964	TL705988	–	–	–	–	10	10	10
TL7672	River Lark	TL731739	TL762728	7	7	7	7	7	7	7
TM1822	Landermere	TM189239	TM197238	2	2	–	–	–	–	–
TM2434	Shotley Marshes	TM244361	TM251344	4	4	4	4	4	4	4
TQ0056	River Wey	TQ020569	TQ033571	5	5	5	–	–	–	–
TQ1480	River Brent	TQ146820	TQ147810	2	2	2	–	2	2	2
TQ1684	Grand Union Canal	TQ182836	TQ144843	10	10	10	10	10	10	10
TQ2288	River Brent	TQ240885	TQ241902	5	–	–	–	–	–	–
TQ3698	R Lee Navigation/Horsemill Stream	TQ372982	TL372042	–	–	–	–	7	7	7
TQ5062	River Darent	TQ521617	TQ527627	3	3	3	–	3	3	3
TQ5244	River Medway	TQ529437	TQ542437	4	4	4	–	4	–	–
TQ5298	River Roding	TQ547996	TQ517981	8	8	8	8	8	8	8
TQ7252	River Medway	TQ740539	TQ704529	9	9	9	–	9	9	9

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
TQ7278	Cliffe Fleet	TQ744782	TQ746792	4	4	4	–	4	4	4
TQ9222	River Rother (non-tidal part)	TQ927243	TQ923227	3	3	3	–	–	–	–
TR0244	Great Stour	TR038449	TR032430	4	4	–	–	–	–	–
TR0826	New Sewer	TR058264	TR090273	7	7	7	7	7	7	7
TR1658	Great Stour	TR155590	TR163598	3	3	3	–	3	3	3
2. WBS-linked (non-random) sites										
NH8350	River Nairn	NH806484	NH838507	–	8	8	–	8	8	8
NJ5117	River Don	NJ528173	NJ496181	–	9	9	9	9	–	–
NS5370	Forth & Clyde Canal	NS531704	NS563690	–	–	8	8	8	8	8
NS8696	River Devon	NS895961	NS863961	–	10	–	–	–	–	–
NT0765	Linhouse Water	NT068640	NT077647	–	7	7	7	7	7	7
NT2034	Manor Water	NT203324	NT218365	–	–	–	–	–	10	10
NT2238	Manor Water	NT218365	NT230395	–	–	–	–	–	10	10
NT5434	River Tweed	NT578346	NT528348	–	–	10	–	–	–	–
NT9139	River Till	NT919386	NT912408	–	–	–	–	–	–	10
NY3714	Goldrill Beck	NY340125	NY393166	–	–	–	–	10	10	10
NY3748	River Caldew	NY371487	NY382516	–	7	7	–	7	7	7
NY8529	River Tees	NY857295	NY889283	–	10	10	–	10	10	10
NZ2612	River Tees	NZ259137	NZ273123	–	–	–	–	10	10	10
SD3710	Leeds & Liverpool Canal	unknown	SD402119	–	–	–	8	–	–	–
SD4610	Leeds & Liverpool Canal	SD494104	SD453112	10	10	10	–	–	–	–
SD4617	Leeds & Liverpool Canal	SD461149	SD458193	10	10	10	–	10	10	10
SD5009	Leeds & Liverpool Canal	SD524093	SD494104	–	7	7	–	7	7	7
SD5064	River Lune	SD522648	SD482631	–	10	10	–	10	10	10
SD5284	Lancaster Canal	SD537831	SD520854	7	7	7	–	7	7	7
SD5308	Leeds & Liverpool Canal	SD540073	SD525092	–	5	5	5	5	5	5
SD5365	River Lune	SD545653	SD523649	–	–	–	–	–	8	–
SD5465	River Lune	SD545653	SD558673	–	5	5	–	5	5	5
SD5768	Rivers Wenning & Lune	SD585684	SD558673	–	6	–	–	–	6	6
SD5870	River Lune	SD592721	SD571683	–	–	5	–	5	–	5
SD5960	River Lune	SD592722	SD611574	–	–	–	–	8	8	8
SD6100	Leigh Branch Canal	SD602018	SJ630996	8	8	8	8	8	8	8
SD6177	River Lune	SD611790	SD609750	–	8	–	–	–	–	–
SD8025	River Limy	SD810237	SD807266	–	–	6	–	–	–	–
SD9060	River Aire	SD907581	SD901623	–	–	–	–	10	10	10
SD9946	River Aire	SD995468	SD986494	–	–	–	–	8	8	–
SE1222	River Calder/Calder & Hebble Canal	SE135228	SE128224	–	2	2	–	–	–	–
SE2796	River Swale	SE291965	SE257974	–	10	10	–	10	–	–
SE4445	River Wharfe	SE440453	SE472447	–	10	10	–	10	10	10
SH7220	River Mawddach	SH718193	SH735223	–	7	7	–	7	7	7
SJ0868	River Clwyd	SJ092659	SJ082687	–	9	10	–	10	–	–
SJ3326	Montgomery Branch Canal	SJ352277	SJ313250	–	–	–	–	–	–	10
SJ4070	Shropshire Union Canal	SJ394706	SJ418719	–	6	6	–	–	–	–
SJ5126	Shropshire Union Canal	SJ526603	SJ541603	–	–	–	3	3	3	3
SJ6452	Shropshire Union Canal	SJ629549	SJ638504	10	10	10	10	10	10	10
SJ6836	Shropshire Union Canal	SJ683348	SJ672389	–	–	9	–	9	9	9
SJ6967	Trent & Mersey Canal	SJ695671	SJ683689	5	5	5	5	5	5	5
SJ9279	Macclesfield Canal	SJ933779	SJ936814	8	8	–	–	–	–	–
SJ9586	Macclesfield Canal	SJ953860	SJ959880	–	5	5	–	–	–	–
SJ9785	Peak Forest Canal	SJ964882	SJ971859	–	5	5	–	–	–	–
SJ9786	River Goyt	SJ975867	SJ967883	–	5	5	–	–	–	–

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
SJ9822	Staffordshire & Worcs Canal	SJ995229	SJ971214	6	6	6	–	6	6	6
SK1241	River Dove	SK124424	SK116404	–	–	–	–	–	–	8
SK1273	River Wye	SK138732	SK103725	–	–	–	–	10	10	10
SK1883	River Noe	SK168846	SK204826	–	8	6	–	8	8	10
SK2181	River Derwent	SK205834	SK234806	–	10	10	–	10	10	10
SK2378	River Derwent	SK233806	SK244761	–	10	–	–	10	10	9
SK2476	River Derwent	SK244761	SK248727	–	8	8	–	8	8	8
SK3084	River Porter	SK302849	SK332857	–	–	–	8	8	8	8
SK3088	River Rivelin	SK322886	SK289871	–	7	7	7	7	7	7
SK4010	Erewash Canal	SK454471	SK469432	–	9	–	–	–	9	9
SK5715	River Soar	SK582152	SK565162	–	5	–	–	–	–	7
SK6236	Grantham Canal	SK639367	SK608368	8	8	8	8	–	–	–
SK6929	Grantham Canal	SK676307	SK709292	10	10	10	10	10	10	10
SK7351	River Trent	SK743515	SK767522	–	10	10	10	10	10	10
SO1024	River Usk	SO123234	SO095253	–	9	9	–	9	9	9
SO3780	River Clun	SO361805	SO382813	–	6	6	–	6	–	–
SO5112	River Monnow	SO495146	SO512122	–	10	10	–	10	10	10
SO5638	River Lugg	SO565372	SO556395	–	–	10	–	10	10	–
SO7407	Gloucester & Sharpness Canal	SO737050	SO757093	10	–	–	–	–	–	10
SO7776	Dowles Brook	SO779764	SO743762	–	–	–	–	9	9	9
SO8687	Staffordshire & Worcestershire Canal	SO864855	SO862887	–	9	9	–	9	9	9
SO8757	Worcester & Birmingham Canal	SO865576	SO889577	5	5	5	–	5	5	5
SP1581	Grand Union Canal	SP181804	SP144818	8	–	8	8	8	8	8
SP1869	Stratford-upon-Avon Canal	SP187711	SP189671	8	8	–	–	–	–	–
SP1972	Grand Union Canal	SP192742	SP189706	–	–	–	–	8	8	8
SP4915	River Cherwell	SP484159	SP497153	–	3	3	–	–	–	–
SP7288	Grand Union Canal	SP727879	SP725901	10	10	10	10	–	–	–
SP9013	Grand Union Canal	SP933136	SP889140	–	10	10	10	–	–	–
SP9221	Grand Union Canal	SP915230	SP929202	8	8	8	8	8	8	8
SS2105	Bude Canal & River Neet	SS207063	SS218038	–	–	–	6	6	6	6
SU4595	River Ock	SU473959	SU432963	–	10	10	–	10	10	–
SU4930	River Itchen	SU488301	SU493314	–	–	–	–	3	–	–
SU8602	Chichester Canal	SU858036	SU842013	8	8	8	8	8	8	8
SU9400	Alding Bourne/Lidsey Rife	SZ945999	SU958027	–	8	8	8	8	8	8
SU9677	River Thames/Jubilee River	SU968772	SU972789	–	–	–	–	–	–	8
SW5533	River Hayle	SW549351	SW566319	–	–	–	–	–	8	8
SX5363	River Plym	SX533637	SX569651	–	9	9	–	9	9	9
SX5365	River Meavy	SX527650	SX548669	–	10	10	–	10	10	10
SX9588	Exeter Canal	SX940894	SX963860	10	10	10	–	10	10	10
SY9999	River Stour	SZ004998	SY982994	–	6	6	6	6	6	6
TF0671	River Witham & South Delph	TF060715	TF090710	–	–	–	7	7	7	7
TF1721	River Glen	TF201245	TF173225	–	10	–	–	7	7	–
TL1210	River Ver	TL123103	TL128084	–	4	4	–	–	–	–
TL1515	River Lea	TL140160	TL162145	–	7	7	7	7	7	7
TL1550	River Ivel	TL156519	TL156508	–	5	5	–	5	–	5
TL3701	River Lea/Lee Navigation	TL371018	TL375026	–	10	–	–	–	–	–
TL4963	River Cam	TL502644	TL487621	–	6	6	6	–	–	–
TL5166	River Cam	TL502643	TL527682	–	–	–	–	–	10	10
TL8187	River Little Ouse	TL817879	TL786869	–	8	8	–	–	–	–
TM1150	River Gipping	TM125491	TM113527	–	10	10	–	–	–	–
TQ0370	River Thames	TQ044695	TQ018721	–	10	10	10	10	–	–

Nominal 1-km reference	Waterway name	Start and end grid references		Number of 500-metre sections surveyed						
				98	99	00	01	02	03	04
TQ0492	Grand Union Canal	TQ062940	TQ044902	10	10	10	10	10	10	10
TQ0558	River Wey Navigation	TQ050578	TQ055586	–	2	2	–	–	–	–
TQ1088	River Pinn	TQ112891	TQ088878	–	–	–	–	6	6	6
TQ1554	River Mole	TQ169543	TQ154570	–	–	–	–	8	8	8
TQ2742	River Mole	TQ276423	TQ259405	–	–	–	–	8	8	8
TQ2865	River Wandle	TQ282651	TQ261687	–	9	9	–	9	–	–
TQ8427	River Rother	TQ837271	TQ856273	–	–	–	–	–	–	5
3. Other non-random sites (1998–2000 only)										
SD5913	Leeds & Liverpool Canal	SD596168	SD599124	10	–	–	–	–	–	–
SD8434	Leeds & Liverpool Canal	SD843365	SD845327	10	–	–	–	–	–	–
SD9012	Rochdale Canal	SD947182	SD917140	10	–	–	–	–	–	–
SD9702	Huddersfield Narrow Canal	SD984041	SD977025	4	–	–	–	–	–	–
SE0225	Rochdale Canal	SE015259	SE039245	7	–	–	–	–	–	–
SE0612	Huddersfield Narrow Canal	SE039119	SE079139	10	–	–	–	–	–	–
SE1138	Leeds & Liverpool Canal	SE107399	SE125384	5	–	–	–	–	–	–
SE2335	Leeds & Liverpool Canal	SE222368	SE238366	5	–	–	–	–	–	–
SE6029	Selby Canal	SE620320	SE585290	10	–	–	–	–	–	–
SE6416	New Junction Canal	SE634151	SE650184	7	–	–	–	–	–	–
SE6518	Knottingley & Goole Canal	SE648187	SE667193	4	–	–	–	–	–	–
SJ3398	Leeds & Liverpool Canal	SJ350994	SJ341969	10	–	–	–	–	–	–
SJ3699	Leeds & Liverpool Canal	SJ387981	SJ350994	10	–	–	–	–	–	–
SJ5659	Shropshire Union Canal	SJ553599	SJ581588	6	–	–	–	–	–	–
SJ6153	Llangollen Branch Canal	SJ621551	SJ617524	6	–	–	–	–	–	–
SJ6386	Bridgewater Canal	SJ669871	SJ625864	10	–	–	–	–	–	–
SJ6575	Trent & Mersey Canal	SJ644753	SJ666759	6	–	–	–	–	–	–
SJ6764	Middlewich Branch Canal	SJ689658	SJ679632	6	–	–	–	–	–	–
SJ7992	Bridgewater Canal	SJ784912	SJ796937	6	–	–	–	–	–	–
SJ7995	Bridgewater Canal	SJ762986	SJ799945	10	–	–	–	–	–	–
SJ8842	Trent & Mersey Canal	SJ881442	SJ885393	10	–	–	–	–	–	–
SJ9273	Macclesfield Canal	SJ930744	SJ925716	6	–	–	–	–	–	–
SJ9396	Peak Forest Canal	SJ935984	SJ944951	8	–	–	–	–	–	–
SJ9398	Ashton Canal (derelict)	SJ925976	SJ948985	6	–	–	–	–	–	–
SK2525	Trent & Mersey Canal	SK273274	SK238241	10	–	–	–	–	–	–
SK4644	Erewash Canal	SK454471	SK469431	10	–	–	–	–	–	–
SK4799	Sheffield & South Yorkshire Canal	SK468997	SE504001	7	–	–	–	–	–	–
SK6279	Chesterfield Canal	SK649808	SK611788	10	–	–	–	–	–	–
SN7305	Swansea Canal	SN752065	SN724041	6	–	–	–	–	–	–
SO8762	Droitwich Canal	SO868611	SO884627	5	–	–	–	–	–	–
SO9387	Dudley Canal	SO932892	SO953883	10	–	–	–	–	–	–
SP1996	Birmingham & Fazeley Canal	SP202984	SP186938	10	–	–	–	–	–	–
SP4083	Oxford Canal	SP382831	SP421822	10	–	–	–	–	–	–
SP6791	Grand Union Canal	SP695916	SP664927	8	–	–	–	–	–	–
SP8737	Grand Union Canal	SP869398	SP877372	6	–	–	–	–	–	–
ST0213	Grand Western Canal	ST023134	SS999131	10	–	–	–	–	–	–
ST3134	Bridgwater & Taunton Canal	ST301365	ST322325	10	–	–	–	–	–	–
ST7666	Kennet & Avon Canal	ST782657	ST755642	10	–	–	–	–	–	–
SU2063	Kennet & Avon Canal	SU224635	SU179618	10	–	–	–	–	–	–
SU8953	Basingstoke Canal	SU809536	SU853527	9	–	–	–	–	–	–
TL8094	River Wissey	TL807945	TL774962	–	10	10	–	–	–	–
TQ9427	Royal Military Canal	TQ958292	TQ938248	10	–	–	–	–	–	–

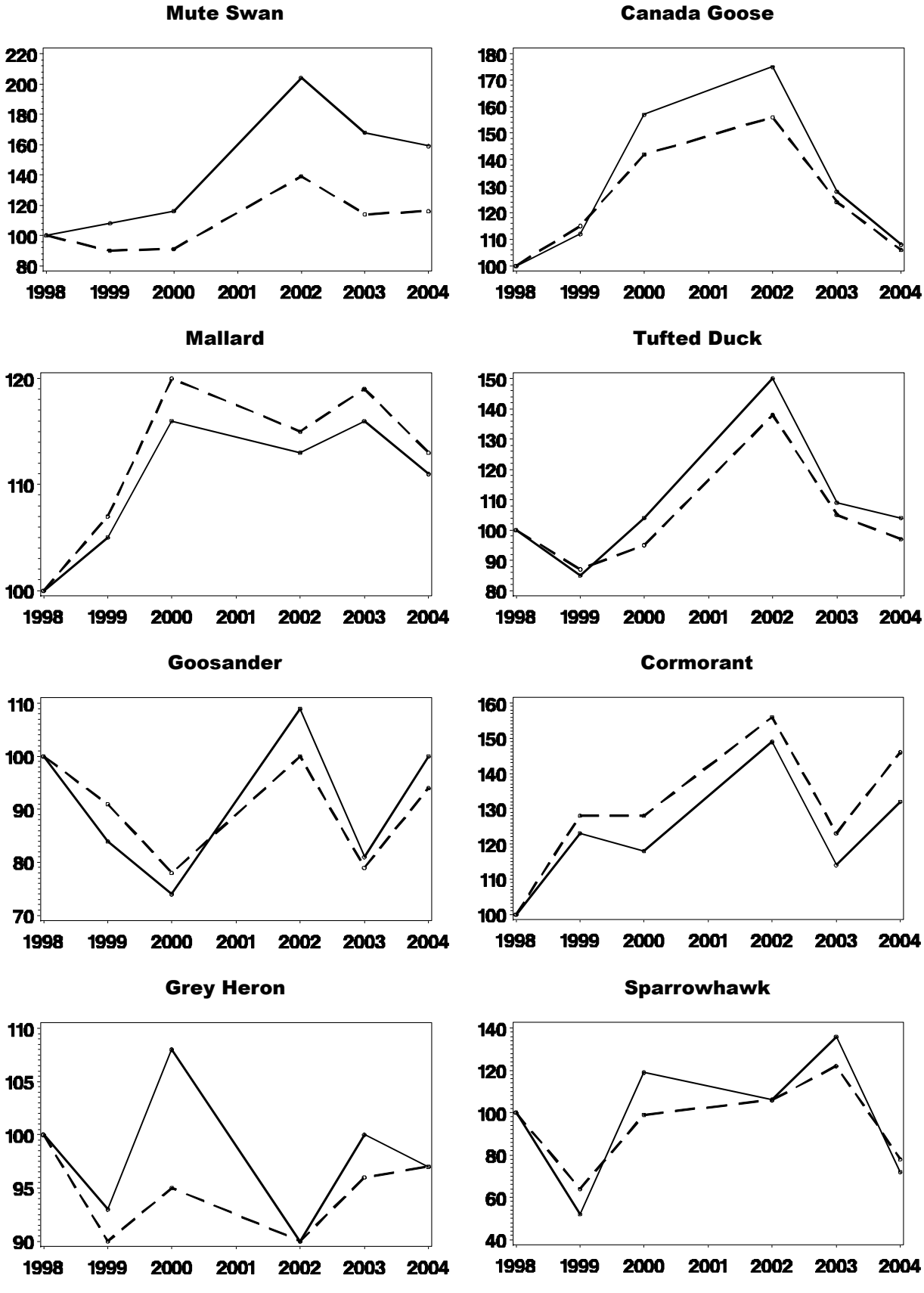
Appendix 2. Names and two-letter codes of bird species mentioned in this report. Two-letter codes are given only where they appear in figures in this report.

English name	Scientific name	Two-letter code
Mute Swan	*Cygnus olor*	MS
Greylag Goose	*Anser anser*	GJ
Canada Goose	*Branta canadensis*	CG
Shelduck	*Tadorna tadorna*	SU
Mandarin	*Aix galericulata*	
Wigeon	*Anas penelope*	
Gadwall	*Anas strepera*	
Teal	*Anas crecca*	
Mallard	*Anas platyrhynchos*	MA
Tufted Duck	*Aythya fuligula*	TU
Goosander	*Mergus merganser*	GD
Red Grouse	*Lagopus lagopus*	
Red-legged Partridge	*Alectoris rufa*	RL
Grey Partridge	*Perdix perdix*	
Pheasant	*Phasianus colchicus*	PH
Little Grebe	*Tachybaptus ruficollis*	
Great Crested Grebe	*Podiceps cristatus*	
Cormorant	*Phalacrocorax carbo*	CA
Grey Heron	*Ardea cinerea*	H.
Red Kite	*Milvus milvus*	
Sparrowhawk	*Accipiter nisus*	SH
Buzzard	*Buteo buteo*	BZ
Kestrel	*Falco tinnunculus*	K.
Moorhen	*Gallinula chloropus*	MH
Coot	*Fulica atra*	CO
Oystercatcher	*Haematopus ostralegus*	OC
Lapwing	*Vanellus vanellus*	L.
Snipe	*Gallinago gallinago*	
Curlew	*Numenius arquata*	CU
Redshank	*Tringa totanus*	
Common Sandpiper	*Actitis hypoleucos*	CS
Black-headed Gull	*Larus ridibundus*	BH
Common Gull	*Larus canus*	
Lesser Black-backed Gull	*Larus fuscus*	LB
Herring Gull	*Larus argentatus*	HG
Great Black-backed Gull	*Larus marinus*	
Common Tern	*Sterna hirundo*	CN
Feral Pigeon	*Columba livia*	FP
Stock Dove	*Columba oenas*	SD
Wood Pigeon	*Columba palumbus*	WP
Collared Dove	*Streptopelia decaocto*	CD
Turtle Dove	*Streptopelia turtur*	
Cuckoo	*Cuculus canorus*	CK
Barn Owl	*Tyto alba*	
Little Owl	*Athene noctua*	
Tawny Owl	*Strix aluco*	
Swift	*Apus apus*	SI
Kingfisher	*Alcedo atthis*	KF
Green Woodpecker	*Picus viridis*	G.
Great Spotted Woodpecker	*Dendrocopos major*	GS
Skylark	*Alauda arvensis*	S.

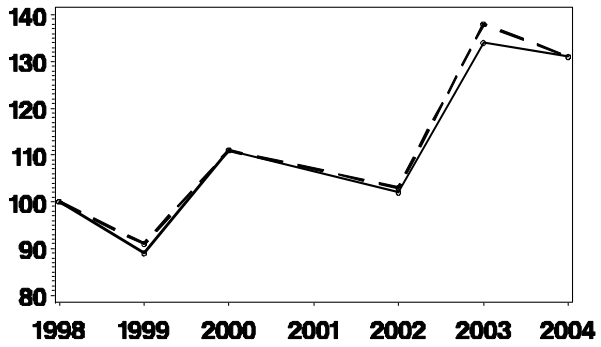
English name	Scientific name	Two-letter code
Sand Martin	*Riparia riparia*	SM
Swallow	*Hirundo rustica*	SL
House Martin	*Delichon urbicum*	HM
Tree Pipit	*Anthus trivialis*	
Meadow Pipit	*Anthus pratensis*	MP
Yellow Wagtail	*Motacilla flava*	
Grey Wagtail	*Motacilla cinerea*	GL
Pied Wagtail	*Motacilla alba*	PW
Dipper	*Cinclus cinclus*	DI
Wren	*Troglodytes troglodytes*	WR
Dunnock	*Prunella modularis*	D.
Robin	*Erithacus rubecula*	R.
Redstart	*Phoenicurus phoenicurus*	RT
Whinchat	*Saxicola rubetra*	
Stonechat	*Saxicola torquatus*	
Wheatear	*Oenanthe oenanthe*	W.
Ring Ouzel	*Turdus torquatus*	
Blackbird	*Turdus merula*	B.
Fieldfare	*Turdus pilaris*	
Song Thrush	*Turdus philomelos*	ST
Mistle Thrush	*Turdus viscivorus*	M.
Grasshopper Warbler	*Locustella naevia*	
Sedge Warbler	*Acrocephalus schoenobaenus*	SW
Reed Warbler	*Acrocephalus scirpaceus*	RW
Blackcap	*Sylvia atricapilla*	BC
Garden Warbler	*Sylvia borin*	GW
Lesser Whitethroat	*Sylvia curruca*	
Whitethroat	*Sylvia communis*	WH
Wood Warbler	*Phylloscopus sibilatrix*	
Chiffchaff	*Phylloscopus collybita*	CC
Willow Warbler	*Phylloscopus trochilus*	WW
Goldcrest	*Regulus regulus*	GC
Spotted Flycatcher	*Muscicapa striata*	SF
Pied Flycatcher	*Ficedula hypoleuca*	
Long-tailed Tit	*Aegithalos caudatus*	LT
Marsh Tit	*Parus palustris*	
Willow Tit	*Parus montanus*	
Coal Tit	*Parus ater*	CT
Blue Tit	*Parus caeruleus*	BT
Great Tit	*Parus major*	GT
Nuthatch	*Sitta europaea*	NH
Treecreeper	*Certhia familiaris*	TC
Jay	*Garrulus glandarius*	J.
Magpie	*Pica pica*	MG
Jackdaw	*Corvus monedula*	JD
Rook	*Corvus frugilegus*	RO
Carrion Crow	*Corvus corone*	C.
Hooded Crow	*Corvus cornix*	
Raven	*Corvus corax*	
Starling	*Sturnus vulgaris*	SG
House Sparrow	*Passer domesticus*	HS
Tree Sparrow	*Passer montanus*	
Chaffinch	*Fringilla coelebs*	CH

English name	Scientific name	Two-letter code
Greenfinch	*Carduelis chloris*	GR
Goldfinch	*Carduelis carduelis*	GO
Siskin	*Carduelis spinus*	
Linnet	*Carduelis cannabina*	LI
Lesser Redpoll	*Carduelis cabaret*	
Bullfinch	*Pyrrhula pyrrhula*	BF
Yellowhammer	*Emberiza citrinella*	Y.
Reed Bunting	*Emberiza schoeniclus*	RB
Corn Bunting	*Emberiza calandra*	

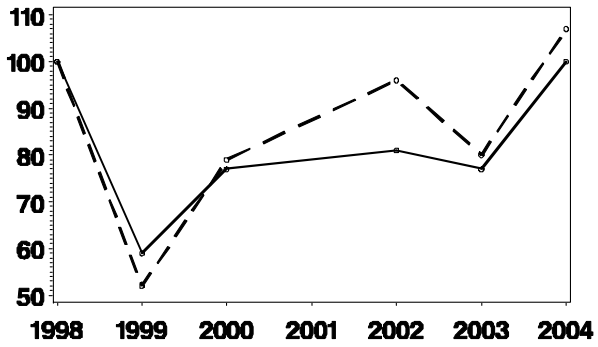
Appendix 3. Comparison of population indices for 1998–2004 between random WBBS sites (solid lines) and all WBBS sites (dashed lines). Weighted analyses are used throughout. Base year is 1998, set to a value of 100.



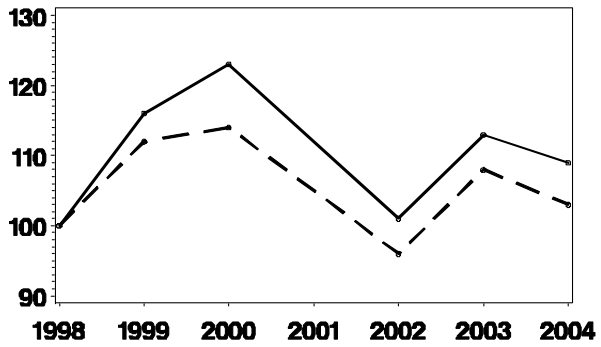
Buzzard



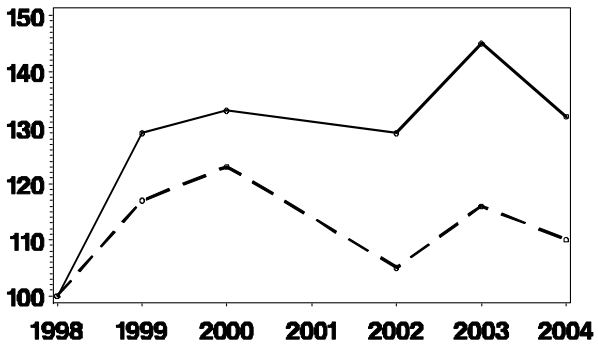
Kestrel



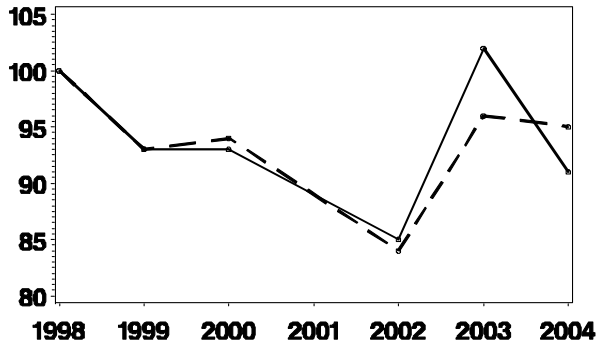
Moorhen



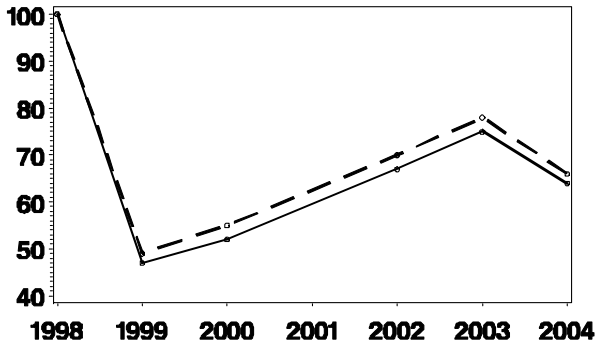
Coot



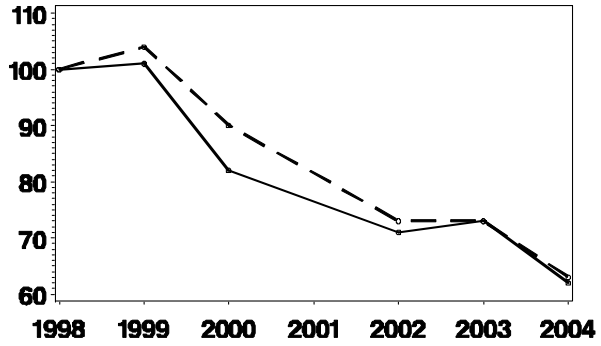
Oystercatcher



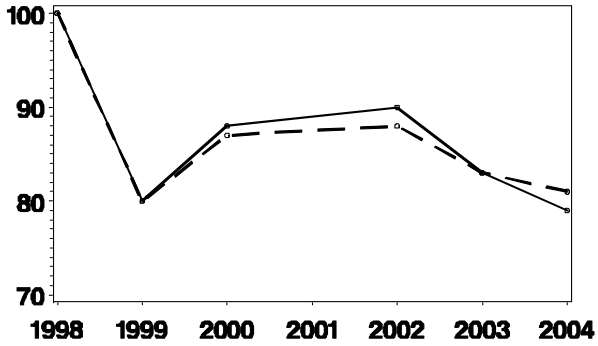
Lapwing



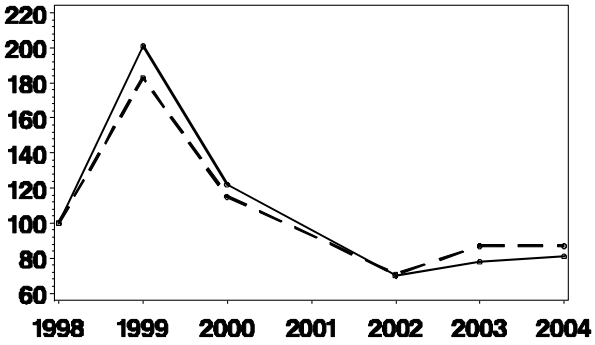
Curlew



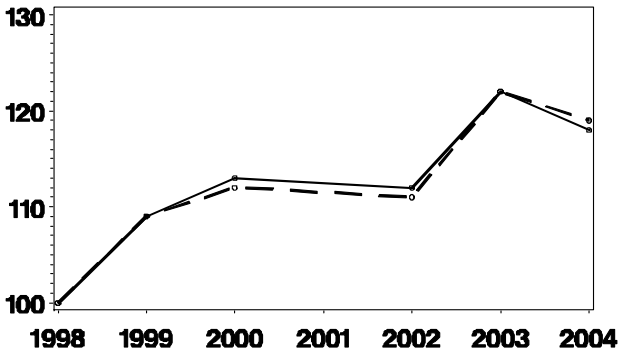
Common Sandpiper



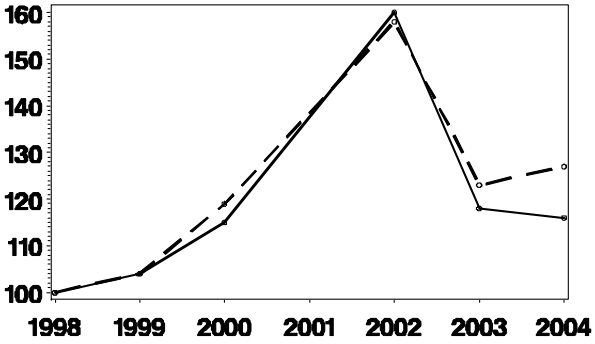
Stock Dove



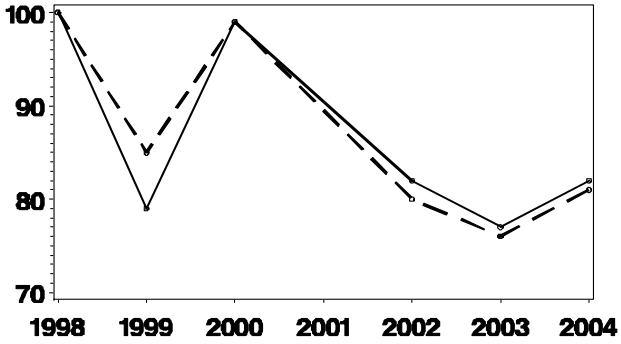
Wood Pigeon



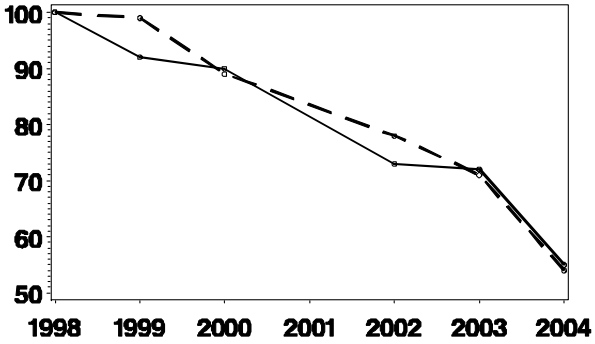
Collared Dove



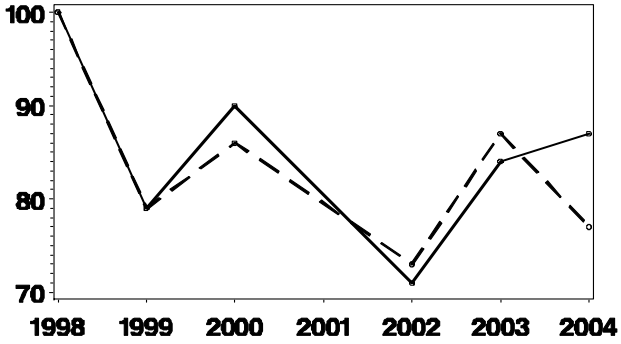
Cuckoo



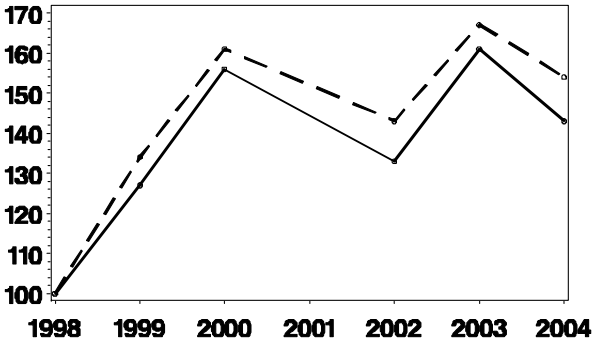
Swift



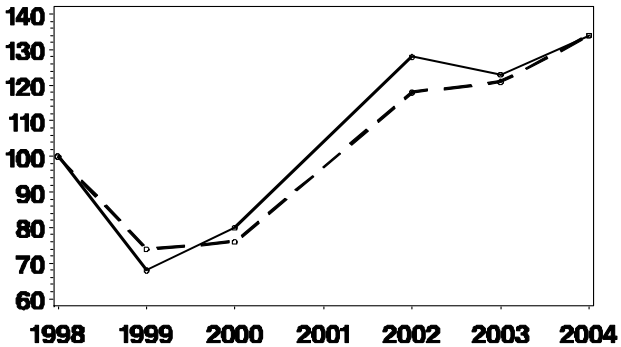
Kingfisher



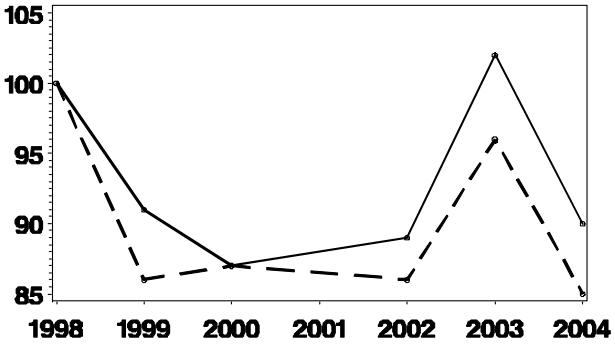
Green Woodpecker



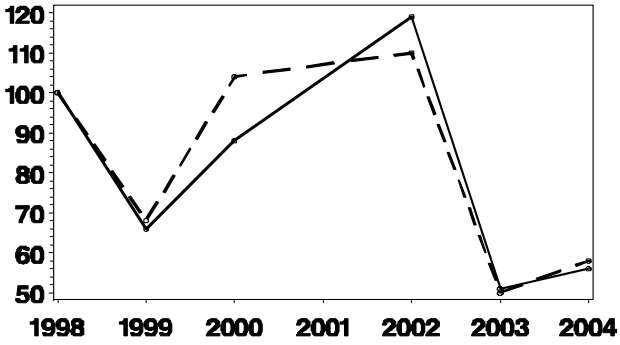
Great Spotted Woodpecker



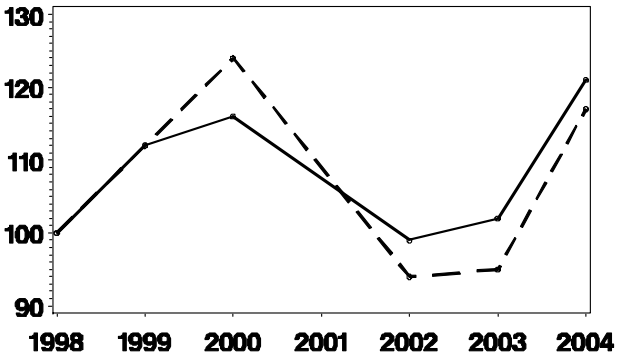
Skylark



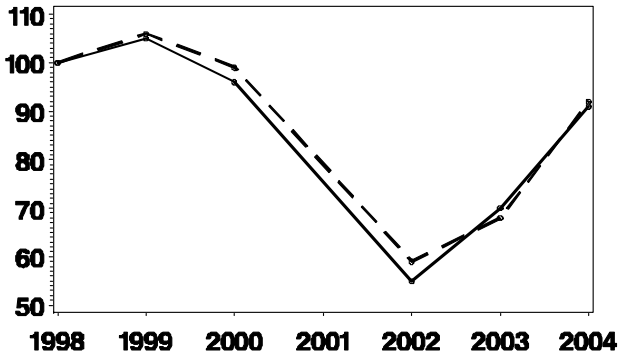
Sand Martin



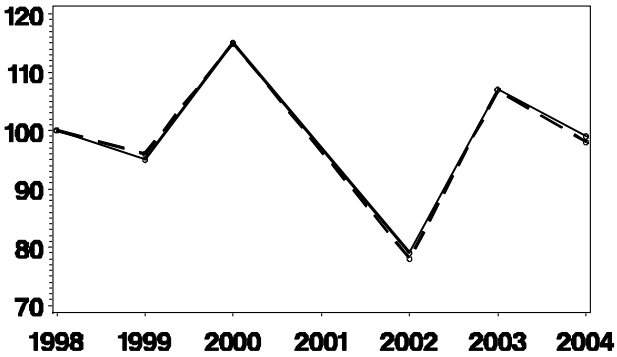
Swallow



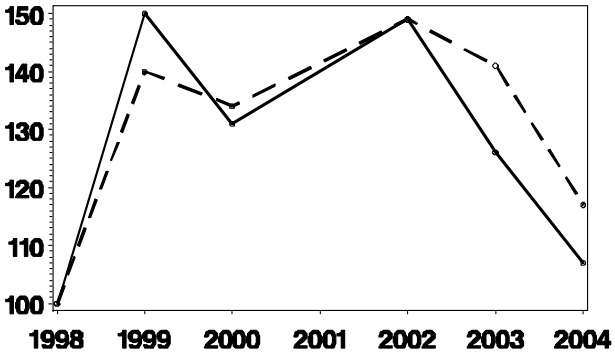
House Martin



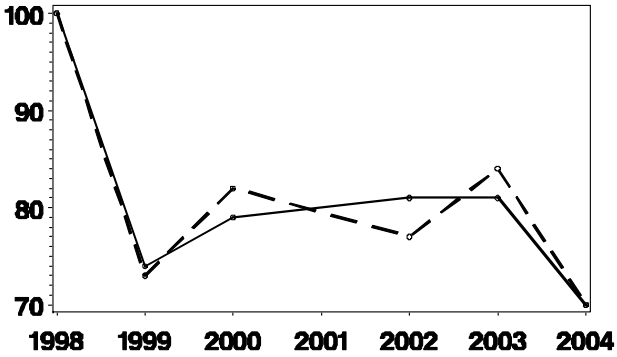
Meadow Pipit



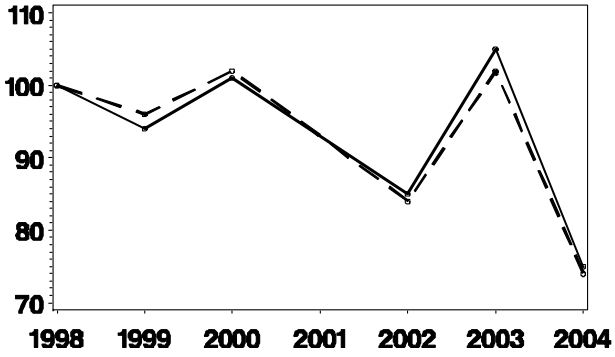
Grey Wagtail



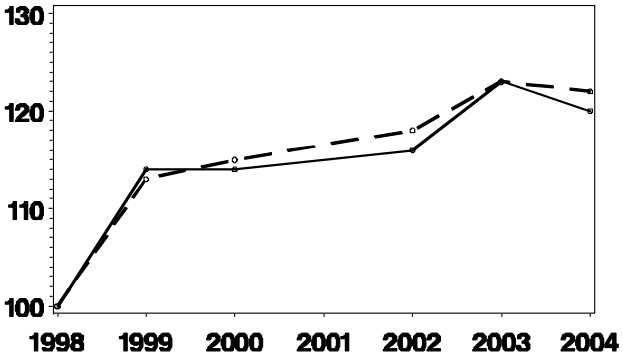
Pied Wagtail



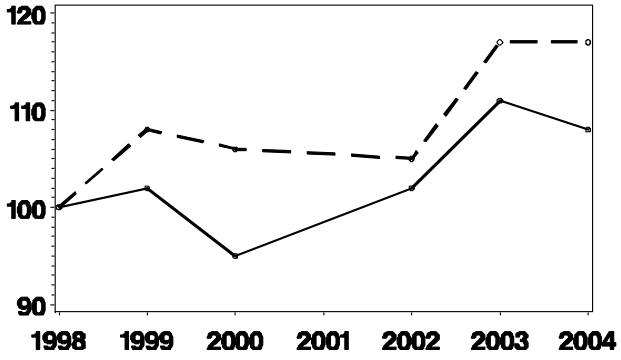
Dipper



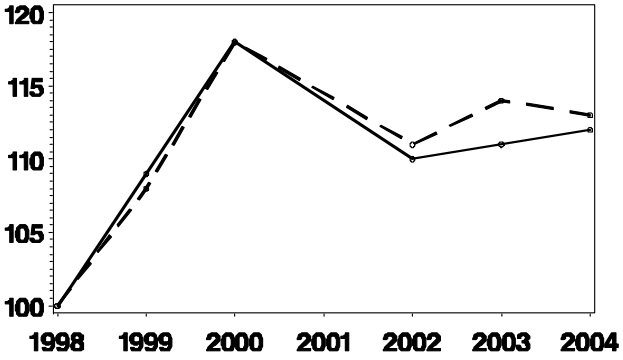
Wren



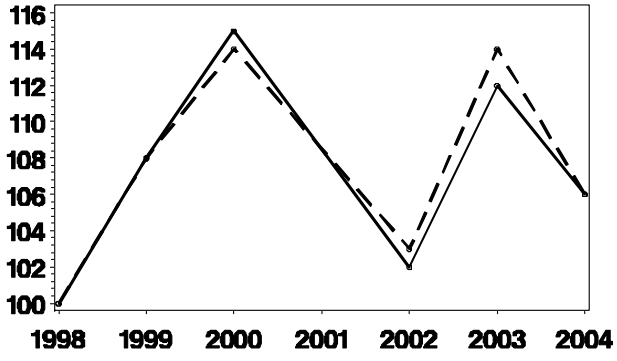
Dunnock



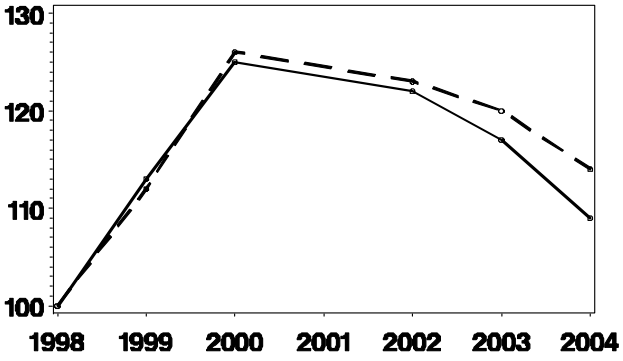
Robin



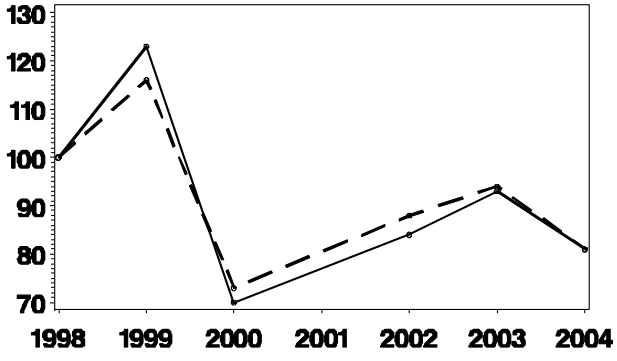
Blackbird



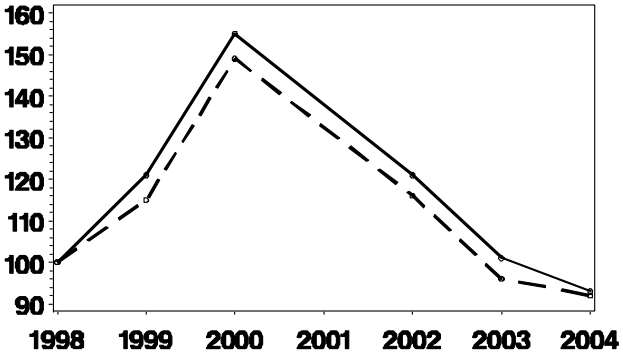
Song Thrush



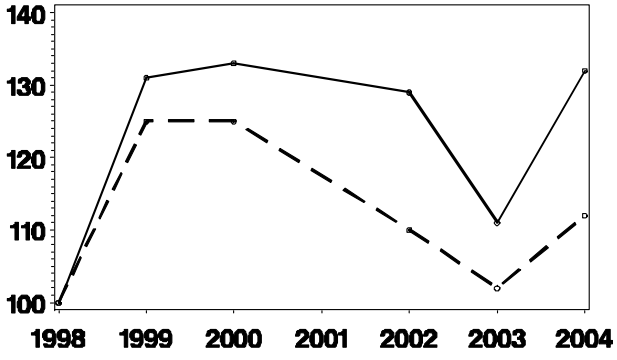
Mistle Thrush



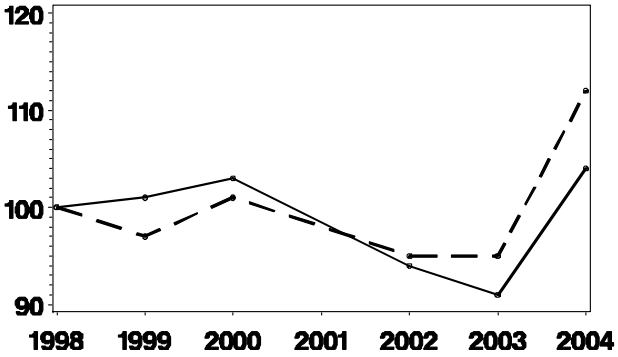
Sedge Warbler



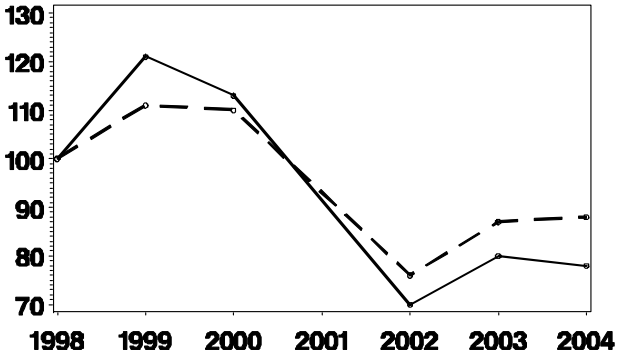
Reed Warbler



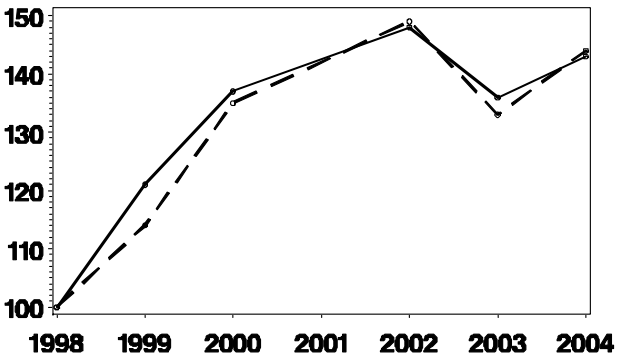
Blackcap



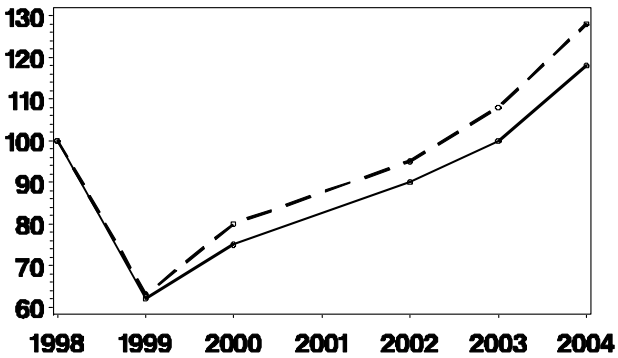
Garden Warbler



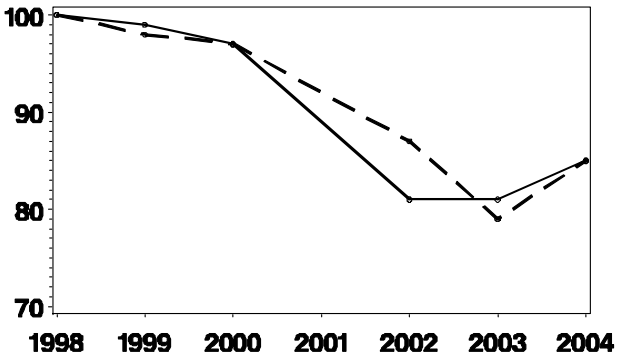
Whitethroat



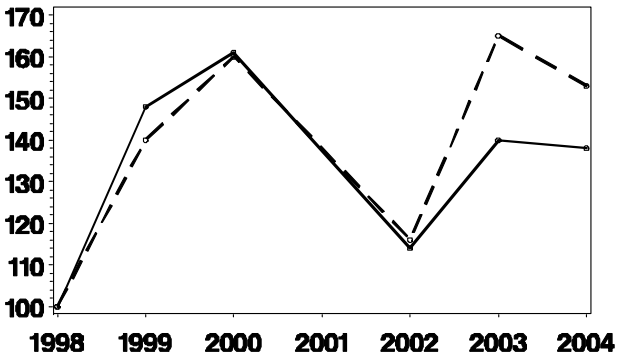
Chiffchaff



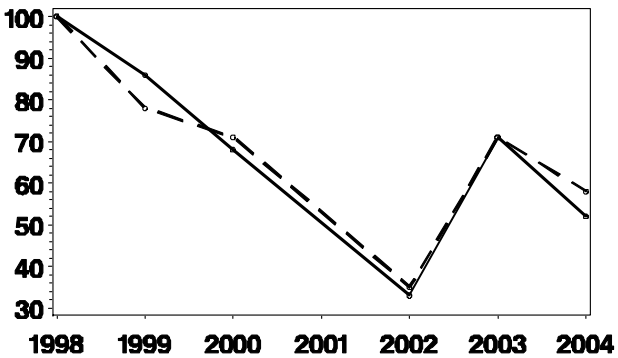
Willow Warbler



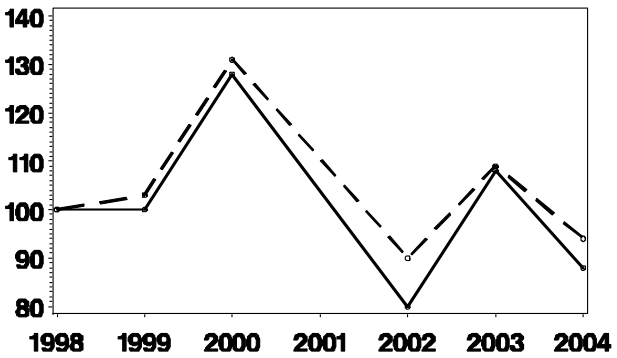
Goldcrest

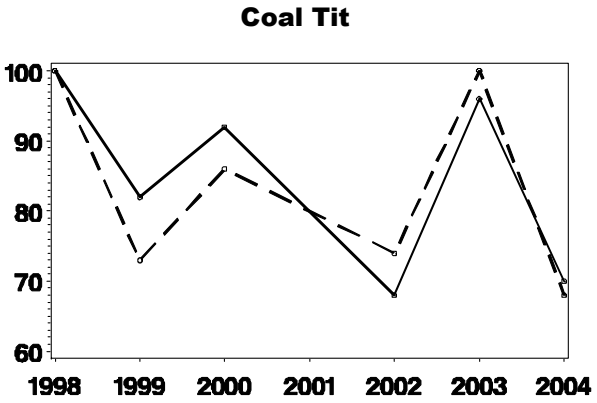


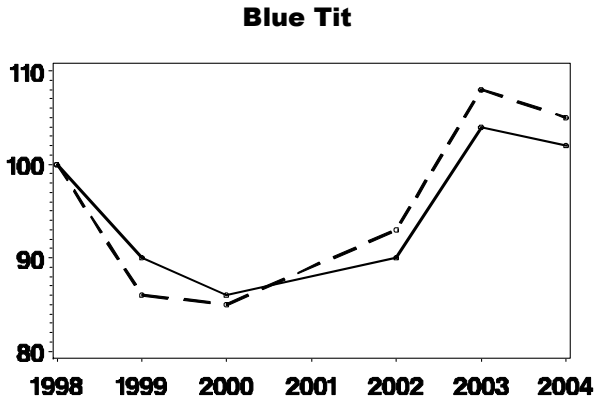
Spotted Flycatcher

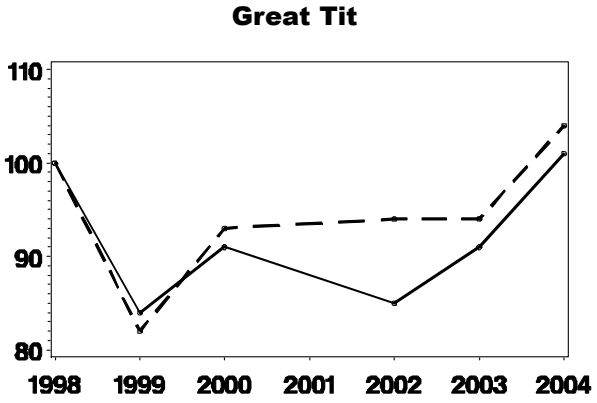


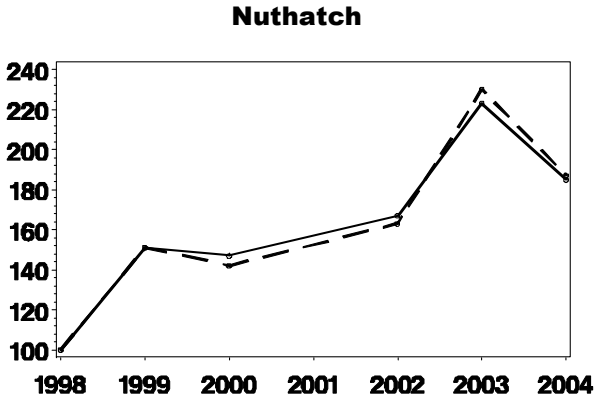
Long-tailed Tit

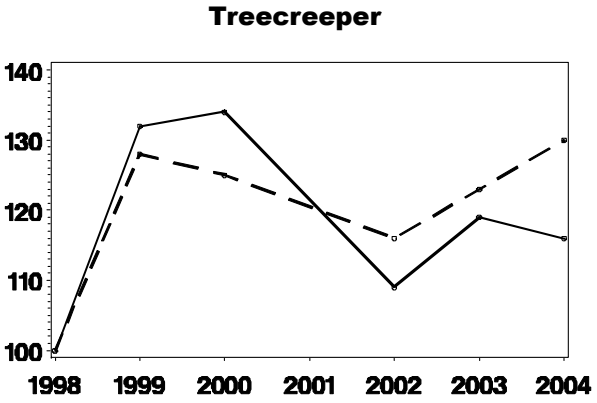


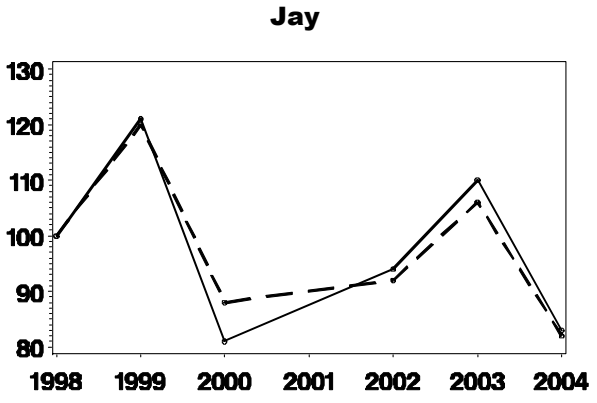

Coal Tit
100
90
80
70
60
1998
1999
2000
2001
2002
2003
2004

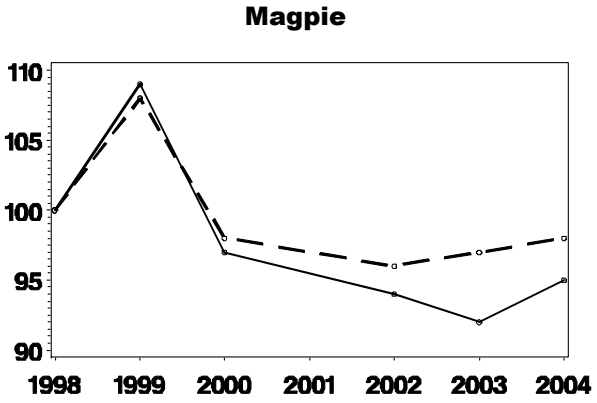

Blue Tit
110
100
90
80
1998
1999
2000
2001
2002
2003
2004

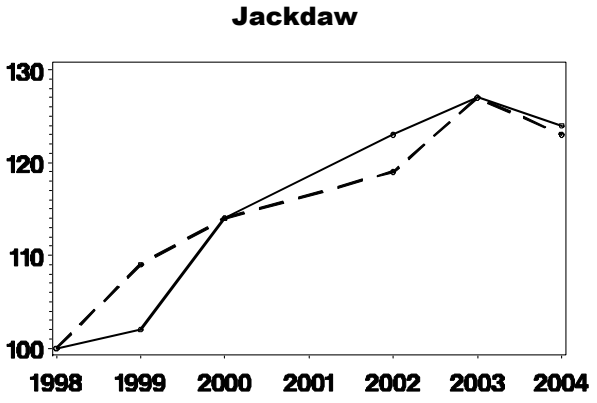

Great Tit
110
100
90
80
1998
1999
2000
2001
2002
2003
2004


Nuthatch
240
220
200
180
160
140
120
100
1998
1999
2000
2001
2002
2003
2004

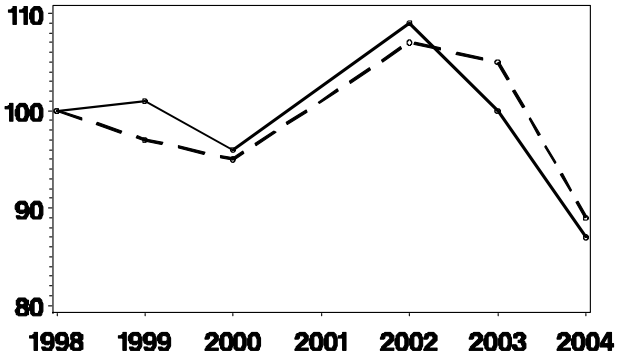

Treecreeper
140
130
120
110
100
1998
1999
2000
2001
2002
2003
2004


Jay
130
120
110
100
90
80
1998
1999
2000
2001
2002
2003
2004

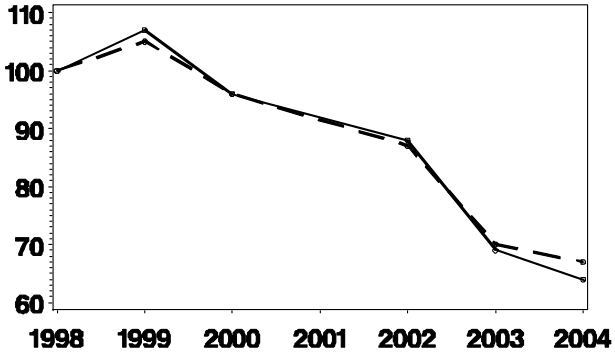

Magpie
110
105
100
95
90
1998
1999
2000
2001
2002
2003
2004


Jackdaw
130
120
110
100
1998
1999
2000
2001
2002
2003
2004

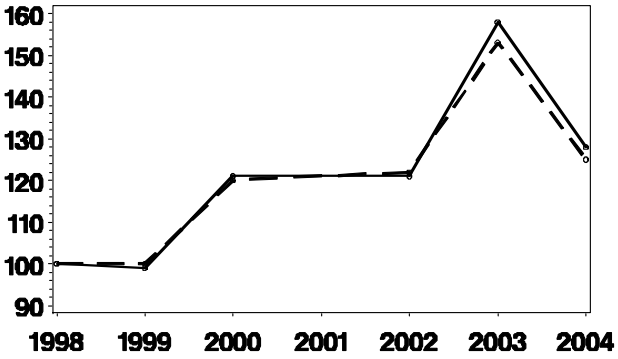
Carrion Crow



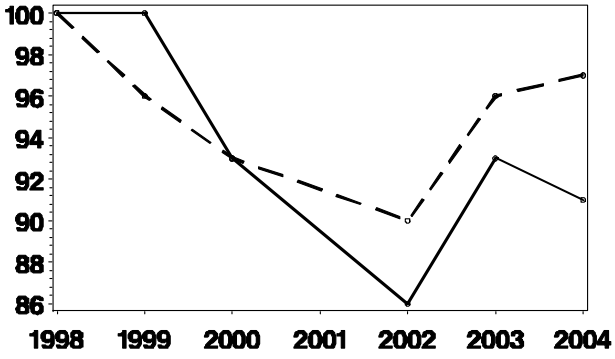
Starling



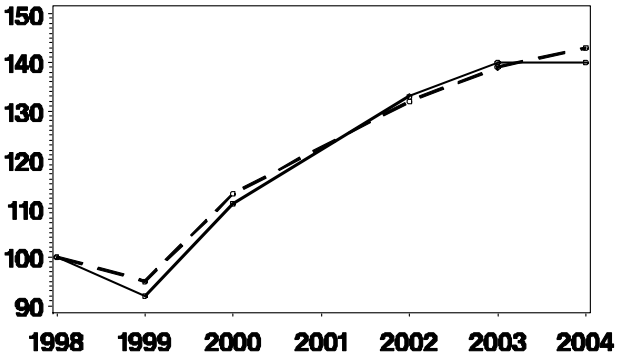
House Sparrow



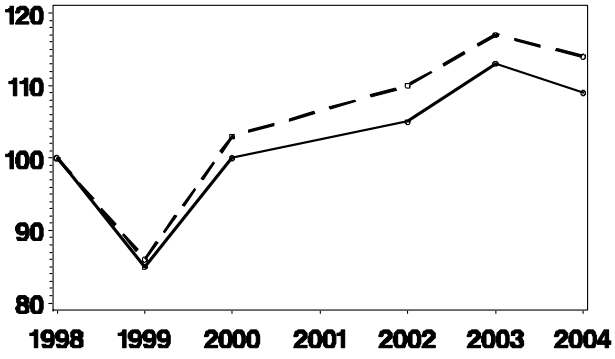
Chaffinch



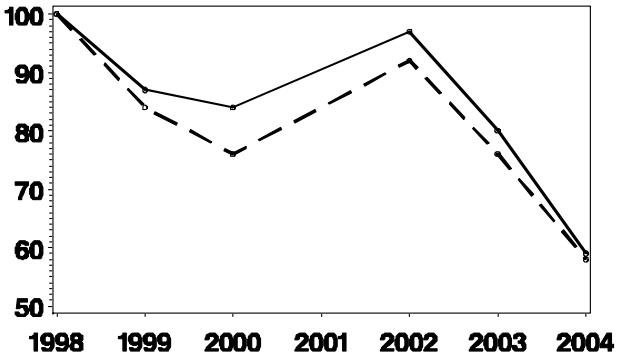
Greenfinch



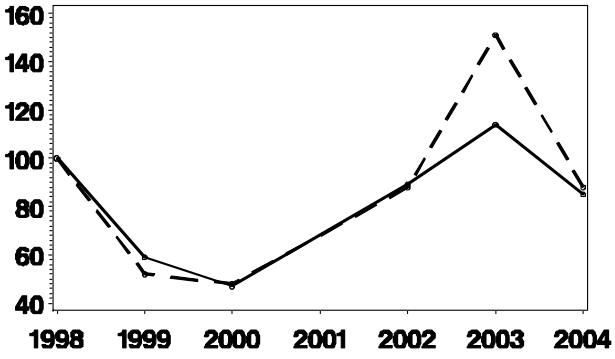
Goldfinch

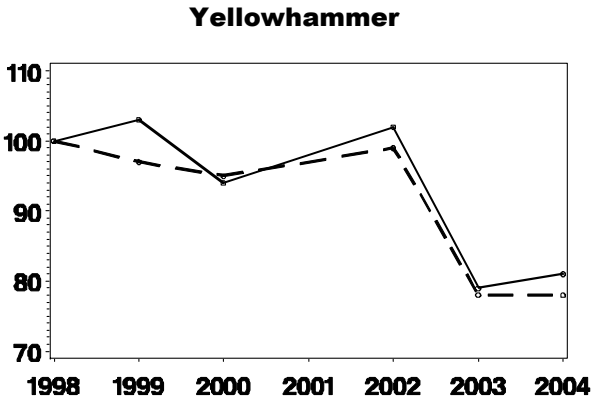


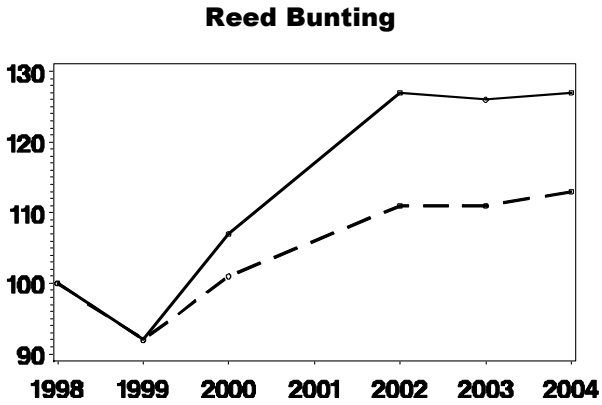
Linnet



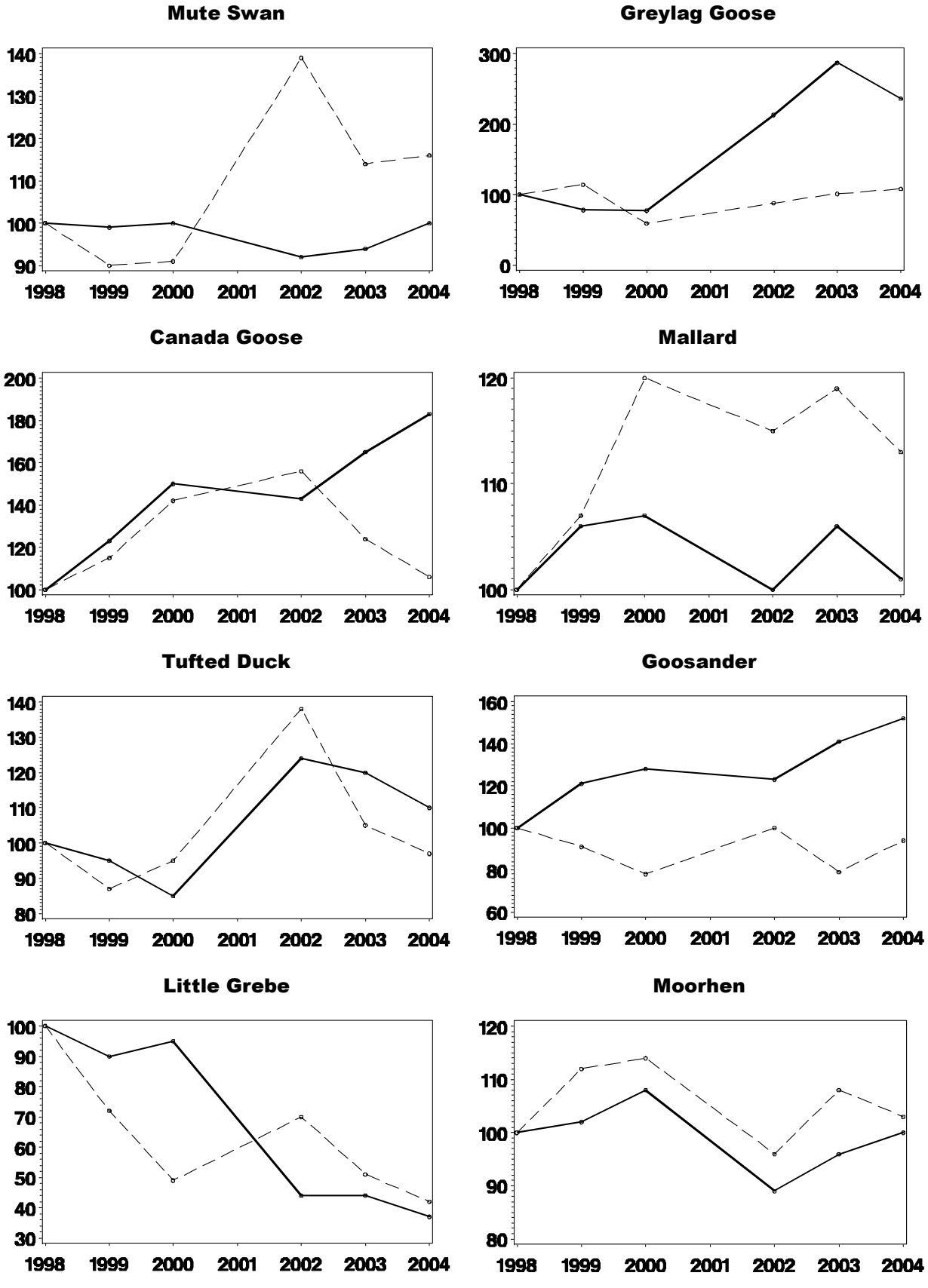
Bullfinch

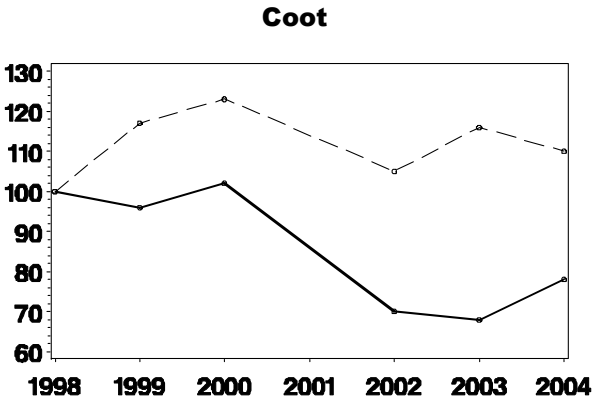


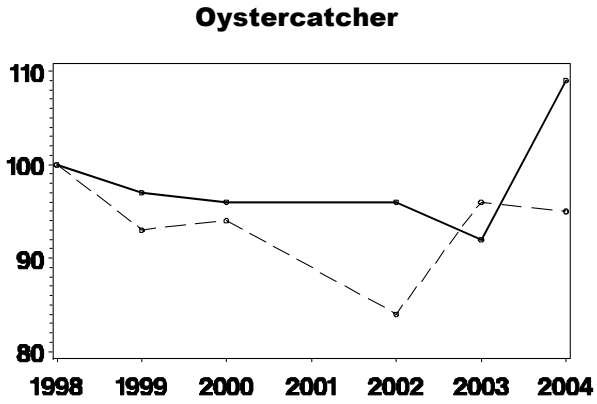

Yellowhammer
110
100
90
80
70
1998
1999
2000
2001
2002
2003
2004

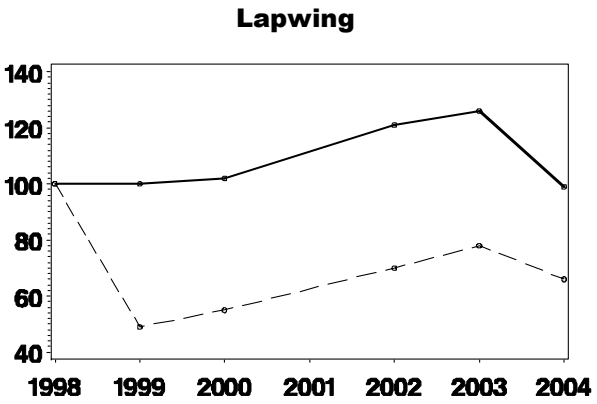

Reed Bunting
130
120
110
100
90
1998
1999
2000
2001
2002
2003
2004

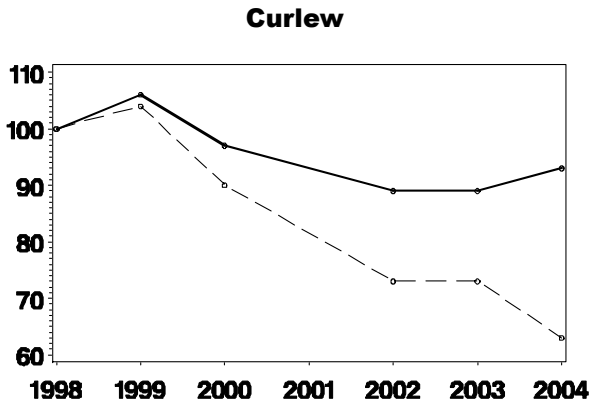
Appendix 4. Comparison of population indices for 1998–2004 between WBS mapping data (solid lines) and all WBBS sites (dashed lines). Weighted analyses are used throughout. Base year is 1998, set to a value of 100.

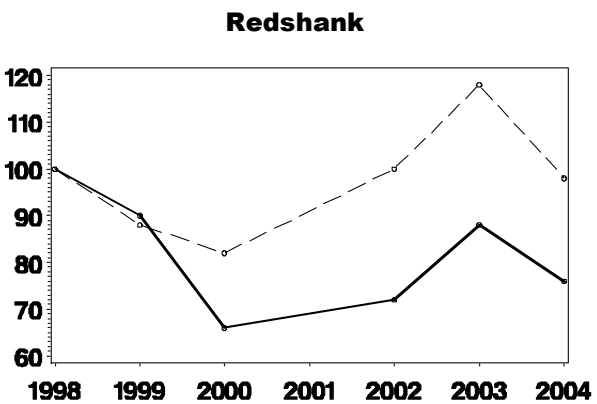


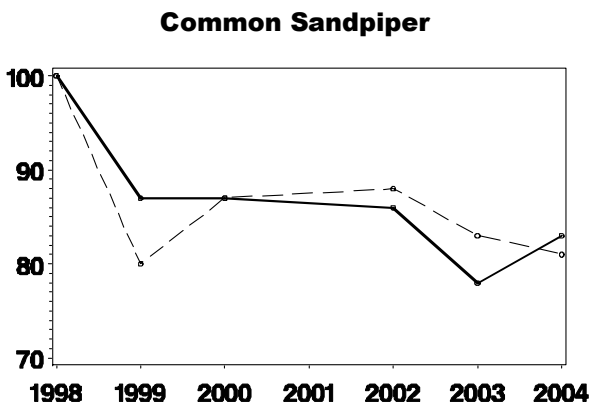

Coot
130
120
110
100
90
80
70
60
1998
1999
2000
2001
2002
2003
2004

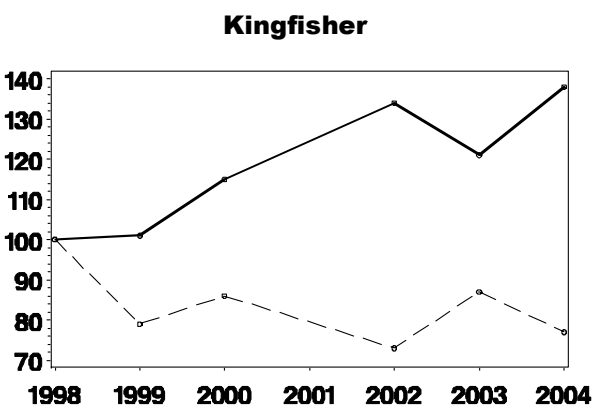

Oystercatcher
110
100
90
80
1998
1999
2000
2001
2002
2003
2004

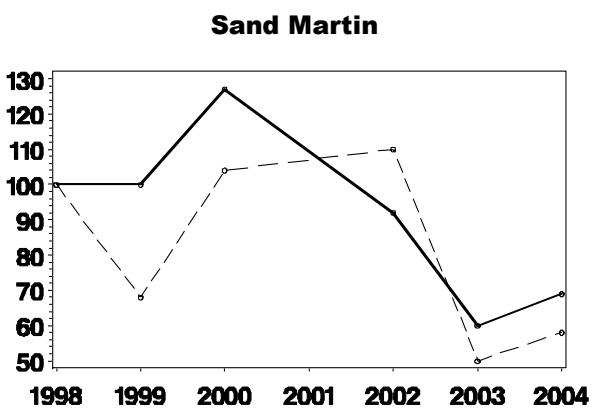

Lapwing
140
120
100
80
60
40
1998
1999
2000
2001
2002
2003
2004


Curlew
110
100
90
80
70
60
1998
1999
2000
2001
2002
2003
2004

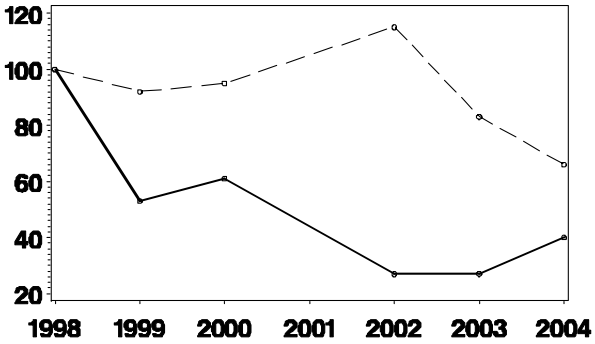

Redshank
120
110
100
90
80
70
60
1998
1999
2000
2001
2002
2003
2004


Common Sandpiper
100
90
80
70
1998
1999
2000
2001
2002
2003
2004

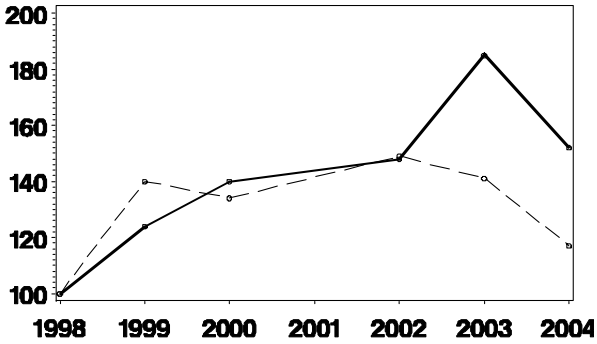

Kingfisher
140
130
120
110
100
90
80
70
1998
1999
2000
2001
2002
2003
2004


Sand Martin
130
120
110
100
90
80
70
60
50
1998
1999
2000
2001
2002
2003
2004

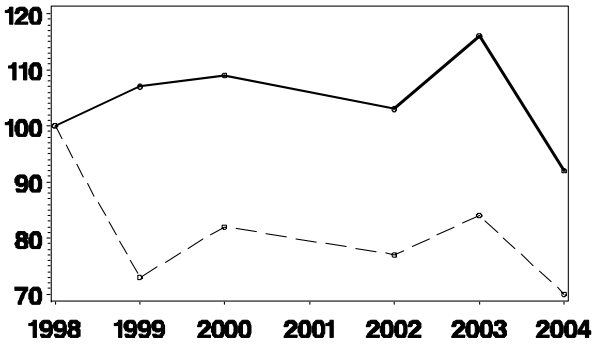
Yellow Wagtail



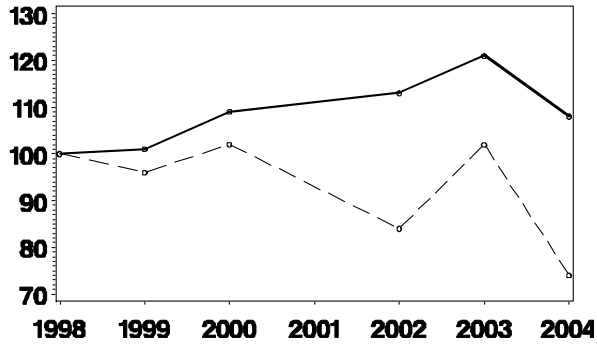
Grey Wagtail



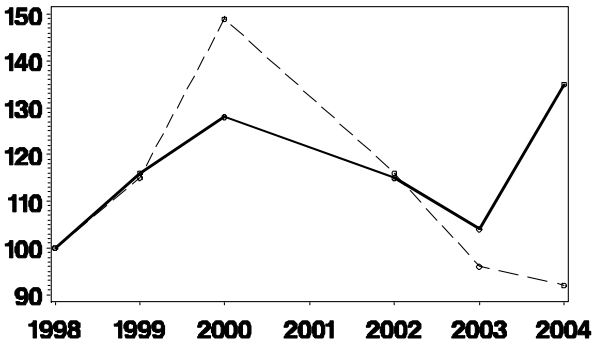
Pied Wagtail



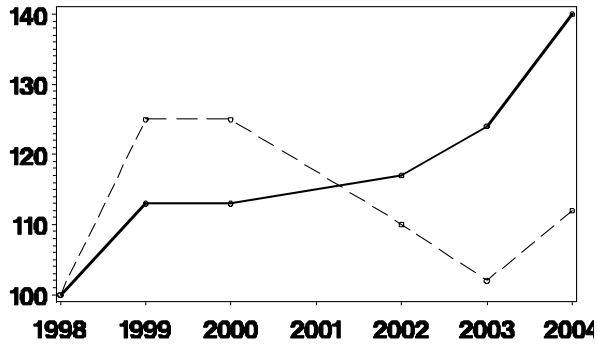
Dipper



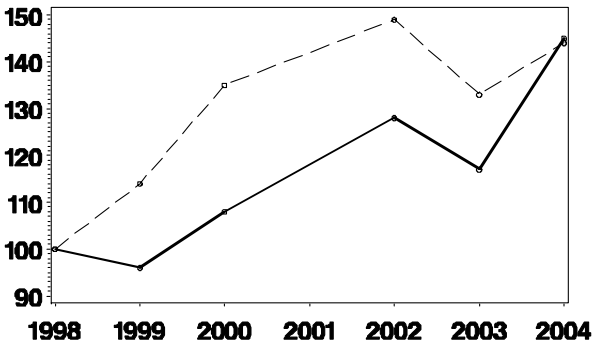
Sedge Warbler



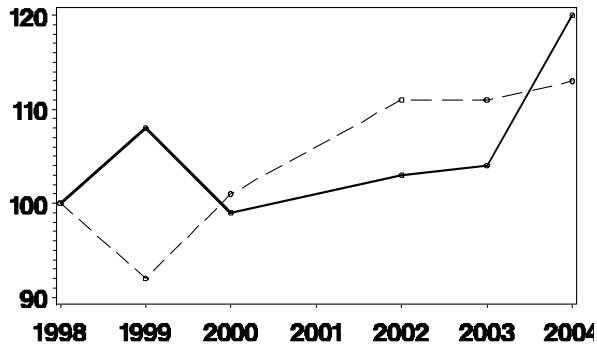
Reed Warbler



Whitethroat



Reed Bunting



Appendix 5. Population change measures for 1998–2004, and their standard errors, for two methods of calculating the count from each stretch. Weightings are applied throughout, and data are drawn from all WBBS sites. Option 1: maxima from early and late visits taken first by section, and then summed. Option 2: counts are summed across sections and the maximum taken of early and late totals. Change measures are reported for species with a mean annual sample size of 20 or more. Gulls, Red-legged Partridge, Pheasant, Feral Pigeon and Rook are excluded. Scientific names of bird species are given in Appendix 2.

Species	Sample size	Population change measure 1998–2004		Standard error of population change measure 1998–2004	
		Option 1 (section)	Option 2 (stretch)	Option 1 (section)	Option 2 (stretch)
Mute Swan	83	+16% *	+11% *	1.0461	1.0503
Greylag Goose	29	+8%	+1%	1.0603	1.0635
Canada Goose	64	+6%	+1%	1.0424	1.0449
Shelduck	21	-39% *	-39% *	1.0526	1.054
Mallard	178	+13% *	+17% *	1.0174	1.019
Tufted Duck	36	-3%	-13%	1.0722	1.0761
Goosander	38	-6%	+8%	1.0836	1.0908
Cormorant	52	+46% *	+32% *	1.0869	1.0926
Grey Heron	131	-3%	-1%	1.0528	1.0584
Sparrowhawk	36	-22%	-9%	1.1759	1.1874
Buzzard	71	+31% *	+25% *	1.0664	1.0731
Kestrel	62	+7%	+1%	1.0994	1.1062
Moorhen	118	+3%	+3%	1.0394	1.0429
Coot	58	+10%	+8%	1.0518	1.0559
Oystercatcher	55	-5%	-5%	1.0317	1.0348
Lapwing	70	-34% *	-36% *	1.0301	1.0331
Curlew	49	-37% *	-38% *	1.0498	1.0556
Common Sandpiper	57	-19% *	-21% *	1.0417	1.0458
Common Tern	25	+11%	+12%	1.116	1.1268
Stock Dove	71	-13% *	-11%	1.0595	1.0658
Wood Pigeon	174	+19% *	+20% *	1.0152	1.0164
Collared Dove	93	+27% *	+29% *	1.0559	1.0596
Cuckoo	64	-19% *	-25% *	1.0976	1.104
Swift	106	-46% *	-48% *	1.032	1.0329
Kingfisher	60	-23% *	-29% *	1.1114	1.1205
Green Woodpecker	61	+54% *	+54% *	1.1082	1.1176
Gt Spotted Woodpecker	84	+34% *	+33% *	1.0813	1.089
Skylark	88	-15% *	-9% *	1.0436	1.0468
Sand Martin	58	-42% *	-46% *	1.0336	1.0359
Swallow	154	+17% *	+20% *	1.0276	1.0291
House Martin	96	-8% *	-9% *	1.0338	1.0352
Meadow Pipit	59	-2%	-4%	1.0249	1.0262
Grey Wagtail	104	+17% *	+12%	1.0569	1.0617
Pied Wagtail	124	-30% *	-21% *	1.0427	1.0473
Dipper	71	-26% *	-27% *	1.061	1.0679
Wren	178	+22% *	+22% *	1.0194	1.0205
Dunnock	136	+17% *	+15% *	1.0439	1.0477
Robin	171	+13% *	+12% *	1.0279	1.0298
Redstart	24	+11%	-4%	1.1028	1.1118
Wheatear	23	-22% *	-24% *	1.0687	1.0752
Blackbird	174	+6% *	+7% *	1.0207	1.0223
Song Thrush	159	+14% *	+10% *	1.0379	1.0411
Mistle Thrush	106	-19% *	-12%	1.0603	1.0654
Sedge Warbler	77	-8%	-13% *	1.051	1.0536
Reed Warbler	47	+12% *	+11%	1.0543	1.0561

Species	Sample size	Population change measure 1998–2004		Standard error of population change measure 1998–2004	
		Option 1 (section)	Option 2 (stretch)	Option 1 (section)	Option 2 (stretch)
Blackcap	132	+12% *	+9%	1.0402	1.043
Garden Warbler	67	-12%	-6%	1.0808	1.0848
Whitethroat	98	+44% *	+38% *	1.0491	1.052
Chiffchaff	115	+28% *	+34% *	1.0431	1.0463
Willow Warbler	141	-15% *	-16% *	1.0294	1.0308
Goldcrest	66	+53% *	+46% *	1.0728	1.0788
Spotted Flycatcher	41	-42% *	-41% *	1.1026	1.1038
Long-tailed Tit	107	-6%	-7%	1.0498	1.0535
Coal Tit	62	-32% *	-33% *	1.0675	1.0724
Blue Tit	170	+5%	+4%	1.022	1.0237
Great Tit	163	+4%	+1%	1.0292	1.0316
Nuthatch	45	+87% *	+70% *	1.1105	1.1164
Treecreeper	59	+30% *	+31% *	1.0965	1.1061
Jay	57	-18% *	-16%	1.1071	1.1156
Magpie	136	-2%	-2%	1.0372	1.0406
Jackdaw	129	+23% *	+18% *	1.024	1.0259
Carrion Crow	172	-11% *	-11% *	1.0209	1.0229
Starling	131	-33% *	-34% *	1.0188	1.02
House Sparrow	99	+25% *	+30% *	1.0341	1.0357
Chaffinch	182	-3%	-2%	1.0182	1.0193
Greenfinch	125	+43% *	+36% *	1.0393	1.0429
Goldfinch	124	+14% *	+12% *	1.0415	1.0453
Linnet	65	-42% *	-38% *	1.0542	1.0582
Bullfinch	55	-12%	-12%	1.0966	1.1037
Yellowhammer	63	-22% *	-27% *	1.0655	1.0722
Reed Bunting	83	+13% *	+18% *	1.0572	1.0626

*indicates statistical significance at the 95% level.

We welcome views from our users, stakeholders and the public, including comments about the content and presentation of this report. If you are happy with our service, please tell us about it. It helps us to identify good practice and rewards our staff. If you are unhappy with our service, please let us know how we can improve it.