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Population changes of riparian birds along rivers and canals in the Severn-Trent region between 1989 and 1993

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A report to the Conservation Office of the National Rivers Authority, Severn-Trent Region, from the British Trust for Ornithology

November 1994

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SUMMARY

Data from the British Trust for Ornithology's Waterways Bird Survey (WBS) were used to compile indices of change in breeding population for 14 species of waterside bird in the Severn-Trent region of the National Rivers Authority (NRA) for the period 1989-93. The species were Little Grebe *Tachybaptus ruficollis*, Mute Swan *Cygnus olor*, Mallard *Anas platyrhynchos*, Tufted Duck *Aythya fuligula*, Moorhen *Gallinula chloropus*, Coot *Fulica atra*, Kingfisher *Alcedo atthis*, Yellow Wagtail *Motacilla flava*, Grey Wagtail *M. cinerea*, Pied Wagtail *M. alba*, Dipper *Cinclus cinclus*, Sedge Warbler *Acrocephalus schoenobaenus*, Whitethroat *Sylvia communis* and Reed Bunting *Emberiza schoeniclus*. To put these trends into a national context, they were compared with trends calculated from WBS plots outside the Severn-Trent region during 1989-93 and with longer-term national population changes.

Most species showed strong similarities between trends inside and outside the Severn-Trent region, indicating a degree of uniformity in population changes across the United Kingdom as a whole. The largest divergences were for Tufted Duck, Kingfisher, Grey Wagtail and Sedge Warbler, where, in each case, the overall trend appeared to have been more positive within the Severn-Trent region than elsewhere. The effects of chance within small samples of both survey plots and birds' territories will, however, have contributed to these differences. Small samples of occupied plots within the Severn-Trent region precluded the compilation of population indices for a further five species that are indexed nationally: these were Oystercatcher *Haematopus ostralegus*, Lapwing *Vanellus vanellus*, Curlew *Numenius arquata*, Redshank *Tringa totanus* and Common Sandpiper *Actitis hypoleucos*. WBS data would allow compilation of similar indices separately for three more NRA regions - Northumbria & Yorkshire, North West and Thames - although, owing to smaller samples of WBS plots, these indices would necessarily cover fewer species.

1. INTRODUCTION

The British Trust for Ornithology (BTO) has operated a Waterways Bird Survey since 1974, covering stretches of river and canal throughout the United Kingdom. Each breeding season, volunteer observers survey their stretches to count and map the territories of waterside birds. Details of the habitats available to the birds are also recorded. The WBS produces data on population changes and on the location of territories in relation to physical features of the waterway environment. These data can be used to investigate, at a variety of spatial and temporal scales, the ways in which breeding birds use river and canal habitats. The primary role of the WBS has been to record population changes among species poorly represented in the BTO's Common Birds Census.

An overview of the WBS and its results has been given by Carter (1989). Marchant *et al.* (1990) provided a short history of the scheme and summarised population trends for waterside birds, derived from WBS and other sources, up to 1988. Index graphs for the twenty years 1974-1993, showing overall population changes for nineteen species, have been published recently (Marchant & Balmer 1994*a*). This is the complete run of WBS data collected to date: 1994 data are currently being collated.

In this study, WBS data are used to investigate population changes of waterways birds in the National Rivers Authority's Severn-Trent region since 1989, the year of NRA's creation, and up to 1993, the most recent year for which data are presently available. These trends are set in the context of the overall WBS trends and further information from other sources.

2. METHODS

2.1 Data available

Field methods for the WBS have been described in full by Taylor (1982). The survey uses a nine-visit mapping method, operated by BTO volunteers, to both count and map breeding territories along linear waterways. Plots are chosen by the observers themselves, under guidance from BTO staff, and are stretches typically 4½-5 kilometres long which are of relatively easy access and of which at least one bank can be walked. Observers forward visit and species maps to BTO headquarters, where the numbers and distribution of bird territories are assessed by staff trained for consistency of treatment between plots and between years. The methods used to assess territories have recently been documented (Marchant 1994).

Table 1 shows the annual and regional distributions of the 436 different stretches of waterway that were surveyed during 1974-93. The largest samples of plots lay in the Severn-Trent, Thames, North West and Northumbria & Yorkshire divisions of NRA, both overall and within the five-year study period. Numbers of surveys increased markedly, both nationally and in several regions including Severn-Trent, between 1990 and 1991. Within the Severn-Trent region, this was in response to a targetted attempt to increase coverage.

The 41 WBS plots that were surveyed within the Severn-Trent region during the study period are listed in Table 2, along with their primary observers, WBS codes, upstream and downstream altitudes and grid references, lengths and years covered. These plots were widely distributed within the region, but with none in the northeast of the region along the lower River Trent.

2.2 Selection of plots by NRA region

Analysis of WBS data by NRA region, which had not previously been attempted, required that additions be made to WBS data-files and that improvement be made to the computer programs available to process the data on a long-term and regionally selective basis. For the purposes of the present study therefore, new codes were assigned to all WBS plots indicating their NRA region, in addition to the previous regional coding based on county boundaries. Programs that had been written to store CBC data in binary format and retrieve them rapidly, according to a variety of criteria, were adapted for use with WBS.

Implementation of this new system has enabled population changes to be calculated and recalculated quickly and easily, for any specified runs of years, using data from selected samples of plots. In addition, extraction of any kind of specific data from WBS files for tabulation or analysis is now much simpler. These improvements have facilitated not only the present study but also all future analyses of WBS data.

2.3 Calculation of population changes

Population changes were assessed using the chain-index method, as has been standard for both WBS and CBC (Marchant *et al.* 1990). Separate chain indices were calculated for the period 1989-93 from plots within the Severn-Trent region, from plots elsewhere in the UK, and from all WBS plots.

Each annual set of percentage changes was estimated by comparing "year 1" and "year 2" totals from a paired sample of census plots. The year totals are the sums of all valid and comparable pairs of counts obtained in each of the two years. A real but abbreviated example from the WBS index for the Severn-Trent region is given below: numbers in the left-hand column are plot codes.

MALLARD	1990	1991
064	9	9
102	36	23
276	5	5
094	18	23
100	65	59

Thus, according to the example, there were five plots with Mallards where coverage in 1991 was comparable to that in 1990 (in fact there were 14). Mallards were stable on plots 064 and 276, but changed in various ways on the other plots. Overall, the year totals in this example were 133 and 119, and the percentage change of Mallards in the region between 1990 and 1991 was -11%. This percentage change would be applied to the index value for 1990 to give the new value for 1991. The index can be initialised in any convenient year. In this study, index values were calculated relative to the baseline figure of 100 applied to 1989.

The precision of the percentage change estimates can be assessed by statistical methods which take into account the variation in changes detected on individual survey plots. Confidence limits on year-to-year percentage changes were determined, where data allowed, according to the formula of Baillie *et al.* (1986).

The numbers of plots contributing data to each year-to-year comparison are shown in Table 3 for each of the three regional groupings. The plots tabulated are those where comparable data were available for two consecutive years. Plots not censused in both years or with differences in coverage are omitted. Numbers are thus lower than in Tables 1 and 2 where all plots are shown. Samples of plots increased markedly between 1990-91 and 1991-92, following the influx of new plots in 1991.

The distribution of plots contributing to the population change estimates in one or more year-to-year comparisons, in relation to NRA regional boundaries, is shown in Figure 1. Plots are not uniformly distributed, but reflect the distribution of BTO members and also the special interest shown in this survey in the Sheffield and Lancaster areas.

3. RESULTS

The results of the Severn-Trent regional index calculations are shown in Table 4, along with the overall national index values 1989-93. In the table, the number of plots is the number contributing data to the year totals for that species and year-to-year comparison. These numbers are lower than those in Table 3 because not all species hold territory on every plot. The year 1 and year 2 totals are the numbers of territories found on those plots in, respectively, the first and second years of the comparison. Percentage changes between the year totals are given, along with their 95% confidence limits where these could be calculated.

Significant changes in population size, defined as those where the confidence interval excluded zero change, are indicated by an asterisk. Where the change estimate and confidence limits were drawn from data from seven or more pairs of surveys, statistically significant population changes are printed in bold type.

Initially, all nineteen species for which UK population trends are routinely calculated (*e.g.* Marchant & Balmer 1994*a*) were included. However, samples for five species were too low to allow a Severn-Trent index to be computed, and population trends for several others require cautious interpretation because numbers of plots or territories were small.

Index values from all three of the regional samples are plotted in Figure 2. The indices are plotted on a logarithmic scale, so that the slopes of the lines are directly proportional to the estimated percentage change. It should be noted that the coincidence of the lines at 100 in 1989 is entirely artificial. Graphs for the Severn-Trent region and for elsewhere in the UK are independent, while the overall UK trend is obtained from the sum of the count data for the other two indices: the UK trend lies between the other two lines, therefore. With these caveats, the width of the envelope of trend lines is a measure of how closely the percentage changes in the Severn-Trent region match those recorded elsewhere. These relationships are discussed below: they are not explored statistically, for example by correlating changes in the Severn-Trent region with those elsewhere, because the number of years in the study was considered too low for meaningful results to be obtained.

4. DISCUSSION

The results are discussed first by species and then generally. For each species, a brief statement of the use made of waterways is followed by a comparison of trends between the Severn-Trent and elsewhere, by a summary of WBS trends during the full run of years 1974-93 and by any information that is available concerning those trends. The relative abundances of each species on waterways plots are indicated by the magnitudes of the year totals in Table 4.

4.1 Little Grebe *Tachybaptus ruficollis*

Little Grebes are relatively scarce waterside birds nesting particularly beside small bodies of standing water. Their use of waterways for breeding is restricted to slow-flowing rivers and canals not subject to large variations in water-level.

The trend in the Severn-Trent region was very similar to that found elsewhere. There was an increase between 1989 and 1990 and a decrease subsequently. Two of the year-to-year decreases were statistically significant. The trend was drawn from between four and seven plots in annual comparisons.

Overall, the national trend from 1974 to 1993 was essentially flat, but with the 1993 index value marginally the lowest recorded (Marchant & Balmer 1994*a*). Little is known about the causes of population change in this species, although severe winter weather can cause decreases (Dobinson & Richards 1964) and summer droughts can decrease nesting productivity (Vinicombe 1982).

4.2 Mute Swan *Cygnus olor*

Mute Swans are familiar and widespread nesting birds along lowland waterways. The WBS has measured breeding territories, taking no account of the changes in size of non-breeding groups. The species increased in the Severn-Trent region, to the same extent overall during 1989-93 as elsewhere in the UK.

The swan population of parts of southern and central England, including within the Severn-Trent region the Warwickshire Avon and the Trent, fell substantially during the 1970s and early 1980s (Ogilvie 1981, 1986), due largely to lethal and sublethal poisoning following ingestion of lead fishing weights (Goode 1981). Lead was banned for fishing weights in 1987, and since then populations in the affected areas have begun to recover (Delany *et al.* 1992). The overall WBS index, reflecting the territorial section of the population, has varied rather little, but was higher than previously recorded in 1992-93 (Marchant & Balmer 1994*a*).

4.3 Mallard *Anas platyrhynchos*

This duck is by far the most abundant of the species monitored by the WBS. It can be found on almost any waterway or water-body, even where disturbance is high.

Mallards increased at a similar rate both in the Severn-Trent region and elsewhere, but a peak was evident in 1990 only within the Severn-Trent region. Two of the year-to-year increases, in 1989-90 and in 1992-93, were statistically significant. The year totals in Table 4 indicate that this was by far the most numerous of the species covered by the WBS in the Severn-Trent region.

Marchant & Balmer 1994*a* (1994) reported that there had been a steady increase in Mallards throughout the twenty years of operation of the WBS, and that numbers along waterways had doubled since 1974. An earlier increase on farmland CBC plots had levelled off by the mid 1970s (Marchant *et al.* 1990). The cause of this upward trend is unknown. Annual autumn release of large numbers by shooting interests may however be an important factor (Marchant *et al.* 1990).

4.4 Tufted Duck *Aythya fuligula*

Tufted Ducks nest beside secluded still or slow-flowing waters. Rivers and canals are often used as corridors to lead ducklings to greater safety on larger waters.

Tufted Duck population changes inside and outside the Severn-Trent region were similar in 1990-91 and 1991-92. In 1989-90, there was a large increase in the Severn-Trent region and a decrease elsewhere, and in 1992-93 there was a substantial and statistically significant decrease in the Severn-Trent region and an increase elsewhere, These two regional differences had opposing effects on the comparison of population indices over the five-year period as a whole: little difference could be detected between the Severn-Trent region and elsewhere in the overall five-year trend.

The apparent differences in year-to-year changes should be interpreted in the light of the generally wide confidence limits for this species (Table 4). Sample sizes of plots and territories were very small for this species within the region and, in any case, the assessment of numbers of "territories" for duck species maps is typically the hardest task of the WBS analyst (Marchant 1994). Despite wide confidence intervals, changes in 1990-91 and 1992-93 were statistically significant.

The WBS has maintained a national index for Tufted Ducks since 1976. There have been fluctuations along waterways but no long-term trend (Marchant & Balmer 1994*a*). However, the population has increased greatly during this century, with the proliferation of new lakes and gravel-pits and the increase and spread of the zebra mussel *Dreissena polymorpha* which is an important food item (Gibbons *et al.* 1993). The overall increase in Tufted Ducks may still be continuing (Marchant *et al.* 1990).

4.5 Moorhen *Gallinula chloropus*

This is the second most abundant species covered by the WBS, breeding at highest density by slow-flowing rivers and canals. It also occurs widely on standing waters, including small farm ponds. Nests may be placed either in emergent vegetation, where present, or in adjacent bushes.

Moorhen population changes were rather small in every year during 1989-93, but remarkably similar in the Severn-Trent region to those recorded elsewhere. The increase between 1991 and 1992 was statistically significant.

During 1974-93, the population has been remarkably stable, despite local losses attributed by some observers to the arrival of mink *Mustela vison* (Marchant & Balmer 1994*a*). River management operations have brought about decreases on some WBS plots (Taylor 1984), although in some cases Moorhens may remain on a managed waterway as non-breeders

(Campbell 1988). Small troughs in the trend are evident on both WBS and CBC plots following severe winter weather (Marchant *et al.* 1990).

4.6 Coot *Fulica atra*

Coots occur mainly on larger standing waters, but can breed on slow-flowing rivers and canals that offer sufficient emergent vegetation to support the nest.

There was virtually no change in population levels of this species between 1989 and 1993, either inside or outside the Severn-Trent region.

In the longer term, WBS data show a doubling of Coot numbers since the mid 1970s, but this increase has levelled off during the 1990s (Marchant & Balmer 1994*a*). It is not clear, however, whether the WBS data are representative of the population as a whole, which breeds mostly on bodies of standing water rather than on rivers and canals.

4.7 Oystercatcher *Haematopus ostralegus*, Lapwing *Vanellus vanellus*, Curlew *Numenius arquata*, Redshank *Tringa totanus* and Common Sandpiper *Actitis hypoleucos*

These are the five wader species whose populations are indexed nationally by the WBS. The first four nest in the wetland and alluvial farmland habitats found in some river valleys, and also breed in other habitats not associated with waterways. Common Sandpiper is a waterside specialist, nesting mostly by upland rivers.

Surveys in the Severn-Trent region held too few wader territories for indices to be calculated for any species. For Lapwing and Redshank, the lack of data from the Severn-Trent region probably reflects the severe decreases that have occurred in these species in lowland England in recent decades (Smith 1983, Gibbons *et al.* 1993). The few counts that were available for these species showed decreasing trends in numbers both of occupied plots and of territories (Table 4). The decreases are attributable to the loss of damp waterside habitats through drainage and reclamation and, in the case of Lapwing, to management practices on adjacent farmland.

The Severn-Trent region is marginal to the breeding ranges of the remaining three species, which are generally more northerly in their distributions in Britain. Curlews and Common Sandpipers are associated predominantly with upland habitats, while Oystercatchers in central and southern England are largely coastal breeders.

4.8 Kingfisher *Alcedo atthis*

Kingfishers nest where there are secluded vertical banks or overhangs in which they can excavate their nesting burrow. They feed by plunge-diving for fish, typically from a branch over relatively still water. Kingfishers occupy a high level in the waterway food-chain and are restricted to waterways and nearby standing waters when breeding: they are therefore important indicator species of the health of waterway ecosystems.

Kingfisher numbers increased from 9 to 14 territories on five WBS plots in the Severn-Trent region between 1989 and 1990, while decreasing overall on plots elsewhere. In 1992-93, there was stability on 16 plots in the Severn-Trent region but a strong increase elsewhere. Overall for the five years, there was an increasing trend in the Severn-Trent region and a shallow decrease

elsewhere. Discrepancies between the trends for the Severn-Trent region and elsewhere are likely to be at least partly the results of small sample sizes of both plots and territories. Kingfisher, Tufted Duck and Yellow Wagtail were the species with the smallest numbers of territories available for calculating percentage changes.

The long-term trend shows little evidence of overall change, but strong fluctuations in response to severe winter weather (Marchant & Balmer 1994*a*). The decreases both inside and outside the Severn-Trent region in 1991 followed a cold spell in February of that year. A partial recovery was recorded in both regions in 1992.

4.9 Yellow Wagtail *Motacilla flava*

Yellow Wagtails feed less by waterways themselves than do the other two species of British-breeding wagtails, but nest in wetlands and farmland adjacent to slow-flowing rivers and canals.

The overall trend during 1989-93 both inside and outside the Severn-Trent region has been a strong decrease. In the Severn-Trent region, counts were numerically small but indicated a massive 59% decrease in just these five years: one of the decreases was statistically significant. The number of occupied plots has not increased, despite the overall increase in the number of surveys. Decrease at such a rapid rate in the Severn-Trent region is of particular conservation concern because the region covers much of the area of Britain in which Yellow Wagtails were present during 1988-91 at highest density (Gibbons *et al.* 1993). Furthermore, the British population (*M. f. flavissima*) is distinct and therefore potentially of global significance.

Marchant & Balmer (1994*a*) drew attention to this as the only species monitored by the WBS that had shown a steady decrease during the twenty-year period 1974-93. On CBC plots, numbers gave no cause for concern before 1991, but decreased very sharply during 1991-93 (Marchant *et al.* 1990, Marchant & Balmer 1994*b*). The species winters in parts of West Africa affected by the series of droughts that began in 1968. However, unlike Whitethroat, the species has apparently not been able to benefit from the trend towards stronger West African rains since 1984. The reasons for its decrease are not known.

4.10 Grey Wagtail *Motacilla cinerea*

Grey Wagtails both feed and nest by fast-flowing water. Slower waters are also occupied, particularly where there are weirs, riffles or lock-gates. They feed extensively on emerging aquatic insects. Because they are highly dependent on waterways, the species is an important indicator of ecological quality.

Population changes inside and outside the Severn-Trent region were almost identical, except in 1991-92 when an increase was recorded in the Severn-Trent region and a small decrease elsewhere. Decreases in both regions in 1991 followed unusually cold weather, to which the species is known to be susceptible (Lack 1986). In the Severn-Trent region, this was followed by a strong and statistically significant recovery. It is not clear why a difference should be apparent between the Severn-Trent region and elsewhere in that year. A possible explanation could be that waterways within the region represent unusually good Grey Wagtail habitat.

No long-term trend of Grey Wagtail numbers has been noticeable during 1974-93, but there have been sharp decreases and phases of recovery following severe winters (Marchant & Balmer

1994*a*). Despite both Grey and Pied Wagtails being partially migratory, with many individuals from Britain wintering in France and Iberia, winter weather appears to be the major influence on their population levels (Marchant *et al.* 1990).

4.11 Pied Wagtail *Motacilla alba*

Pied Wagtails are widespread in small numbers along rivers and canals and also breed in other habitats, such as farmland, where buildings or stone walls offer safe nesting sites. Many Pied Wagtails recorded on WBS plots feed extensively in adjacent farmland habitats.

The graph shows a similar dip and recovery in numbers of Pied Wagtails between 1989 and 1993, both inside and outside the Severn-Trent region. The low point, however, was in 1992 in the Severn-Trent region and 1991 in other regions combined. A shallow drop in numbers in 1991, evident nationally and in both subsamples, was probably the result of severe weather in February 1991. Apparently, recovery from the losses in 1991 was delayed by a year in the Severn-Trent region. It is not clear why this should have been the case, and the delay is surprising in view of the strong 1992 upturn of Grey Wagtails.

The trend during 1974-93 has been of fluctuations following severe winter weather. There were many similarities between Pied and Grey Wagtails in the direction of changes between years, but the amplitude of fluctuations has been much smaller in the case of Pied Wagtail (Marchant & Balmer 1994*a*).

4.12 Dipper *Cinclus cinclus*

Dippers are arguably the most important avian indicators of the health of waterway ecosystems, because they are largely sedentary birds that use waterway habitats almost exclusively throughout the year. They feed on aquatic invertebrates at the water surface and also, uniquely for a passerine bird, by diving to the river-bed.

A shallow decrease has been evident, as much in the Severn-Trent region as elsewhere, during 1989-93. The decrease in the Severn-Trent region between 1989 and 1990 was statistically significant.

In the long term, the national WBS index has been relatively stable, but with highest numbers during the late 1980s (Marchant & Balmer 1994*a*). The effects of winter weather on the population appear to be relatively minor. Pollution and stream acidity are known to be major influences on the densities of the large aquatic invertebrates, particularly mayfly nymphs and caddis larvae, on which Dippers feed. The mechanisms by which increasing stream acidity may reduce Dipper breeding densities have been reviewed by Tyler & Ormerod (1992). The disappearance or decline of Dippers on some streams since 1968-72 may be due to the acidification which follows the planting of catchments with conifers (Ormerod & Tyler 1987, Gibbons *et al.* 1993).

4.13 Sedge Warbler *Acrocephalus schoenobaenus*

Sedge Warblers hold small breeding territories among reedbeds and bushes, rarely far from water. Some slow-flowing rivers and canals provide habitat for scattered pairs or small breeding colonies. The species winters in the West African wetlands lying just south of the Sahara.

While Sedge Warblers were almost stable in the Severn-Trent region, the trend for plots outside the region was downward. The observed pattern may be due to chance effects, given that the difference in 1989-90 percentage change between the Severn-Trent region and elsewhere falls well short of statistical significance, or to local effects of changing habitat quality.

Overwinter survival of Sedge Warblers is known to be strongly dependent on the rainfall on the wintering grounds in the months before the birds arrive there (Peach *et al.* 1991). Trends in indices for this species from both WBS and CBC since 1968 have been related closely to rainfall amounts in the western Sahel (Marchant *et al.* 1990). Given that the major influence in numbers is on the wintering grounds, regional differences in trends within Britain would not be expected.

4.14 Whitethroat *Sylvia communis*

Whitethroat is not a species with any particular association with waterways, but is frequently present in adjacent bushy or scrubby habitats: it is included in WBS because CBC results had shown its population changes to be of special interest. The species winters in West Africa south of the Sahara.

Whitethroat showed a series of sharp population changes during 1989-93 which were very similar in both direction and magnitude in the regions investigated. There were three year-to-year increases, a decrease between 1990 and 1991, and overall a substantial increase. Within the Severn-Trent region, however, none of the changes was statistically significant.

The pattern of year-to-year changes in the national index was like that shown by Sedge Warbler, but with a lower amplitude of change and an underlying increase rather than decrease. Population changes of both species are known to be strongly influenced by rainfall conditions in West Africa (Marchant *et al.* 1990). The long-term national WBS indices for these two species were strikingly similar from 1974 to the mid 1980s but since then Whitethroat alone has increased (Marchant & Balmer 1994*a*). It is not known why a difference in trends has now begun to emerge.

4.15 Reed Bunting *Emberiza schoeniclus*

Reed Buntings are associated particularly with beds of reeds and sedges alongside standing or slow-flowing waters, but also nest in drier habitats, especially on farmland.

Changes in Reed Bunting numbers between 1989 and 1993 were relatively small both inside and outside the Severn-Trent region, and the overall five-year trend was almost stable. Year-to-year changes differed only in 1989-90, when an increase was estimated in the Severn-Trent region and a small decrease elsewhere.

The WBS index showed a strong decrease amounting to about 50% from the late 1970s to early 1980s but stability or a very shallow upward trend has been evident since 1983 (Marchant & Balmer 1994*a*). A similar phase of decrease was also evident on CBC plots (Marchant *et al.* 1990). This decrease has been attributed to changes in farmland management which have reduced the availability of seeds for a range of seed-eating birds (O'Connor & Shrubb 1986, Gibbons *et al.* 1993, Marchant & Gregory in press).

4.16 Trends among waterside birds in Severn-Trent and other NRA regions

There was considerable correspondence between the trends in the Severn-Trent region during 1989-93 and those recorded on WBS plots elsewhere (Figure 2). For several species, most notably Moorhen and Whitethroat, year-to-year fluctuations have been similar as well as the overall five-year trend. The widest discrepancies have been in Tufted Duck, Kingfisher, Grey Wagtail and Sedge Warbler: in Grey Wagtail and Sedge Warbler, however, the divergence between the trend lines was the result of a difference in percentage change estimates for just one year. For Tufted Duck, differences in two years had opposing effects, so that the five-year trend was quite similar (1993 index was 40% greater than 1989 in the Severn-Trent region, 21% greater elsewhere).

Close congruity of trend lines derived from independent parts of the sample suggests, first, that there is a tendency for trends to be similar across the country and, second, that the accuracy of estimation of percentage changes by the WBS is high enough to give confidence in the trends that are detected by the scheme, even where (as for regional subsamples) the number of survey plots is relatively small.

On the basis of the results obtained for the Severn-Trent region and of the sample sizes for other NRA regions as tabulated in Table 1, it should also be possible to build meaningful WBS population indices individually for the Northumbria & Yorkshire, North West and Thames NRA regions. Since plot samples are smaller in these regions than in the Severn-Trent region, the number of species that could be included in such indices would necessarily be fewer. For other NRA regions, indices could be compiled on the basis of combining data for adjacent regions.

The use of a longer time-period than in the present study would increase the possibilities of detecting differences in trends between regions.

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Table 1.Numbers of Waterways Bird Survey plots in NRA regions, and elsewhere in Britain and Ireland, during 1989-1993 and in total.

Region	1989	1990	1991	1992	1993	1974-93
Anglian	6	6	11	11	12	39
Northumbria & Yorkshire	13	13	21	21	17	49
North West	16	19	20	20	19	58
Severn-Trent	20	23	31	33	33	76
Southern	5	4	7	7	6	20
South Western	8	8	9	7	10	40
Thames	14	13	13	14	15	66
Welsh	7	5	5	5	6	23
Scotland	8	7	12	15	15	42
Northern Ireland	4	3	2	1	1	17
Irish Republic	.	.	.	.	.	3
Isle of Man	.	.	.	.	.	3
Total	101	101	131	134	134	436

Table 2.Details of the WBS plots in the NRA Severn-Trent region that were surveyed during 1989-1993. Plot lengths are in kilometres and altitudes in metres above sea-level. Habitat codes are: S slow river, F fast river, C canal and M mixed river and canal.

Code	Hab	Altitude Up	Dn	Observer	Waterway	Grid reference Up	Down	Length	Years 89-93
397	S	45	43	Eccles, H.W.	Avon	SP275622	SP256607	3.1	··___
275	S	31	29	Hildred, D.W.	Avon	SP143521	SP117515	3.4	·____
409	S	24	23	James, J.F.	Avon	SP096515	SP069485	4.6	···__
234	C	91	70	Harrison, M.	Birmingham & Fazeley C.	SP186938	SP202988	5.1	_____
253	C	30	20	Vickers, M.B.	Chesterfield Canal	SK596791	SK695815	14.0	__·_·
407	S	145	135	Armstrong, J.S.	Clun	SO361805	SO394803	5.8	··___
064	C	9	9	Garner, K.	Coombe Hill Canal	SO886272	SO849265	4.3	____·
094	F	152	145	Wooddisse, J.S.	Derwent	SK205834	SK234806	4.8	_____
104	F	146	126	Archer, M.G.	Derwent	SK234804	SK244761	5.9	_____
102	S	125	121	Deighton, A.	Derwent	SK244761	SK248727	3.6	_____
100	S	118	104	Rotherham, I.D.	Derwent	SK252723	SK260685	4.4	____·
306	F	200	170	Barber, J.	Dove	SK129587	SK148551	5.5	_____
404	F	40	27	Harrison, M.	Dowles Brook	SO743762	SO779764	4.4	··___
345	C	46	30	Stratford, J.C.	Droitwich Canal	SO888630	SO860600	4.0	__···
180	S	80	72	Burgess, N.	Eye	SK802187	SK772192	6.0	_____
432	C	10	10	Lodge, A.	Gloucester & Sharpness C.	SO746085	SO737050	3.7	····_
377	C	110	110	Roberts, D.J.	Grand Union Canal	SP138821	SP181804	4.6	··___
346	C	46	46	Collins, C.W.	Grantham Canal	SK676307	SK711292	4.9	_____
367	C	30	28	Ellis, B.	Grantham Canal	SK639367	SK608368	3.4	·_·__
382	F	229	152	Brotherton, J.M.	Lathkill	SK171659	SK213655	5.3	··___
098	S	170	144	Hornbuckle, J.	Noe	SK168845	SK205825	5.4	_____
341	C	16	16	Hollands, E.	North Oxford Canal	SP443793	SP481779	3.8	__···
068	S	142	134	Packwood, J.	Severn	SN997852	SO025885	3.3	____·
435	S	60	50	Bird, K.	Severn	SJ456168	SJ463166	5.7	····_
406	S	55	55	Wallace, M.F.	Severn	SJ346162	SJ378152	5.9	··___
292	S	46	46	Wright, C.E.	Severn	SJ541092	SJ562081	5.5	_____
299	S	36	33	Jones, B.A.	Severn	SO710980	SO724944	5.0	_____
429	C	110	100	Davis, E.V.	Shropshire Union Canal	SJ880088	SJ855129	5.6	····_
371	C	108	90	Fox, M.	Shropshire Union Canal	SJ869115	SJ845157	5.0	··___
387	M	49	46	Birstall Birdw. Club	Soar/Grand Union Canal	SK598080	SK604103	3.6	··___
372	S	46	46	Gillham, M.J.	Soar	SK594129	SK586154	3.5	··___
408	S	38	35	Gamble, P.H.	Soar	SK573173	SK555206	4.2	··___
436	M	36	33	Jones, G.H.	Soar/Grand Union Canal	SK528210	SK503236	4.2	····_
374	C	44	44	Jennings, B.	Staffs & Worcs Canal	SO853825	SO842804	3.2	··___
334	C	74	72	Kirkby, J.P.	Staffs & Worcs Canal	SJ973214	SJ995226	3.3	_____
386	S	70	70	Greenhill, I.R.	Tame	SP215943	SP209971	4.5	··___
276	S	73	64	Thomas, G.	Tern	SJ666329	SJ628314	7.5	___··
356	S	40	40	Derbyshire Orn. Soc.	Trent	SK343273	SK369287	4.5	___··
411	S	28	26	Marks, P.	Trent	SK506316	SK525341	4.9	···__

342	S	15	15	Sorrell, R.L.	Trent	SK769522	SK784531	4.0	_____
097	F	228	152	Clifton, J.	Wye	SK159730	SK172706	5.5	·____

Table 3.Numbers and lengths of WBS plots providing paired counts for calculation of percentage changes between 1989 and 1993.

Years	NRA Severn-Trent region		elsewhere in United Kingdom		all United Kingdom	
	Number of plots	Total kilometres	Number of plots	Total kilometres	Number of plots	Total kilometres
1989-90	14	68.6	59	271.6	73	340.2
1990-91	14	63.9	58	277.3	72	341.2
1991-92	22	101.4	76	354.9	98	456.3
1992-93	25	116.8	77	347.8	102	464.6

Table 4.Population changes recorded for waterways birds in the Severn-Trent region, with comparative data drawn from the United Kingdom as a whole.

Species	Year (year 2)	No. of plots	Year 1 total	Year 2 total	% change	Lower 95% c.l.	Upper 95% c.l.	% change elsewhere	Severn-Trent index	National index
Little Grebe	89								100	100
	90	4	12	16	+33	-56	+238	+13	133	119
	91	3	16	12	-25*	-54	-14	+5	100	109
	92	7	29	29	0	-35	+30	-16	100	100
	93	7	29	22	**-24***	-63	-7	-7	76	84
Mute Swan	89								100	100
	90	6	10	9	-10	-52	+152	+20	90	114
	91	7	9	10	+11	-32	+115	-4	100	113
	92	9	16	19	+19	-6	+67	**+37***	119	150
	93	12	22	28	+27	-15	+78	-4	151	153
Mallard	89								100	100
	90	14	160	249	**+56***	+19	+107	**+12***	156	118
	91	14	246	205	-17	-33	0	+10	130	124
	92	21	250	259	+4	-14	+23	**+6***	134	131
	93	25	336	399	**+19***	+2	+39	+7	160	143
Tufted Duck	89								100	100
	90	4	7	10	+43	-38	+355	-17	143	92
	91	6	11	20	+82*	+10	+217	+26	260	127
	92	8	12	11	-8	-33	+69	0	238	126
	93	12	29	17	**-41***	-61	-22	+10	140	121
Moorhen	89								100	100
	90	14	149	170	+14	-7	+38	**+10***	114	111
	91	13	116	104	-10	-26	+5	**-11***	102	98
	92	20	193	243	**+26***	+13	+44	**+11***	129	113
	93	25	284	251	-12	-27	+1	-2	114	108
Coot	89								100	100
	90	7	38	38	0			**+13***	100	111
	91	7	44	46	+5	-14	+138	0	105	112
	92	13	96	101	+5	-36	+47	-2	110	111
	93	14	137	132	-4	-38	+30	-2	106	108
Oystercatcher	89									100
	90	0	0	0				-6		94
	91	0	0	0				-1		93
	92	0	0	0				+2		95
	93	1	0	1				0		95
Lapwing	89									100
	90	6	9	8	-11	-159	+118	+6		105
	91	5	12	14	+17	-55	+1331	-2		104
	92	4	10	8	-20			**-14***		89
	93	2	5	5	0			-1		89

Curlew	89									100
	90	1	4	3	-25			-10		89
	91	2	3	6	+100			-2		93
	92	4	6	6	0			+10		101
	93	4	3	6	+100			-2		104

Table 4 (continued)

Species	Year (year 2)	No. of plots	Year 1 total	Year 2 total	% change	Lower 95% c.l.	Upper 95% c.l.	% change elsewhere	Severn-Trent index	National index
Redshank	89									100
	90	2	4	0				+6		101
	91	1	0	1				-9		93
	92	1	1	0				**-16***		77
	93	1	0	1				+2		79
Common Sandpiper	89									100
	90	3	3	3				+6		106
	91	4	7	8				**-13***		94
	92	4	10	4				-12		80
	93	1	0	1				+5		84
Kingfisher	89								100	100
	90	5	9	14	+56	-40	+167	-15	156	100
	91	5	9	7	-22	-66	+4	**-39***	121	64
	92	9	12	13	+8	-33	+168	+14	131	72
	93	16	17	17	0	-35	+55	**+37***	131	90
Yellow Wagtail	89								100	100
	90	6	14	16	+14	-25	+96	+17	114	116
	91	4	12	9	-25*	-76	-6	**-31***	86	82
	92	4	10	6	-40	-58	+470	+4	51	75
	93	6	10	8	-20	-55	+125	-19	41	61
Grey Wagtail	89								100	100
	90	7	19	23	+21	-21	+90	+12	121	113
	91	5	16	11	-31	-58	+3	**-31***	83	78
	92	11	23	32	**+39***	+13	+88	-14	116	73
	93	11	28	32	+14	-12	+39	**+17***	132	85
Pied Wagtail	89								100	100
	90	8	21	17	-19	-51	+24	-4	81	94
	91	8	23	22	-4	-58	+117	**-13***	77	83
	92	12	16	15	-6	-58	+74	**+21***	73	98
	93	12	11	16	+45	-7	+227	+3	106	103
Dipper	89								100	100
	90	6	21	17	-19*	-42	-7	-5	81	92
	91	5	13	13	0	-18	+40	-8	81	86
	92	9	33	33	0	-22	+20	-7	81	82
	93	7	28	26	-7	-22	+8	+6	75	84
Sedge Warbler	89								100	100
	90	6	78	90	+15	-16	+50	**-14***	115	92
	91	7	68	65	-4	-25	+30	**-27***	110	71
	92	9	78	78	0	-18	+16	+12	110	78
	93	14	123	114	-7	-19	+11	-10	102	70

Whitethroat	89								100	100
	90	8	30	35	+17	-11	+55	+9	116	111
	91	8	33	23	-30	-62	+64	-22	81	84
	92	12	33	45	+36	-24	+85	**+63***	111	129
	93	17	45	50	+11	-17	+67	**+39***	123	170
Reed Bunting	89								100	100
	90	7	53	64	+21	-25	+34	-6	121	101
	91	9	37	42	+14	-27	+96	+7	137	109
	92	11	76	68	-11	-31	+13	-1	123	105
	93	14	94	95	+1	-16	+30	+10	124	112

Figure 1.Distribution of plots used to calculate Waterways Bird Survey population indices between 1989 and 1993, and regional divisions of the National Rivers Authority. Symbols used are: open circles - fast rivers; filled circles - slow rivers; squares - canals; and stars - mixed river/canal plots.

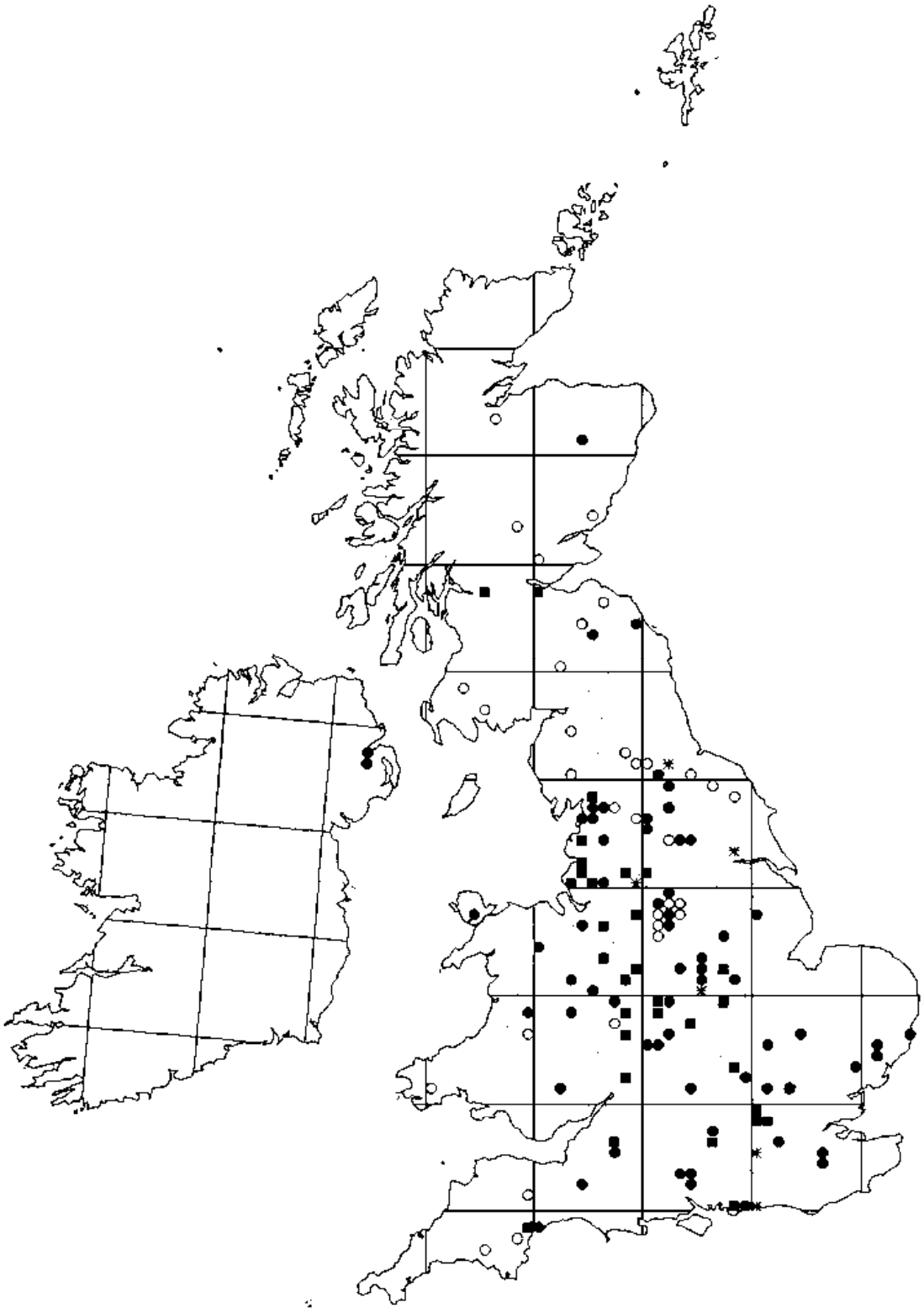

Figure 2.Graphs of WBS population index against year, for the fourteen species for which a Severn-Trent index could be compiled, for the period 1989-1993. The overall national index is indicated by a dotted line, and two components of this are shown separately: the Severn-Trent index by a solid line, and an index compiled from plots elsewhere in the UK by a dashed line.

Figure 2 (continued).Graphs of WBS population index against year for the period 1989-1993. The overall national index is indicated by a dotted line, and two components of this are shown separately: the Severn-Trent index by a solid line, and an index compiled from plots elsewhere in the UK by a dashed line.

Figure 2 (continued).Graphs of WBS population index against year for the period 1989-1993. The overall national index is indicated by a dotted line, and two components of this are shown separately: the Severn-Trent index by a solid line, and an index compiled from plots elsewhere in the UK by a dashed line.

Figure 2 (continued).Graphs of WBS population index against year for the period 1989-1993. The overall national index is indicated by a dotted line, and two components of this are shown separately: the Severn-Trent index by a solid line, and an index compiled from plots elsewhere in the UK by a dashed line.