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Measuring population changes from the Breeding Bird Survey

Authors

R.H. Field & R.D. Gregory

January 1999

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EXECUTIVE SUMMARY

1. The BTO/JNCC/RSPB Breeding Bird Survey (BBS) involves volunteers making bird counts in randomly selected Ordnance Survey (OS) 1 km squares using a line transect method. Within each 1 km survey square volunteers are asked to establish two parallel line transects oriented north-south or east-west. The line transects should be 500m apart and 250m from the edge of the square. The 2 km of transect are divided into ten 200m sections. Three visits are made to each transect in a season, the first to record the habitat, and then early and late season visits to record the number and species of birds present. This report uses data collected between 1994 and 1997.

2. BBS primarily monitors temporal changes in British breeding bird populations by calculation of annual population indices. It is essential that these indices reflect the real populations from which the data are collected. Here we assess the statistical models used to calculate these indices and the influence of environmental variables, timing of sampling visits and occurrence of flocks and passage birds upon them.

3. The timing of early and late visits to BBS squares was very consistent between years, with a slight tendency to a wider spread of dates in 1997. Early counts tended to sample residents and early migrants whilst late counts sampled summer migrants. Therefore, the plasticity of visit timing within local BBS schemes appears to be sufficient to allow good sampling of common breeders. These results justify the use of maximum counts for the calculation of indices.

4. Correlations of species counts with weather conditions were highly variable and often appeared contradictory. Recalculation of indices after removal of counts made under non-ideal, but acceptable, weather conditions was felt to be unreliable. BBS will probably benefit more from the rigid adherence to not counting in adverse weather conditions. The influence of weather appears to vary between species and more detailed analyses incorporating year and site effects would be beneficial once more data are available.

5. Removal of flocks of greater than ten birds per 200m section produced reliable revised indices for the seven commonest wader species. That for Golden Plover also incorporated the removal of birds on non-upland (by ITE land classification) squares. Wildfowl indices were recalculated after flock removal but these generally showed little improvement in standard errors and are probably no more reliable than the standard indices. However, some screening for very large counts would seem appropriate. Gull indices were not revised due to the aggregated nature of breeding in these species and the presence of groups of non-breeding birds. The BBS is unlikely to be the best source of information on population changes for the latter two groups.

6. The standard BBS index model (site x year) was assessed in relation to a linear trend (site x year count) index model. Both indicated broadly similar population changes over the first four years of BBS data. The linear trend model may

become more reliable when more years' data are included in index calculations. The use of different models largely depends upon what is being assessed. If it is the overall trend that is of interest, a linear trend, or more appropriately a non-linear trend, model should be adopted, although we need many more years of data before this would be useful. BBS coverage of the commoner species is adequate to produce reliable estimates of population changes, but coverage should be increased further, or targeted towards less frequent species to enhance their monitoring.

1.1 INTRODUCTION

The Breeding Bird Survey (BBS) began in 1994, and will eventually take over the role of the Common Birds Census (CBC) as the main census tool monitoring populations of common British birds. The BBS aims to cover a wide range of regions and habitats, therefore maximising the number of species monitored.

The BBS, supported by the BTO, JNCC and RSPB, is based on surveys of randomly selected 1 km squares of the Ordnance Survey (OS) national grid, by a largely volunteer field workforce. A stratified random sampling regime is employed to select squares to be surveyed in each of 83 regions. In all a total of 1569 squares were surveyed in 1994, reporting data on 192 species, rising to 2173 squares and 209 species in 1997 (Field & Gregory, 1998; Gregory *et al.*, 1998).

The primary purpose of the BBS is to monitor temporal changes in British breeding bird populations by the calculation of annually updated population indices from the data collected each year. Therefore it is essential that these indices reflect the situation in the real bird populations being sampled as accurately and precisely as possible. The latter is ensured by the survey design, whilst the former is influenced by the design and the analyses that produce the indices. To this end, we have examined the accuracy and fits of the statistical models that produce population indices, the influence of environmental variables, the timing of sampling visits and the occurrence of flocks and passage birds upon the indices.

1.2 Aims

1. To assess the influence of visit timing on BBS indices;

2. To assess the influence of weather conditions in different years on BBS indices;

3. To assess the influence of large flocks and passage birds on BBS indices;

4. To explore the accuracy and precision of change measures within BBS;

5. To assess model fits and simple variants of BBS indices.

2. METHODS

2.1 Field Data Collection

Each observer is allocated one or more 1 km Ordnance Survey (OS) grid squares within which both habitat and bird numbers are to be sampled. This is done by means of two 1 km parallel transect lines, evenly spaced across each square, running either north-south or east-west. Ideally, transect routes should be 500m apart and 250m from the edge of the square, divided into ten 200m sections within which bird numbers and a variety of habitat and weather variables are recorded (Appendix 1 - BBS Instructions 1998). In practice, however, ideal routes are rarely possible and the transects covered are usually the best available compromise. After an initial 'setup' visit, two bird recording visits are made to each square (early and late season visits), at least four weeks apart, with early visits made in April to mid-May and late visits made in mid-May to late June, dependent on local bird activity, altitude and latitude. Counts are made in the morning, and only in relatively fair weather conditions (not in heavy rain, poor visibility or strong wind), ambient weather conditions are recorded for each transect visit according to the scheme given in Appendix 2 (BBS Instructions 1998). Bird numbers and species seen or heard are recorded in each 200m section in one of four distance categories (three on the ground and flying birds, (Appendix 1 - BBS Instructions 1998).

2.2 Timing of visits: Year-to-year variations and species count variations

The sampling regime of the BBS requires that observers make two bird recording visits to each OS square after an initial planning and habitat recording visit. These visits are approximately timed to ensure sampling of both early and late breeding species, but the voluntary nature of the fieldwork force and the geographical spread of the survey inevitably mean that timings of first and second ('early' and 'late') visits are somewhat variable. Consequently it is of some importance to know the degree to which the timings of the two visits to each square vary from year to year, and also which species show variation in the numbers counted at each visit.

Median times (in days from the beginning of the year) were calculated for early and late visits for each of the four years of the BBS, along with five and ninety-five percentiles. The difference between these percentiles gives the number of days during which 90% of visits were made. Mean counts for each of the 100 commonest BBS species in the 1997 survey were calculated for each square, for early and late visits separately in each year. Within each square and species, counts for the four distance categories were summed, giving one count for each species, per square, visit and year. Mean counts by species for early and late visits were compared square-wise by paired t-test. Those species showing significant differences in mean visit counts between early and late visits in two or more years were regarded as showing a seasonal tendency.

2.3 Influence of weather conditions on bird counts and indices

BBS fieldworkers are instructed to 'not attempt to census birds in conditions of heavy rain, poor visibility or strong wind' (BBS Instructions, 1998). However, surveys are, by necessity, conducted in a variety of weather conditions, which recorders report on the BBS summary sheet of each visit. Four weather variables, Rain, Wind, Visibility and Cloud (cover) are reported, each being divided into three degrees of severity (see above). It is well known that birds' activity, and the ability of observers to detect birds, vary with ambient weather conditions and differ between species (Bibby *et al.*, 1992). It is therefore useful to know which species within the BBS are so affected and to what degree.

Counts made of the 100 commonest BBS species (in 1997, summed for the four distance categories) during the early and late visits under the three different condition categories of each weather variable were compared by Poisson regression for each of the four years of BBS data. For each species where significant differences in counts were found, this produced up to two (early and late) significant correlations per year, with a sign of correlation (positive or negative) for each weather variable. These were summarised for the four survey years and those species found to show significant correlations with a variable with the same sign in two or more years were taken to exhibit a significant tendency with respect to that variable. The significance level was taken as 5% throughout this report.

Since the counts of some species are likely to vary with changing weather conditions, it is reasonable to assume that counts of these species made in years of differing prevailing weather conditions may also vary. Therefore, indices based on such counts may be influenced by prevailing conditions either in a random way or directionally if weather conditions change systematically. To assess the possibility of weather influences on BBS indices, these were recalculated using the standard indexing procedure, but only using counts made in Wind, Visibility and Cloud category 1 & 2 conditions, and rain category 1 conditions (2, drizzle and 3, showers are not strictly gradations on the same scale and so only 1, not raining was used in this case; see Appendix 2). These revised indices were then compared with the standard figures and with the results of the weather variable correlations described above.

2.4 Influence of large flocks and passage birds on non-passerine indices

Examination of the frequency distributions of 200m transect section counts of certain species (waders, wildfowl and gulls) has suggested that small numbers of relatively large counts may be having an undue influence on population indices of some species. Therefore the possibility of the removal of large flocks from index calculations was investigated for the three broad groupings of species and the viability of the revised indices assessed.

2.5 Assessment of the accuracy and precision of the BBS indexing models used to calculate population changes

The standard indices of population change for the BBS are assessed using a loglinear model with Poisson error terms (ter Braak *et al.*, 1994). The higher count from the early or late visit for each species on each square is taken as the best estimate of the abundance of that species on that square, this is termed the maximum count. Counts are modelled as a function of square and year effects (= site x year model) with counts weighted to account for the under- or over-sampling of BBS (sampling) regions in the UK. Correction for under- or over-dispersion of the count data was also incorporated (using the dscale option in SAS). Any square with two or more annual counts between 1994 and 1997 is included in the analyses. A linear trend version of this model was developed (= site x year count model; where year count is a continuous variable) to describe the overall trend in bird numbers.

Assessment of model fit is not possible because the deviance is scaled by the dispersion factor. It is also difficult to see what could be done if the model fit was poor since there are no sensible alternative models to adopt. We could, in principle, assess the relative fits of the annual and linear models by comparison of their Log likelihoods. In practice, however, this would be a labourious task in the present modelling framework and it is unclear what the test would mean. In fitting and comparing indices in this report it is important to recognise that the time-series is too short to draw definitive conclusions about the most appropriate models and hence the absolute precision of the indices. The analyses set out to explore some of these issues and to come to preliminary conclusions.

The design of BBS field protocols ensures that the data collected by volunteers reflects real bird populations as accurately as possible, but it is also essential that the indexing analyses conducted on these data summarise and reflect them as accurately and precisely as possible. Therefore, the standard BBS indexing model, (based on annual site and year variations) has been compared with the linear trend index (based on a regression model of site and year count, which is much less influenced by an individual year). Standard and linear trend indices for the 1994-1997 population changes were calculated for the 100 commonest BBS species and the changes indicated by each model and their significance and standard errors were then compared. Thereafter, the standard errors of the standard indices were examined to give an indication of the precision of the measurement of population change over 1994 to 1997, since twice the standard error of the change is equal to the minimum significant detectable change. The influence of sample size on the precision of indices was then explored by comparing sample size with the minimum detectable change for the 100 commonest species. To examine the relationship between precision and sample size for individual species, data were extracted, plots sorted randomly and the standard site year model fitted to sequentially larger proportions of the available data until all data were included. This was done for four common and widespread species and for 8 rarer species currently on the edge of being effectively monitored (species occurring on between 50 and 100 squares and monitored at a very imprecise level). We also explore the precision of change measures for species occurring on fewer than 50 squares and not currently routinely indexed. Population changes of

25% and 50% have particular importance since they are frequently used to indicate conservation priorities, although usually over larger time periods (e.g. 25 years) than considered in this report.

3. RESULTS

3.1 Visit timings

3.1.1 Between year variations

Comparison of the median times of early and late visits shows a remarkable consistency between the first four years of the BBS (Figure 3.1.1). There was slightly more variation in the timings of the earliest and latest visits made in each year, with the overall season progressively getting longer between 1994 and 1997 (4/4 to 7/8 - 118 days 1994, to 18/3 to 2/9 - 168 days 1997). However, within these times, the five and 95 percentiles remained remarkably comparable and therefore so did the difference between them - the period during which 90% of visits were made, ranging between 41 and 44 days for early visits and 36 to 43 days for late visits (Table 3.1.1). Noticeable within the visit date frequency distributions in all years is a marked periodicity in visit timing, this being approximately seven days and represents increased observer activity at weekends (Figure 3.1.1).

3.1.2 Bird count variations

The mean counts of each species were compared between the early and late visits for each year by square using paired t-tests (Table 3.1.2). Fifty-two of the 100 commonest species showed no significant differences between early and late counts in any year, whilst of the remaining 48 species, 32 species showed significant seasonal variation in mean counts in at least two years when counts were compared square-wise. Many of the non-significant differences between visits may be explained by the lower abundance of such species, leading to poor statistical power. Thus some species not included in Table 3.1.2 may also exhibit a degree of variation in seasonal abundance, but this was not detected in the tests performed. In all cases except one (that of Lesser Whitethroat in 1994 and 1995) significant trends for any given species were always in the same direction across years. Table 3.1.2 also shows a comparison of timing of peak counts with migratory status and timing of breeding (Snow & Perrins, 1998; Gibbons *et al.*, 1993) for those species which showed significant consistent trends in timing of peak counts. The majority of species exhibiting highest counts at the early visits were sedentary species over-wintering in Britain (15/18 - 83%), whose egg-laying period starts from February to April. Exceptions are Blackcap, Chiffchaff (migrants of which increasing numbers are remaining in Britain throughout the winter) and Willow Warbler (an early returning species) (3/18 - 17%). Those with late visit peak counts showed more variation in movement and laying dates, with seven migratory or partially migratory (47%) and eight sedentary species (53%). This may be in part due to the inclusion of juveniles in late counts of some species e.g. Long-tailed tit, Starling and Wren, all of which winter in Britain. Laying start dates vary from mid-March to late May. Of the 67 remaining species which showed no variation in mean counts with visit timing, 46 (69%) were sedentary and 21 (31%) migratory or partially migratory. These compare with figures of 32% and 68% for migratory and sedentary species in the whole sample of the 100 commonest species in the survey. These correlations have shown the tendency of early visits to sample residents, whilst late counts tend to sample summer migrants. The only migrant species sampled significantly more by early visits are those of which some individuals overwinter in the UK and an early returning migrant.

3.2 Influence of weather conditions

3.2.1 Influence on bird counts

A total of 55 of the 100 commonest BBS species showed consistent significant correlation with one or more environmental variables in at least two years (Table 3.2.1). Twenty-two species showed significant correlations between degree of Rain and mean counts, 16 positive and six negative; seven species correlated significantly with Visibility, five positive and two negative; 25 species correlated significantly with Cloud cover, nine positively and 16 negative and 22 species with Wind strength, 12 positive and ten negative. Within these, some relationships along broad taxonomic lines were apparent. Two closely related warbler species (Chiffchaff & Willow Warbler) showed consistently higher counts in showery weather, as did three finches (Goldfinch, Linnet and Siskin) and three waders (Curlew, Lapwing and Oystercatcher). Two finches (Linnet and Redpoll) and two pigeons (Wood Pigeon and Feral Pigeon) showed higher counts in cloudy weather, whilst five warblers were recorded in lower numbers in cloudy weather (Grasshopper Warbler, Garden Warbler, Lesser Whitethroat, Whitethroat and Wood Warbler). Gulls (Herring Gull and Lesser Black-backed Gull) and corvids (Magpie and Raven) were more in evidence at higher windspeeds, whilst counts of tits (Blue Tit, Coal Tit and Great Tit) and thrushes (Blackbird and Song Thrush) were reduced. These varied and sometimes contradictory correlations show few consistent, predictable trends and are unlikely to offer a route for the improvement of BBS data collection or analyses.

3.2.2 Influence on indices

The indices of 31 species were substantially altered by the removal of counts made in non-ideal but acceptable weather conditions from the models (Table 3.2.2). Given, however, that many species show such varied correlations with weather conditions, and there are marked differences between species in the numbers counted in different conditions, these new indices are probably less reliable than the standard ones.

We can conclude that weather effects vary between species so it may be difficult to come up with general rules for improving index reliability through the exclusion of counts made in particular weather conditions. However, what is of interest are the weather conditions that give us the least variable counts and hence most precise population changes - these may not be the same as the weather that is associated with the highest counts.

3.3 Frequency distributions of counts of non-passerines

Frequency distributions of counts per 200m transect section of the seven most common wader species (Figure 3.3.1) show, with the exception of Common Sandpiper and Snipe, the presence of small numbers of large aggregations of birds. Since large aggregations of these species in relatively small areas are unlikely to be breeding birds, probably being passage birds, pre-breeding flocks or non-breeders, densities of greater than ten birds per

200m section were removed from the models used to calculate population indices (see below). Biologically, it is difficult to envisage of circumstances where wader densities should exceed this level. This has the effect of curtailing the 'stretched' frequency distributions of counts of these species, but the bulk of counts remain (Figure 3.3.1). Counts of greater than five and greater than twenty per 200m transect section were removed from frequency distributions but these were found to be less effective; the loss of greater than five counts significantly truncated the frequency distributions of most species, whilst greater than twenty was considered to leave too many large counts in datasets. The geographical distribution of counts greater than ten are shown in Figure 3.3.2. High counts of Oystercatcher and Lapwing were well dispersed throughout the country, corresponding to the widespread occurrence of these species. Curlew and Redshank exhibited more localised distributions of high counts. The majority of large counts of Curlew were coastal, whilst those of Redshank were exclusively on the east coast. The frequency distribution of Snipe showed only two incidences of more than ten birds occurring in a single transect section in the four years of the survey, and Common Sandpiper none. These birds seldom forming large aggregations at any time of year. These patterns support the view that passage birds occur in certain species and that a simple exclusion rule is able to remove them in an efficient manner.

Counts of Golden Plover were treated separately, because of the discrete, easily identifiable nature of this species' breeding habitat. In addition to large aggregations of Golden Plover (greater than ten per 200m section), all birds counted on non-upland squares were removed. Upland was defined as landclasses 17-24 and 28-32 of the ITE land classification scheme (marginal upland and upland respectively) (Bunce *et al.*, 1993). The majority of large flocks of Golden Plover were counted on non-upland squares and are almost certainly not breeding sites (Figure 3.3.3).

Whilst the frequency distributions of section counts of common wildfowl (six species - Greylag Goose, Canada Goose, Mute Swan, Shelduck, Mallard, Tufted Duck; Figure 3.3.4) and gulls (five species - Black-headed Gull, Common Gull, Lesser Black-backed Gull, Herring Gull, Great Black-backed Gull; Figure 3.3.5) show similar patterns to those of waders, with a long distribution 'tail' of small numbers of high counts, the identities of these counts is less certain. The status of large groups of gulls within BBS counts is difficult to define, since they are generally colonial. Thus such large numbers could be breeding birds near their colony rather than non-breeders or migrants. Similarly, though perhaps to a lesser extent, wildfowl tend to be associated with discrete landscape features (rivers and lakes) and hence aggregated. Therefore the removal of counts of greater than ten birds may well remove significant numbers of breeders from the index calculations. Furthermore, there was no geographical basis for the exclusion of counts, since the majority of these species are widespread and breed in a variety of habitats (Figure 3.3.6 & 7). The incidence of these species tend to concur with the overall distribution of surveyed squares throughout the UK, showing the same concentrations around highly populous areas, in the south-east, south-west and north-west of England, and to a lesser extent the Forth-Clyde Valley in Scotland.

3.3.1 Revised population indices for waders

The population indices for the seven commonest wader species in the first four years of BBS were recalculated after the removal of large single transect section counts of birds (i.e. greater than ten, being pre-breeding or passage flocks; Table 3.3.1). This resulted in significant changes in indices for Oystercatcher and Redshank. Originally, the indices indicated significant declines in the populations of these species, by 42% and 25% respectively. After revision, however, the indices indicated no significant changes in the populations of these birds over the first four years of BBS. Conversely, revised indices for Curlew and Lapwing suggest that these birds have declined significantly by 10.5% and 10.7% respectively between 1994 and 1997, rather than remaining unchanged as previously indicated. Unsurprisingly, the indices for Common Sandpiper and Snipe remain unchanged, since there were few (if any) large counts of these species.

In the case of Golden Plover, three revised indices were calculated after removal of 1) counts of aggregations of greater than ten birds per transect section; 2) incidences of Golden Plover in non-upland squares; and 3) counts of greater than ten birds per section and non-upland incidences of Golden Plover. All three revised indices showed no significant changes had occurred in Golden Plover numbers over the four years between 1994 and 1997, in contrast to the original estimate of a 42% decline. These new indices are more precise (exhibiting lower standard errors than the original indices) and we believe they better reflect the breeding populations of the species concerned.

We recommend the removal of flocks of greater than ten birds per transect section from the index calculations of these common wader species in future years, that for Golden Plover also incorporating the removal of birds on non-upland squares.

3.3.2 Revised population indices for wildfowl

The population indices for the six commonest wildfowl species in the first four years of BBS were recalculated after the removal of large single transect section counts of birds (i.e. potentially pre-breeding or passage flocks - Table 3.3.2). Change measures and sometimes their standard errors varied with the particular index chosen. The standard errors on the revised indices were generally similar to those derived from the standard index. The revised indices for Greylag Goose, Mute Swan, Shelduck and Tufted Duck all differ to some degree from the standard index suggesting that flocks may be obscuring the underlying population trends. They remain, however, difficult to interpret for most of the waterfowl. In light of the risk of losing relevant data from the indices of these wildfowl species, and the fact that changes in the revised indices are small, it is recommended that these revised indices not be used for wildfowl, at present and the standard indices be employed with appropriate explanations of the nature of the bird counts. It is conceivable that the removal of very large groups of waterfowl would improve the accuracy of the indices and should be considered in the future.

3.4 Assessment of the accuracy and precision of BBS indices

Comparison of the standard BBS index method (site x year) with the linear trend model (site x year count) (Table 3.4.1, Figure 3.4.1) shows that, for the majority of species, both indices indicate broadly similar population changes over the first four years of BBS. Exceptions, where the linear trend model is considerably different from the annual model, tend to occur when there is a large change in the number of birds counted in a single year e.g. Kestrel and Great Black-backed Gull, which both showed marked declines in 1995. In five species, the linear trend model produced significant change where no significant change was indicated by the standard model (Lapwing, Black-headed Gull, Sand Martin, Chaffinch and Linnet), whilst the reverse was true in two cases (Pied Wagtail and Jay). In all other cases (93 species) the two models were in close agreement, even where the degree of change differed markedly (e.g. Kestrel). The linear trend model is less influenced by particular yearly counts and so will become a more reliable indicator of the overall trend as more years of data are incorporated in BBS indices.

As one would expect, the standard error of the standard BBS indices shows a tendency to decrease with increasing sample size, and therefore so does the minimum detectable population change over the survey period (Table 3.4.2; Figure 3.4.2). Thus the more common a species (and the more detectable it is) the more precise is the estimate of population change. For common and widespread species found annually in 1000 or more squares, such as Blackbird, Woodpigeon, Carrion Crow and Chaffinch, this means changes of around 5% are detectable over the period 1994-1997. Sample size is more important in the case of less common species, particularly those which only occur in 100 or less squares in each year's survey. The rarity of these birds means that standard errors of their indices are relatively large, and so even at present BBS coverage, indices are only capable of detecting a 23% change at best (Red Grouse) and a 49% change at worst (Stonechat; Table 3.4.2). For a total of twenty-five species, we would not be able to detect population changes of less than 25% between 1994 and 1997 (Figure 3.4.2).

As one would predict, the standard error (of the 1994 -1997 change measure) declines with sample size (Figure 3.4.3 and 3.4.4). Furthermore, population changes of less than 10% are detectable for abundant species with sample sizes of around 200 squares (Figure 3.4.3). This implies that population changes among these species were relatively homogeneous over the period under consideration. Calculation of the standard errors of change indices for 8 or the rarer species after resampling show that even a small reduction of sample size (by as little as one or two squares in some cases e.g. Stonechat, Grasshopper Warbler and Crossbill) may result in a significant reduction in the precision of the indices (Figure 3.4.4). This group of rarer birds includes a number that are of particular conservation concern and are not routinely monitored by other schemes. Thus if BBS sampling were to cover fewer squares in future years, even a small decrease in the number of squares reporting these rarer species would further reduce the precision of their indices and they would no longer be monitored adequately.

At the present time, those species occurring on fewer than fifty squares per year are not routinely indexed since change measures for these species are likely to be highly imprecise. To test this assumption in a more rigorous manner we fitted a site x year model to the data for the more abundant rare species (Table 3.4.3). The analyses indicated that our ability to detect population change among these birds was low. In most cases only changes greater than 50% would be detectable. In the case of Pied Flycatcher however, the standard error of the 1994-1997 change measure indicated an ability to detect a 40% change which suggests that this species should be included among those routinely indexed.

4. DISCUSSION

Although the maximum range of visit timings increases across the first four years of BBS, the median timings of both early and late season visits has remained remarkably consistent. This would suggest that yearly variations in weather, in the arrival of first migrants and first nesting attempts are not catered for. However, there is probably sufficient plasticity at a local level for visits to be timed effectively. This was masked in the yearly summaries due to the range in latitude covered by the survey. Analysis of the timing of visits to individual squares across several years, and its variation with latitude would elucidate this point further. The consistency of the correlation of visit timing with the counts of certain species lends further weight to this conclusion. The tendency of early visits to sample residents and late visits summer migrants, together with the similarity of the proportion of migrant species showing no bias toward early or late counts to that in the entire sample of 100 species, add further weight to the assertion that migrants and residents are being sampled equally well by BBS. Variation in the timing of peak counts between species also justifies the use of maximum count from the two visits in the calculation of change indices.

The correlation of species counts with weather variables showed many apparently variable relationships and indicates that they are the result of a combination of factors affecting the counting of birds and bird behaviour. Different weather conditions will variously affect the ability of observers to detect the presence of certain species, and also the activity of those species - their ability to be detected. For instance, songbirds and others most readily detected by sound showed negative correlations with poorer weather conditions, whilst larger birds, particularly gulls and corvids showed positive ones. Smaller birds may be harder to detect in poor weather conditions, but are also less active, whereas larger birds are more detectable in strong winds, being more active and more easily seen. Observers may also more readily detect large birds if fewer small birds are active to hold their attention. However, since these weather variables are not consistently linked (e.g. strong wind does not always entail rain or poor visibility), and species' relationships to them are not consistent, are of unknown reliability. BBS and its indices may therefore benefit more from ensuring that surveys are conducted in as good weather conditions as possible, poor weather years (entailing more sampling in poorer weather conditions) having a lesser influence on indices the longer the survey runs, and the inclusion of weather variables in the site x year index model. This would reduce the chances of weather influences on counts being swamped by inter-site variations and observer related factors. It may also be of interest in the future to examine multi-variate weather effects and combinations of weather factors that may indicate counts affected by adverse weather.

The removal of section counts of greater than ten from the indices calculated for the larger waders (Curlew, Lapwing, Oystercatcher and Redshank) produces acceptable changes in their respective indices, with standard errors reduced or equal to those for the standard indices. Likewise for Snipe and Common Sandpiper, though large counts of these are rare (or absent). Although all three revised indices calculated for Golden Plover produce a broadly similar result, reversing an apparent 42% decline to no significant change, we favour the use of index three, the removal of all counts greater than ten and all counts made on non-upland squares. Index two, birds on upland squares only, should also be considered, since Golden Plover can form sizeable feeding flocks in upland areas during breeding, although the standard error for this index is larger (0.14) than that of index three (0.12). It is a matter of debate as to whether index three is superior to index two, but we suspect the former is a more sensitive measure of the numbers of Golden Plover.

The removal of large counts of gulls appears acceptable from examination of count frequency distributions. However, these birds are all to some extent colony breeders, and breeding birds will form large aggregations, risking the loss of relevant data from indices if large counts are removed. Furthermore, colony counts within BBS and surveys by other organisations provide a more accurate assessment of the populations of gulls than the standard BBS methodology. Therefore, no revised indices have been calculated for these birds, and we recommend publication of the standard indices. Those using this information need to be aware of the nature of BBS counts for these species. Undoubtedly, many of the gulls counted will be non-breeding birds and some are likely to be passage birds breeding further north in Europe.

Similarly, altering the frequency distributions of the six wildfowl species by the removal of large counts appears acceptable, but the revised indices calculated thereafter showed little (if any) improvement in standard errors, although the population trends varied considerably. The one exception to this was the revised index for Greylag Goose, which showed an improvement in the standard error. The revised indices differed for Mute Swan, Shelduck and Tufted Duck. Population trends, however, remain difficult to interpret, and misgivings about the efficacy of this revision suggest the standard index is probably more reliable for all wildfowl species. Some exclusion of very large counts of waterfowl should be considered in more detail in the future. The Wetland Birds Survey (WeBS), specifically designed to sample these species, provides a more accurate monitor of their populations but only in the non-breeding season. The. Again, those using the BBS wildfowl indices need to be made aware of the nature of the counts.

The standard BBS (site x year) and the linear trend indexing models generally indicated very similar temporal changes and the significance of changes for the majority of the 100 commonest species. There are a few exceptions, where a difference in the indicated population change was probably due to the large influence of a single year's data. The linear trend model will probably provide a useful measure in future years, when more data are available and anomalous years' counts (poor breeding years or adverse weather) may have an undue influence on the standard indexing model. The choice of model depends mostly on what is required. If it is the long-term trend that is of interest then a linear model, or a more sophisticated non-linear trend model (e.g. a General Additive Model with smoothing) is preferable. If it is the year-to-year variation that is of interest then the standard site x year model should be used.

Examination of the standard index precision has shown that the data for common and widespread species provides a very precise measure of population change, and that these measures are robust to a large reduction in sample size. This is not so for some of the less common or less widespread species, and if the precision of their indices is to be maintained or increased (the favoured option) the general coverage of BBS should be maintained or increased. This is also true if some of the species which at present receive marginal coverage are to be regularly monitored by indexing as part of BBS.

A key issue is how much we would need to increase sample sizes of the rarer but widespread species, e.g. those in Figure 3.4.3, in order to derive reasonably precise population indices (i.e. measuring changes of 25% or more) and how much we would need to increase the entire BBS sample in order to achieve this. This issue could be explored by extrapolation of the relationships considered in this report and this should be a high priority for future research.

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Table 3.1.1 Timing of early and late season visits to BBS 1 km squares 1994-1997 (90% coverage is the difference between 5+95 percentiles - number of days taken for coverage of 90% of squares to be visited).

	Date of			Median Date		5 Percentile		95 Percentile		90% Coverage Time	
Year	First Visit	Last Visit	No. of days	Early	Late	E	L	E	L	E	L
1994	4/4 (93)	7/8 (211)	118	5/5 (125)	13/6 (164)	105	147	147	183	42	36
1995	26/3 (84)	17/8 (220)	136	4/5 (124)	15/6 (166)	103	145	144	184	41	39
1996	1/4 (91)	25/8 (237)	146	4/5 (125)	14/6 (166)	105	146	148	189	43	43
1997	18/3 (76)	2/9 (244)	168	3/5 (123)	14/6 (165)	101	144	145	189	44	43

Table 3.1.2 A comparison of timing of peak counts with migratory status and time of breeding in 32 of the 100 commonest BBS species. The Years column indicates the years in which significant variations in counts occurred, by paired t-test. (Blackcap was included here for comparison despite only showing significance in one year).

EARLY				LATE			
Species	Years	Status	Egg Laying	Species	Years	Status	Egg Laying
Blackbird	95-97	RES	Starting late March	Canada Goose	94-97	RES	Starting mid March
Blackcap	97	MIG	Starting late April	Coal Tit	95, 97	RES	Starting April
Blue Tit	94, 96	RES	Starting early April	House Martin	94-97	MIG	Starting early May
Chiffchaff	94-97	MIG	Starting late April	Jackdaw	94, 96, 97	RES	Starting late April
Chaffinch	94-97	RES	Starting late April	Lapwing	94, 95	MIG/RES	Starting late March
Dunnock	94, 97	RES	Starting late March	Long-tailed Tit	94, 95	RES	Starting late March
Great Tit	94-97	RES	Starting April	Magpie	94-97	RES	Starting mid April
Jay	94, 96, 97	RES	Starting April	Meadow Pipit	94-97	MIG	Starting late April
Grey Partridge	94-97	RES	Starting late April	Pied Wagtail	94, 95, 97	MIG/RES	Starting April
Pheasant	94-97	RES	Starting mid March	Rook	95, 96	RES	Starting mid March
Robin	94-97	RES	Starting early March	Reed Warbler	95, 96, 97	MIG	Starting mid May
Red-legged Partridge	94-97	RES	Starting late April	Starling	94-97	RES	Starting April
Red Grouse	95, 96	RES	Starting mid April	Swift	94-97	MIG	Starting late May
Woodpigeon	94-97	RES	Starting Feb/Mar	Swallow	94, 95, 97	MIG	Starting early May
Willow Warbler	94-97	MIG	Starting late April	Wren	94, 95, 97	RES	Starting late March
Yellowhammer	94, 96	RES	Starting April				
Skylark	94, 95	RES	Starting late March				
Tufted Duck	95, 96	RES	Mid May				
TOTAL	18 Species 15 Resident 3 Migratory/Partial migrants			TOTAL	15 Species 8 Resident 7 Migratory/Partial migratory		

Table 3.2.1 **Correlations of some of the 100 commonest BBS species with 4 recorded weather variables. Heavy boxes indicate taxonomic groupings (Broken boxes indicate broader species groupings). Species codes are as given in Appendix 3.**

WEATHER VARIABLE	POSITIVE CORRELATION	NEGATIVE CORRELATION
RAIN	B. CC WW GO LI SK HS LT LB RO WP CU L. OC SU PH	CT GT GR R. TC WR
VISIBILITY	ST TP CM JD OC	WP PH
CLOUD	GC GT LI LR SG WR WW FP WP	C. CH D. GH GW LW WH WO NH PW TP R. ST TS MA TU
WIND	CO MP YW RW HG LB MG RN WP SL K. GG	B. ST BT CT GT CC CH R. WR PH

Table 3.2.2 Population changes between 1994 and 1997 with removal of poor weather conditions (* = significant change).

	Standard Index		S.E.	New Index		S.E.	Change of Index
Greylag Goose	30	ns	0.22	110	*	0.32	+
Canada Goose	23	*	0.09	9	ns	0.13	-
Mallard	3	ns	0.04	18	*	0.06	+
Kestrel	-15	*	0.07	-9	ns	0.09	+
Red Grouse	13	ns	0.12	80	*	0.27	+
Pheasant	0	ns	0.03	-10	*	0.04	-
Moorhen	-9	ns	0.06	-27	*	0.08	-
Oystercatcher	-42	*	0.06	5	ns	0.11	+
Lapwing	-2	ns	0.05	25	*	0.07	+
Snipe	1	ns	0.12	41	*	0.18	+
Curlew	-7	ns	0.05	34	*	0.08	+
Redshank	-25	*	0.15	-16	ns	0.23	+
Black-headed Gull	-11	ns	0.06	-22	*	0.10	-
Common Gull	36	*	0.11	60	*	0.16	+
Lesser Black-backed Gull	45	*	0.07	73	*	0.10	+
Great Black-backed Gull	46	*	0.15	21	ns	0.23	-
Woodpigeon	-4	ns	0.02	-7	*	0.03	-
Collared Dove	10	*	0.03	-1	ns	0.05	-
Turtle Dove	-16	ns	0.11	-32	*	0.14	-
Sand Martin	30	ns	0.16	93	*	0.23	+
House Martin	4	ns	0.05	-15	*	0.07	-
Meadow Pipit	-6	*	0.03	8	ns	0.06	+
Dunnock	-6	*	0.03	-7	ns	0.04	+
Whinchat	8	ns	0.14	55	*	0.22	+
Whitethroat	41	*	0.04	18	ns	0.05	-
Jay	-12	*	0.06	-15	ns	0.08	+
Jackdaw	8	*	0.03	7	ns	0.05	-
House Sparrow	-2	ns	0.02	-14	*	0.04	-
Linnet	-5	ns	0.04	-16	*	0.06	-
Crossbill	-17	ns	0.23	-45	*	0.21	-
Corn Bunting	-21	*	0.09	-21	ns	0.13	+

Table 3.3.1 **Comparison of standard BBS population indices for 7 commonest wader species calculated as follows 1) removal of all 200m transect section counts greater than 10. 2) (Golden Plover only) Inclusion of all counts conducted on ITE upland and marginal upland landclass squares. 3) (Golden Plover only) removal of all counts greater than 10 and all counts on upland and marginal upland squares. All indices are 1994-1997 change percentages. Preferred indices are highlighted (SE = standard error, * = significant change).**

Species	Standard Index 94-97		Revised Index 1 1994-97		Revised Index 2 1994-97		Revised Index 3 1994-97	
	Change	S.E.	Change	S.E.	Change	S.E.	Change	S.E.
Common Sandpiper	-2.4	0.15	-2.4	0.15	-	-	-	-
Curlew	-7.1	0.05	-10.5*	0.05	-	-	-	-
Golden Plover	-42.1*	0.14	-1.6	0.12	-20.0	0.14	-2.8	0.12
Lapwing	-2.3	0.05	-10.7*	0.05	-	-	-	-
Oystercatcher	-42.1*	0.06	-10.5	0.06	-	-	-	-
Redshank	-24.9*	0.15	1.4	0.14	-	-	-	-
Snipe	1.0	0.12	9.7	0.12	-	-	-	-

Table 3.3.2 **Comparison of standard BBS population indices for 6 commonest wildfowl species with revised indices calculated by removal of all transect section counts greater than 10 (Revised Index 1) and greater than 20 respectively (Revised Index 2). Indices are 1994-1997 change percentages (SE = standard error, * = significant change).**

Species	Standard Index 94-97		Revised Index 1		Revised Index 2	
	Change	**S.E.**	**Change**	**S.E.**	**Change**	**S.E.**
Canada Goose	23*	0.09	20.8*	0.09	16.2	0.10
Greylag Goose	30	0.22	62.9*	0.17	114.7*	0.16
Mallard	3	0.04	6.7	0.04	5.4	0.04
Mute Swan	-8	0.10	0.6	0.11	20.8	0.11
Shelduck	-13	0.13	18.4	0.12	11.7	0.12
Tufted Duck	3	0.13	-18.2	0.14	-16.1	0.13

Table 3.4.1 **Comparison of standard BBS annual (site x year) model with a linear trend model for the 100 commonest species surveyed in BBS 1994-1997 (* indicates significant change), for the linear trend this is a test of whether the slope of the line differs from zero, for the annual model this test whether the change differs from zero.**

	Indexing Model		
	Linear Trend (Site x year count)	**Annual (Site x year)**	**Comments**
Great Crested Grebe	-12	-1	Slight increase then stable
Cormorant	14	-2	Slightly downward
Grey Heron	-5	3	Increase in 95 then steady
Mute Swan	-5	-8	Decline in 95 then slight increase
Greylag Goose	20	30	Increase in 95 then declining
Canada Goose	14*	23*	Increase to 96 then slight decline
Shelduck	-12	-13	Variable around 0
Mallard	3	3	Slight increase in 95 then stable
Tufted Duck	8	3	Stable
Sparrowhawk	-8	-12	Decline in 95
Buzzard	15*	18*	Steady Increase
Kestrel	-1*	-15*	Decline in 1995
Red Grouse	12	13	Variable around 0
Red-legged Partridge	21*	26*	Steady increase
Grey Partridge	9	10	Stable (increase 96)
Pheasant	-1	0	Stable
Moorhen	-13	-9	Increase in 95 then decline
Coot	9	8	Increase to 96 then decline
Oystercatcher	-25*	-42*	Steady decline
Golden Plover	-55*	-42*	Decline to 96 then slight increase
Lapwing	-10*	-2	Increase 95 then stable
Snipe	-3	-1	Variable around 0
Curlew	-9	-7	Increase in 95 decrease 97
Redshank	-31*	-25*	Decline in 96
Common Sandpiper	-2	-2	Steady around 0
Black-headed Gull	-11*	-11	Increase in 95 then decline
Common Gull	47*	36*	Steady increase
Lesser Black-backed Gull	35*	45*	Steady increase
Herring Gull	39*	33*	Increase in 96 then slight decline
Great Black-backed Gull	-1*	46*	Decrease 95 then increase
Feral Pigeon	9*	0	Decrease 95 then increase
Stock Dove	6	8	Increase in 96
Woodpigeon	-1	-4	Decline in 95 then increase
Collared Dove	12*	10*	Large increase in 96 then stable
Turtle Dove	-16	-16	Increase in 95 then decline
Cuckoo	-17*	-13*	Large decline in 97
Little Owl	25	9	Stable
Tawny Owl	-10	-18	Decrease in 95
Swift	-17*	-20*	Decrease in 96
Green Woodpecker	4	1	Decrease in 95 then increase
Great Spotted Woodpecker	23*	25*	Increase to 96 then steady
Skylark	-8*	-4	Decline from 96
Sand Martin	23*	30	Increase to 96 then decrease
Swallow	11*	10*	Decrease in 95 then increase
House Martin	-2	4	Increase in 95 then decrease
Tree Pipit	-8	-7	Variable around 0
Meadow Pipit	-8*	-6*	Increase in 95 then decline
Yellow Wagtail	26*	30*	Increase in 96 then decrease

	Indexing Model		
	Linear Trend (Site x year count)	Annual (Site x year)	Comments
Grey Wagtail	-38*	-38*	Increase in 95 then decline
Pied Wagtail	7	12*	Increase in 95 then decrease
Wren	-23*	-19*	Increase in 95 then decline
Dunnock	-9*	-6*	Increase 95 then decrease
Robin	-9*	-10*	Increase 95 then decline
Redstart	55*	63*	Steady increase
Whinchat	6	8	Increase in 96 then stable
Stonechat	-21	-26	Increase in 95 then decline
Wheatear	21*	35*	Increase in 95
Blackbird	-5*	-5*	Large decline in 1997
Song Thrush	-17*	-17*	Decrease in 97
Mistle Thrush	-15*	-15*	Steady decline
Grasshopper Warbler	74*	112*	Steady increase
Sedge Warbler	3	5	Increase to 96 then decrease
Reed Warbler	16	7	Slight increase 95
Lesser Whitethroat	-50*	-49*	Steady decline
Whitethroat	23*	23*	Steady increase to 96, stable
Garden Warbler	19*	23*	Steady increase
Blackcap	15*	18*	General increase - decline in 96
Wood Warbler	-9	-5	Decline to 96 then increase
Chiffchaff	12*	15*	Steady increase
Willow Warbler	9*	15*	Steady increase
Goldcrest	26*	36*	Peaks in 95 and 97
Spotted Flycatcher	-14	-13	Decline in 95
Long-tailed Tit	-7	4	Variable around 0
Marsh Tit	6	14	Increase in 95 then decrease
Willow Tit	-13	-4	Decline in 95 then increase
Coal Tit	27*	35*	Steady increase
Blue Tit	16*	21*	Steady increase
Great Tit	5*	12*	Steady increase
Nuthatch	27*	41*	Steady increase
Treecreeper	19*	32*	Steady increase
Jay	-11	-12*	Big decline 95 then slight increase
Magpie	1	4	Increase in 97
Jackdaw	12*	8*	Slight increase
Rook	7	5	Slight increase
Carrion Crow	5	3	Slight increase
Raven	9	12	Increase 95 then decrease
Starling	-2	3	Increase in 95 then stable
House Sparrow	-4	-2	Steady
Tree Sparrow	-12	-13	Variable around 0
Chaffinch	3*	1	Variable around 0
Greenfinch	15*	19*	Steady Increase
Goldfinch	-1	1	Stable
Siskin	88*	64*	Increase in 96
Linnet	-8*	-5	Increase in 95 then stable
Lesser Redpoll	22*	41*	Increase in 96/97
Common Crossbill	-21	-17	Big decline in 95 then steady increase
Bullfinch	-3	-2	Slight increase - very variable, down 95 up 96
Yellowhammer	-12*	-12*	Steady decline
Reed Bunting	-12	-7	Variable around 0
Corn Bunting	-14*	-21*	Large drop in 96 then steady

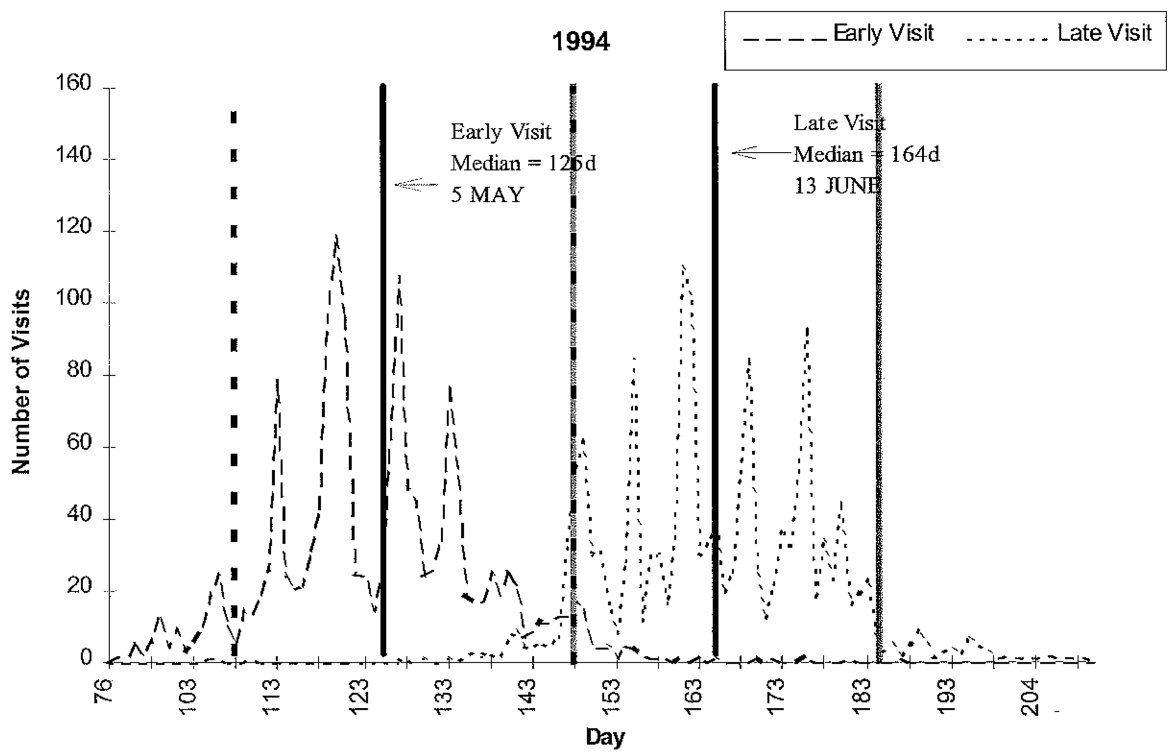
Table 3.4.2 **Variation of standard error and level of detectable change with sample size of the 100 commonest species surveyed in BBS 1994-97. Sample = mean number of squares occupied over the four years of the survey.**

Species	Sample	SE of 1994-1997 Change	Level of change detectable between 1994-1997
Blackbird	1495	0.015	3
Chaffinch	1503	0.016	3
Blue Tit	1395	0.021	4
Robin	1422	0.020	4
Skylark	1212	0.020	4
Woodpigeon	1523	0.022	4
Wren	1474	0.019	4
Dunnock	1220	0.027	5
Great Tit	1252	0.027	5
House Sparrow	1040	0.023	5
Magpie	1148	0.025	5
Meadow Pipit	548	0.027	5
Willow Warbler	1064	0.024	5
Carrion Crow	1514	0.028	6
Greenfinch	1060	0.031	6
Pheasant	1014	0.028	6
Swallow	1160	0.030	6
Song Thrush	1141	0.031	6
Yellowhammer	883	0.028	6
Blackcap	794	0.035	7
Chiffchaff	736	0.037	7
Collared Dove	817	0.033	7
Jackdaw	951	0.034	7
Starling	1252	0.033	7
Whitethroat	817	0.037	7
Linnet	880	0.041	8
Mallard	746	0.040	8
Goldfinch	847	0.043	9
Pied Wagtail	780	0.043	9
Rook	849	0.046	9
Cuckoo	697	0.048	10
Coal Tit	445	0.049	10
Curlew	372	0.049	10
Goldcrest	415	0.050	10
House Martin	602	0.050	10
Mistle Thrush	774	0.048	10
Swift	728	0.048	10
Lapwing	498	0.053	11
Feral Pigeon	445	0.058	12
Moorhen	412	0.062	12
Oystercatcher	202	0.059	12
Stock Dove	495	0.058	12
Black-headed Gull	393	0.064	13
Buzzard	323	0.066	13
Green Woodpecker	415	0.063	13
Great Spotted Woodpecker	454	0.063	13
Herring Gull	358	0.067	13
Jay	422	0.064	13

Species	Sample	SE of 1994-1997 Change	Level of change detectable between 1994-1997
Kestrel	445	0.067	13
Long-tailed Tit	509	0.065	13
Red-legged Partridge	315	0.065	13
Bullfinch	400	0.071	14
Grey Heron	378	0.070	14
Reed Bunting	290	0.070	14
Garden Warbler	311	0.073	15
Lesser Black-backed Gull	336	0.073	15
Wheatear	211	0.076	15
Nuthatch	228	0.082	16
Sedge Warbler	202	0.079	16
Corn Bunting	140	0.092	18
Canada Goose	224	0.091	18
Grey Partridge	217	0.095	19
Treecreeper	230	0.094	19
Yellow Wagtail	152	0.093	19
Coot	147	0.098	20
Mute Swan	132	0.101	20
Sparrowhawk	219	0.103	21
Turtle Dove	167	0.106	21
Spotted Flycatcher	170	0.108	22
Common Gull	119	0.113	23
Red Grouse	90	0.116	23
Redstart	110	0.114	23
Lesser Whitethroat	182	0.120	24
Snipe	113	0.121	24
Tree Pipit	107	0.118	24
Siskin	102	0.126	25
Shelduck	97	0.126	25
Tree Sparrow	122	0.125	25
Tufted Duck	101	0.127	25
Reed Warbler	70	0.129	26
Lesser Redpoll	102	0.136	27
Cormorant	104	0.140	28
Golden Plover	78	0.142	28
Raven	125	0.141	28
Marsh Tit	103	0.146	29
Redshank	60	0.146	29
Whinchat	77	0.143	29
Common Sandpiper	58	0.148	30
Great Black-backed Gull	72	0.154	31
Grey Wagtail	116	0.157	31
Sand Martin	80	0.160	32
Wood Warbler	54	0.167	33
Little Owl	79	0.170	34
Great Crested Grebe	49	0.173	35
Willow Tit	58	0.194	39
Tawny Owl	61	0.203	41
Greylag Goose	66	0.219	44
Common Crossbill	35	0.227	45
Grasshopper Warbler	50	0.232	46
Stonechat	49	0.247	49

Table 3.4.3 **Standard BBS index variables for 10 common but infrequent species which are not routinely indexed within the BBS.**

Species	Sample Size (No. of Squares) 1996	1997	Standard Error	Approximate % Change Detectable
Pied Flycatcher	34	48	0.203	~40
Little Grebe	43	48	0.269	~54
Dipper	46	42	0.278	~56
Kingfisher	34	48	0.289	~58
Goosander	32	32	0.341	~68
Twite	19	26	0.349	~70
Dunlin	33	28	0.619	~81
Nightingale	20	30	0.532	~106
Fieldfare	25	30	0.622	~124
Common Tern	32	45	0.899	~180



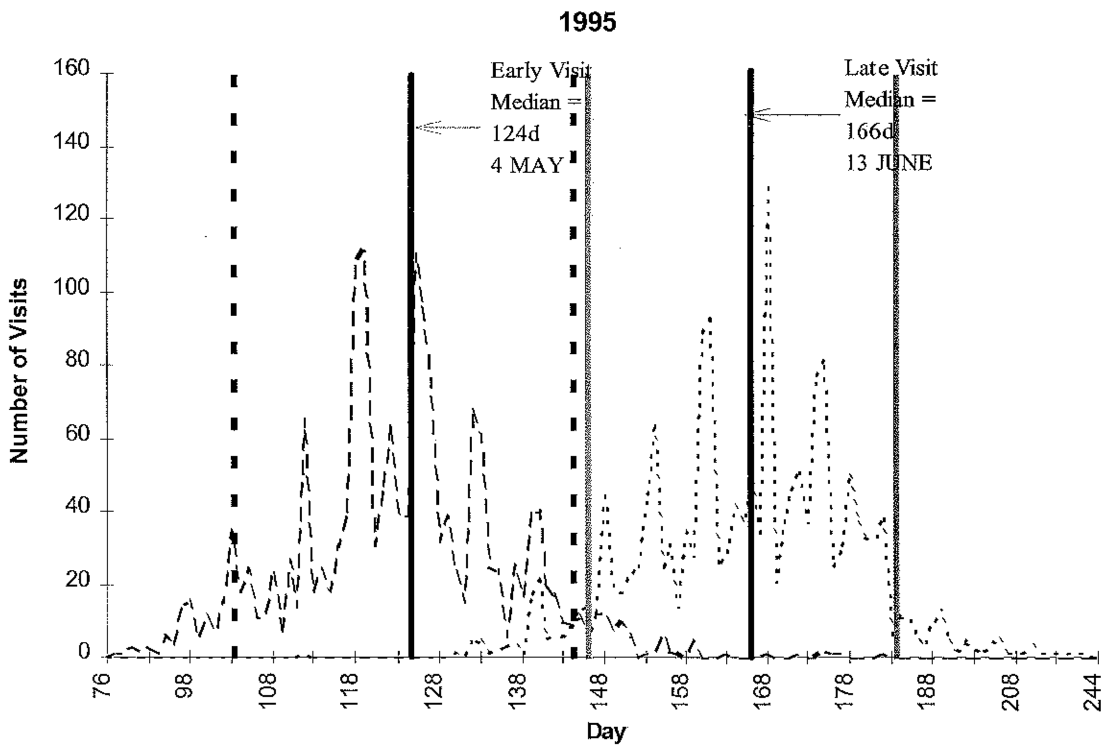
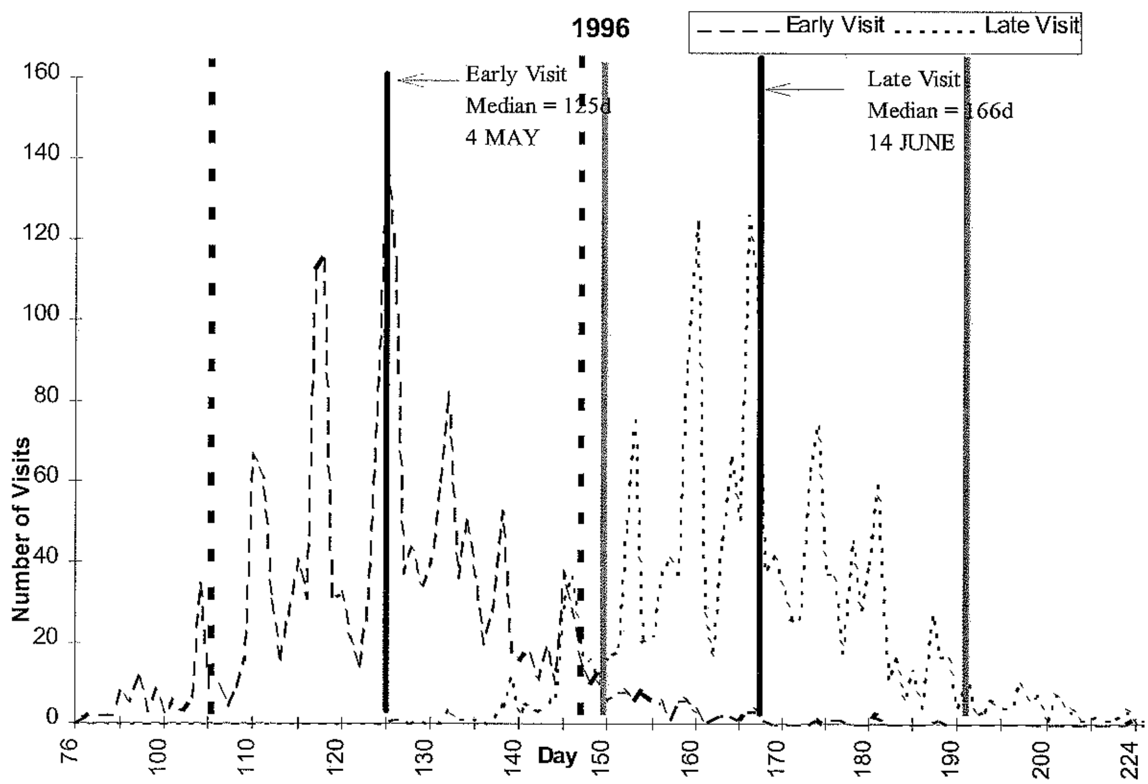


Figure 3.1.1 Timings of early and late visits by BBS fieldworkers in 1994 and 1995. Heavy lines indicate median visit dates, broken lines early 5 and 95 percentiles and shaded lines late 5 and 95 percentiles.



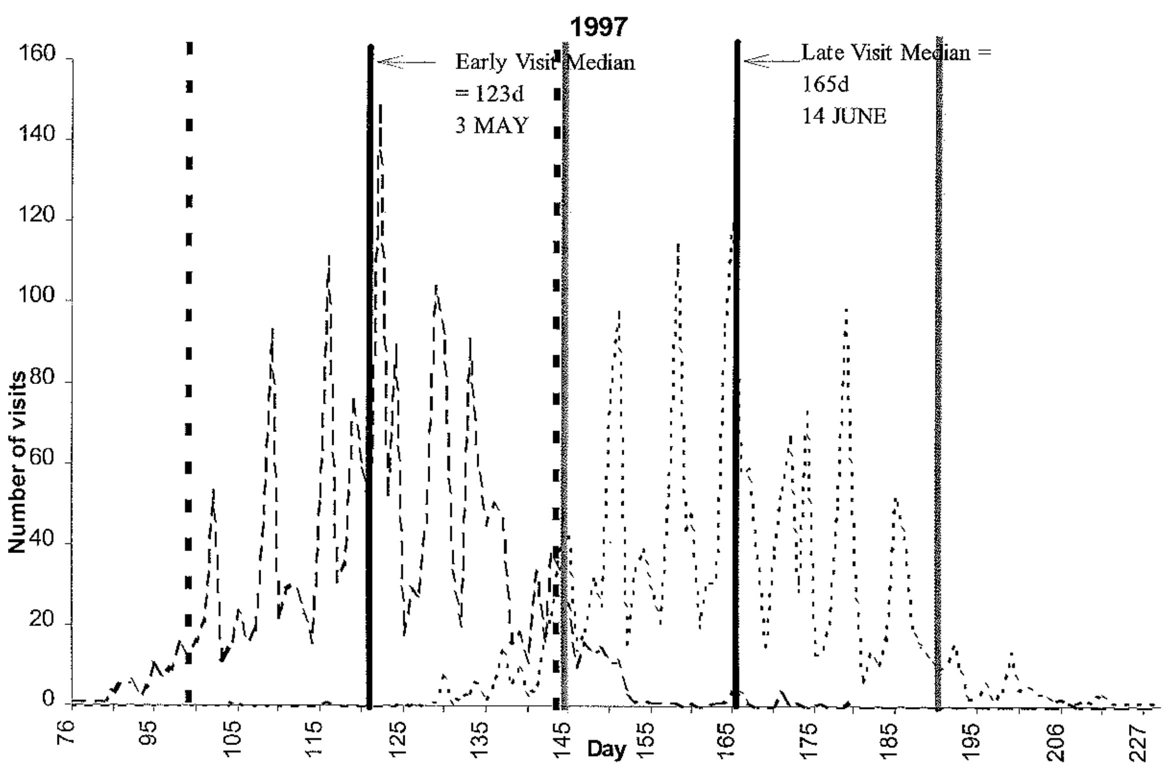


Figure 3.1.1 (Contd.) **Timings of early and late visits by BBS fieldworkers in 1996 and 1997. Heavy lines indicate median visit dates, broken lines early 5 and 95 percentiles and shaded lines late 5 and 95 percentiles.**

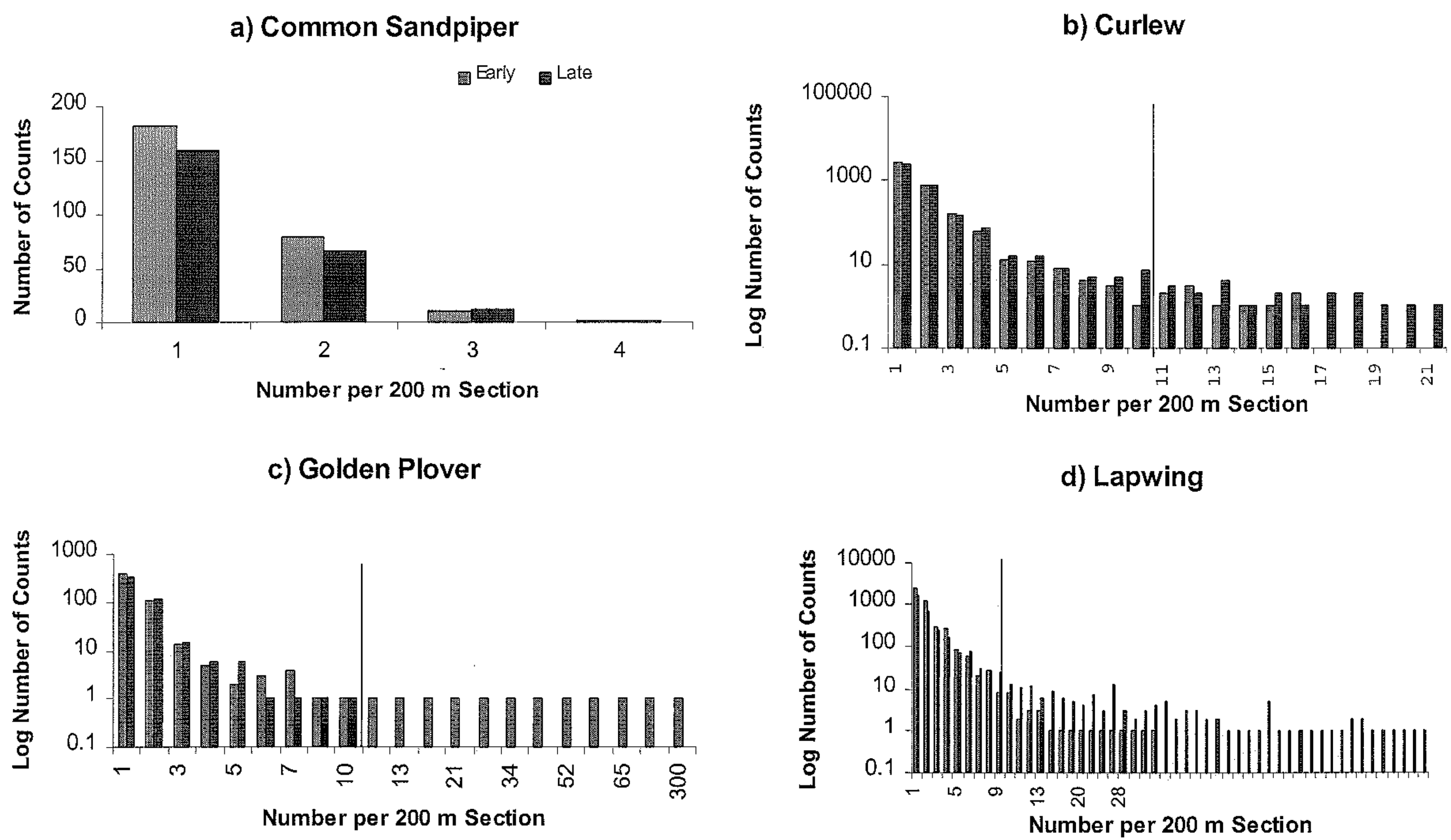
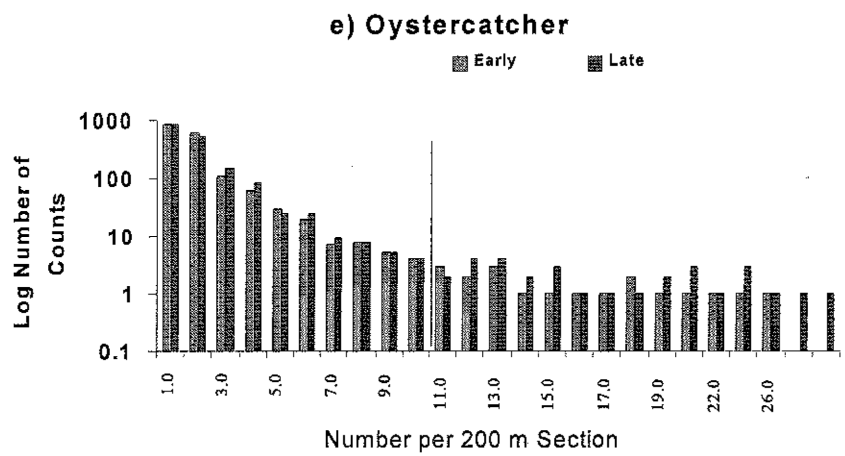
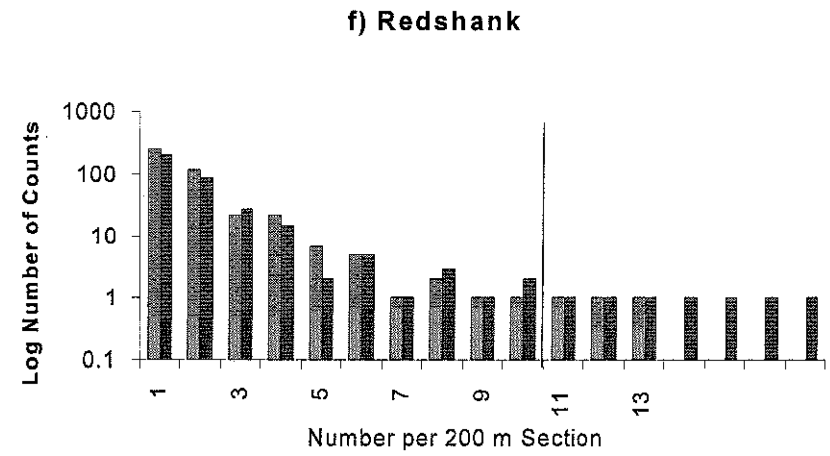


Figure 3.3.1 Frequency distributions of 200m transect section counts of the 7 most common wader species in BBS 1994-1997. Vertical line represents counts of greater than ten.





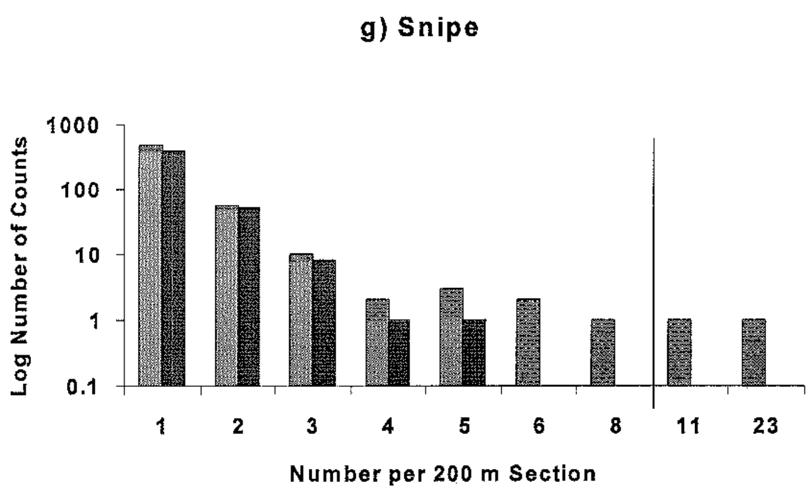


Figure 3.3.1 (Contd.)

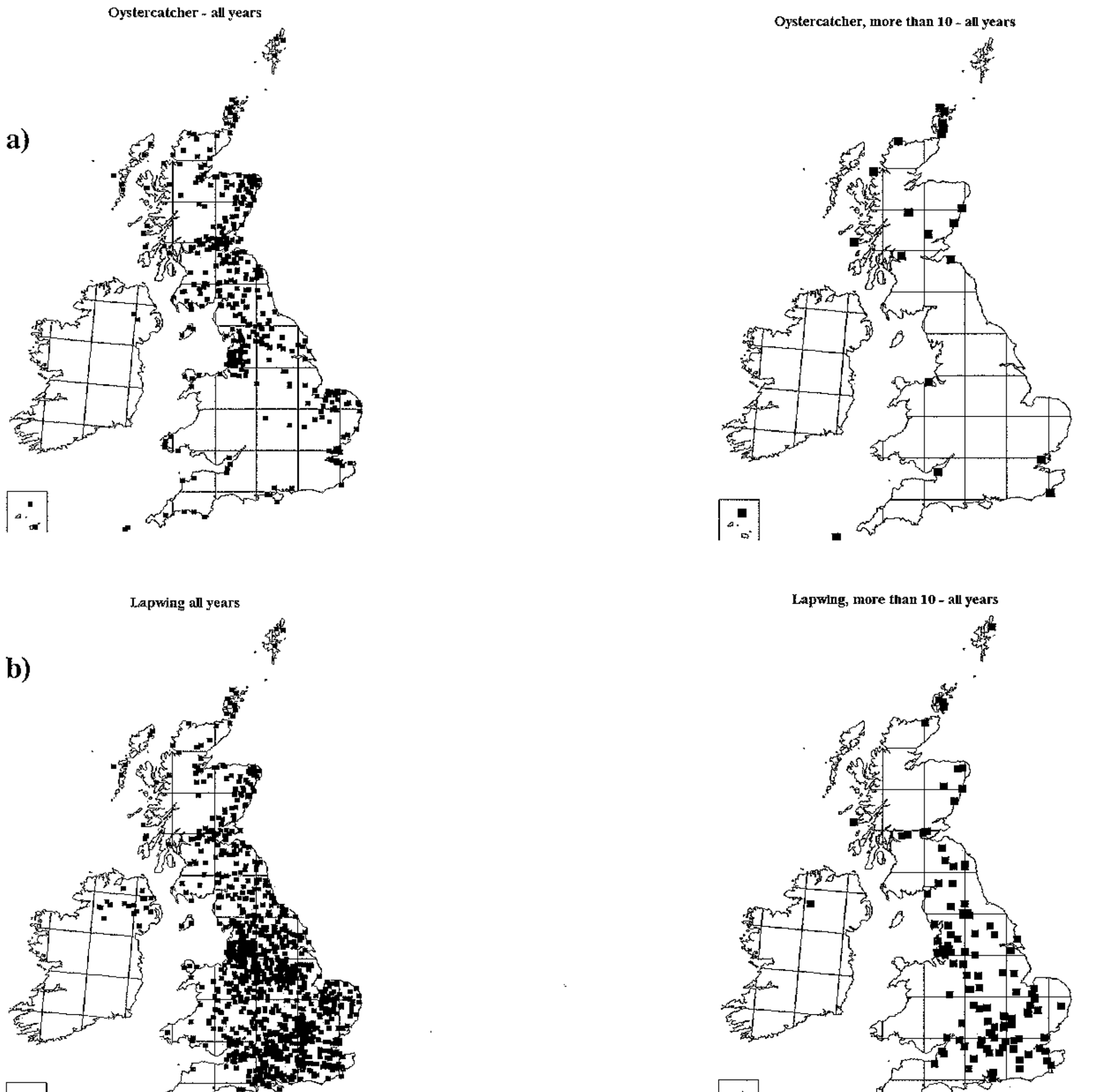
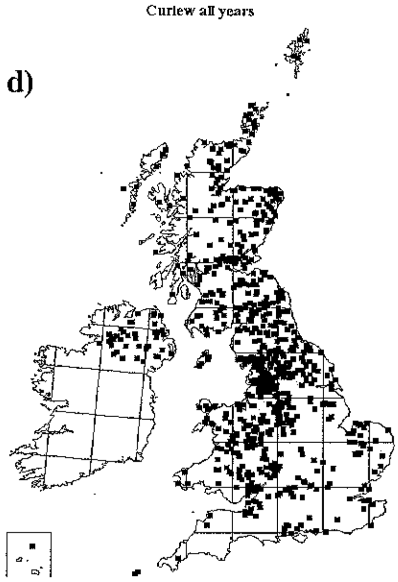
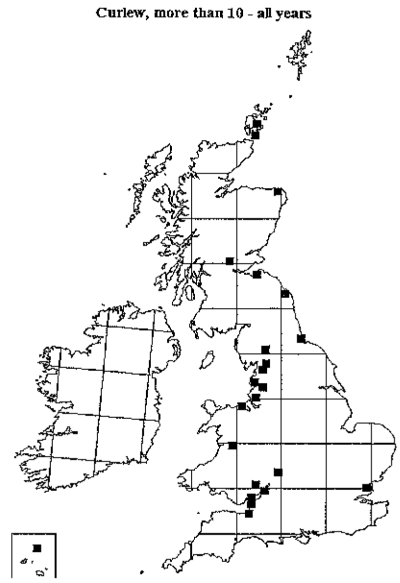


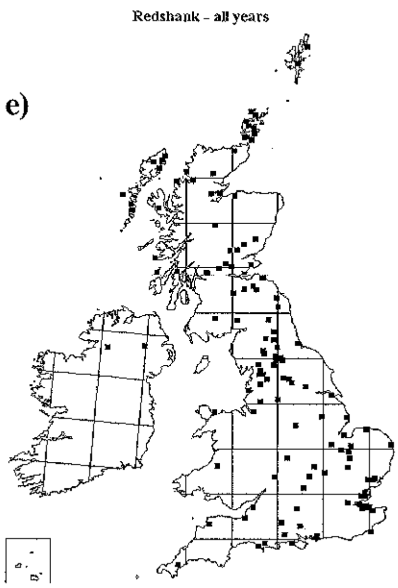
Figure 3.3.2 **Distribution of BBS squares where 6 of the commonest wader species were encountered, and those squares where transect section counts greater than 10 were encountered, 1994-97. (Note : no counts of Common Sandpiper exceeded 10).**

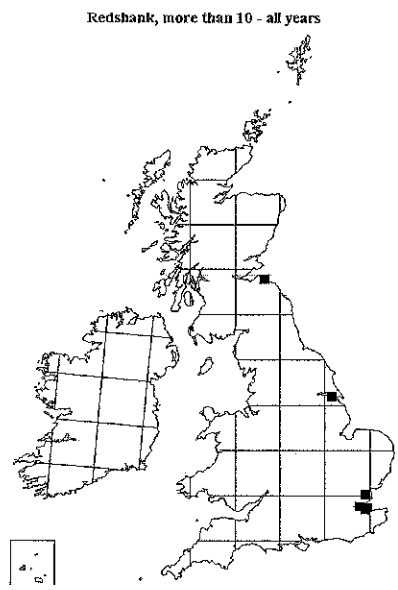
d)





e)





f)

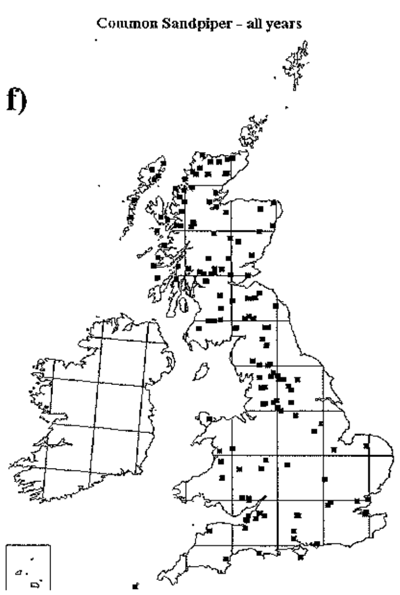


Figure 3.3.2 (Contd.)

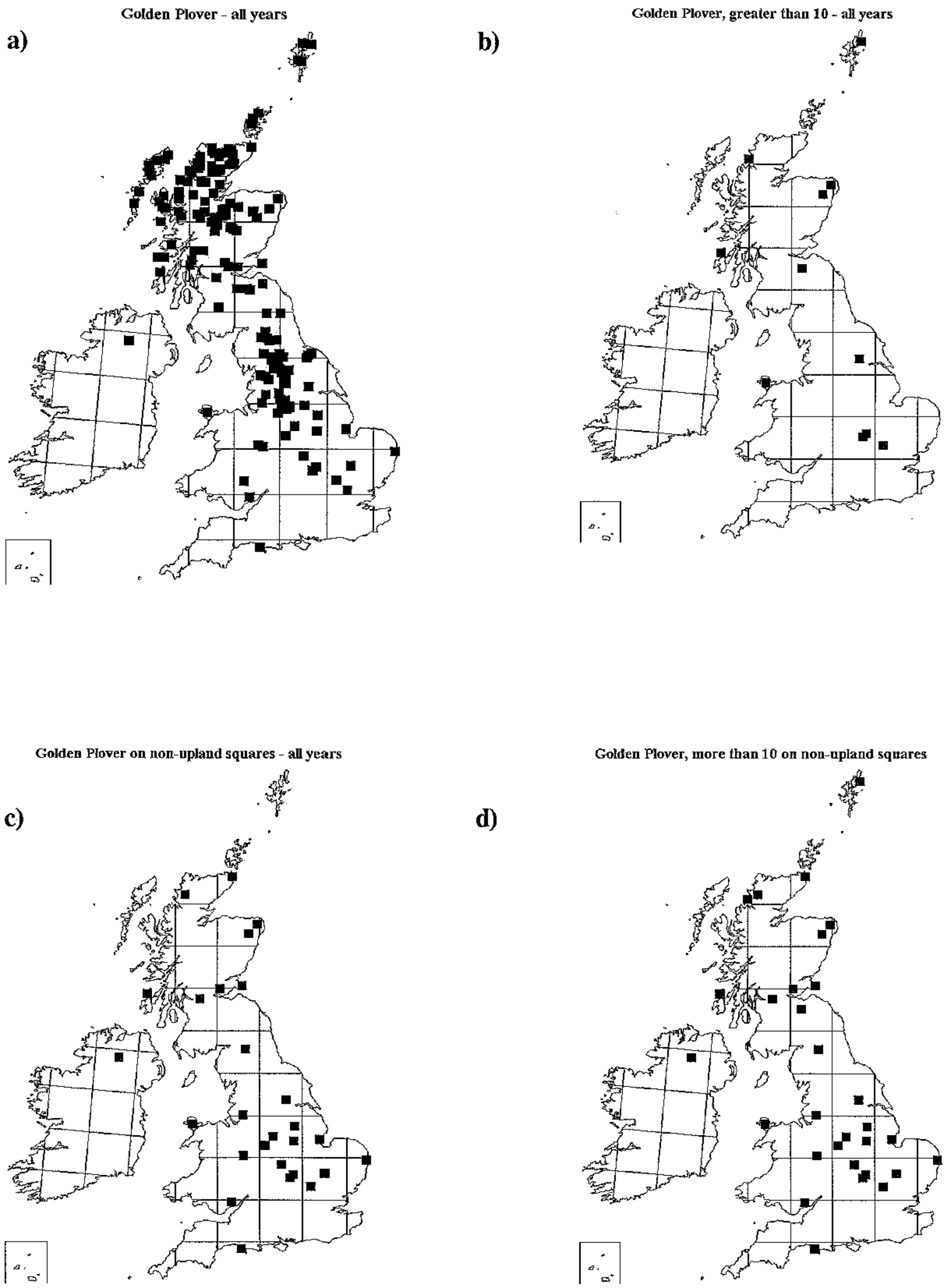


Figure 3.3.3 Distribution of BBS squares where Golden Plover were encountered a) all squares; b) transect section counts greater than 10; c) birds on ITE non-upland squares; d) counts greater than 10, and non-upland counts. All maps show counts for 1994-1997.

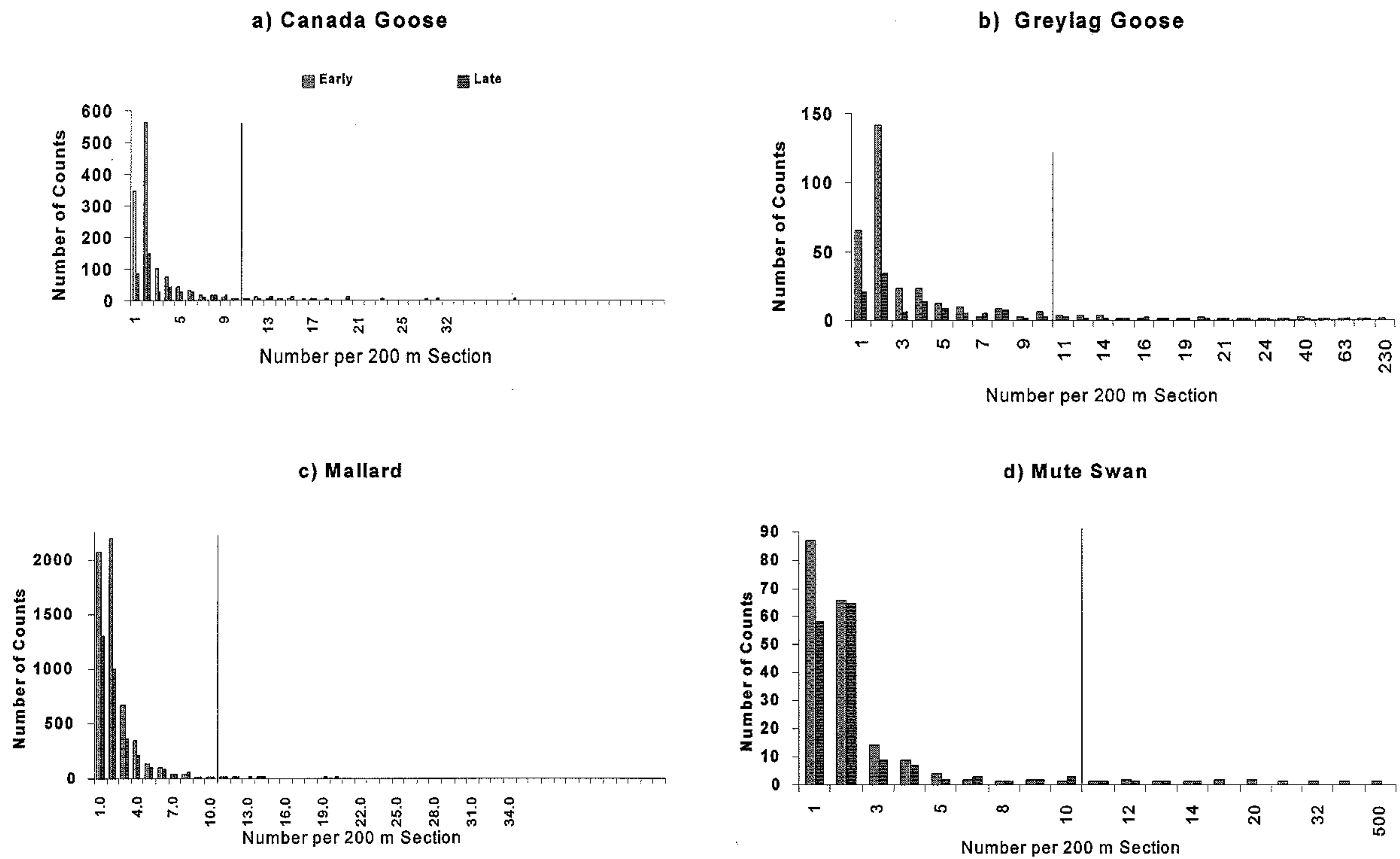


Figure 3.3.4 Frequency distributions of 200m transect section counts of the 6 most common wildfowl species in BBS 1994-1997. Vertical line represents counts of greater than ten.

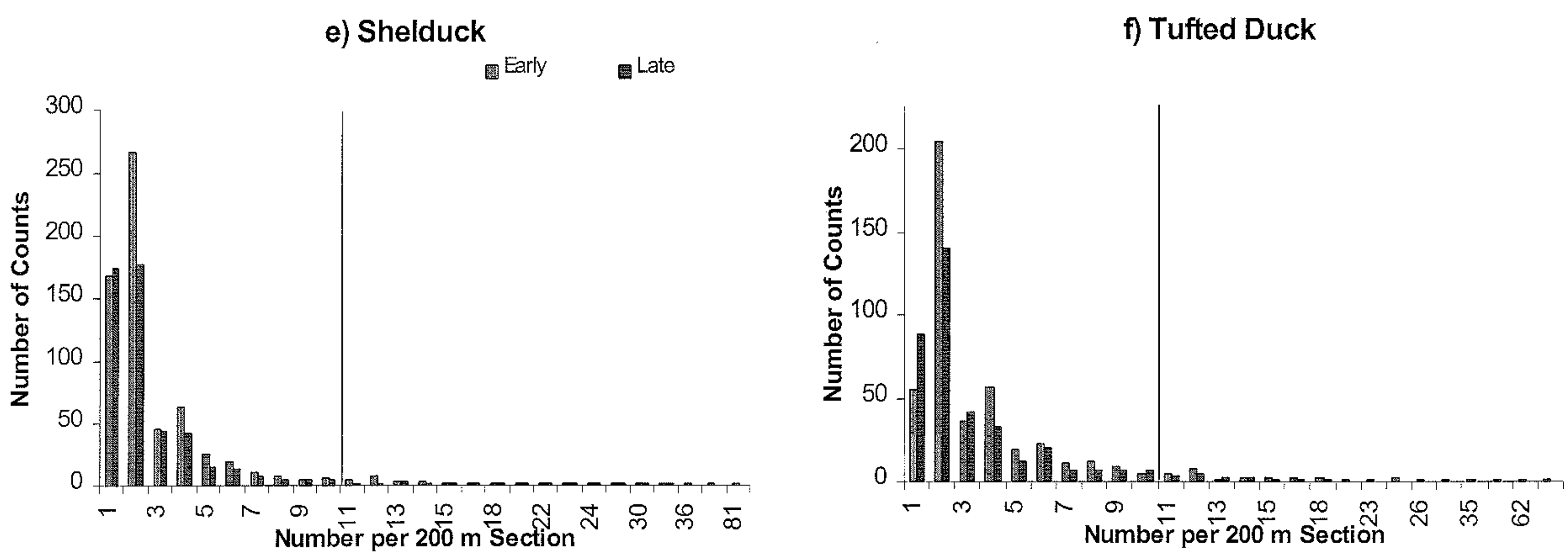


Figure 3.3.4 (Contd.)

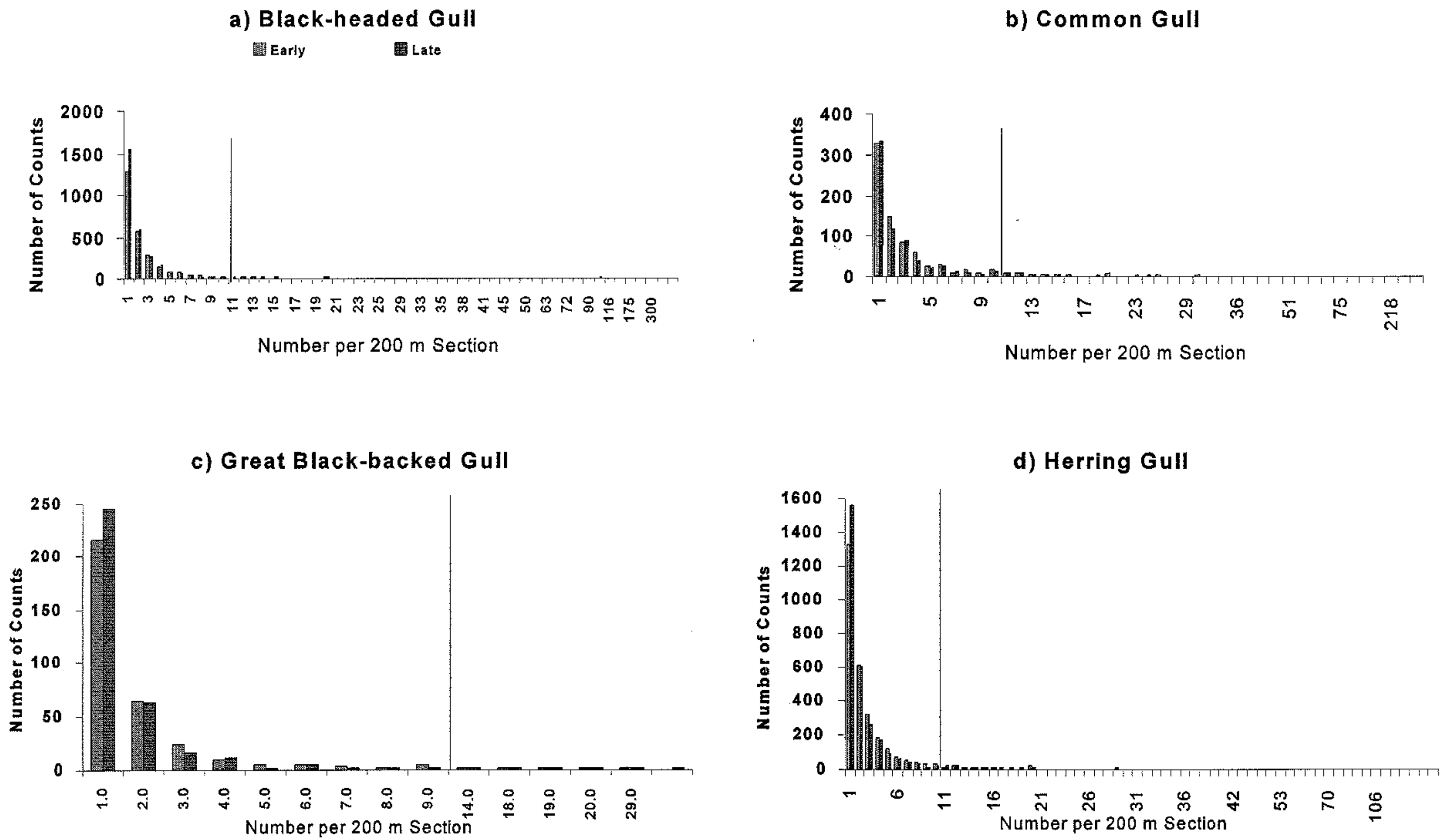


Figure 3.3.5 **Frequency distributions of 200m transect section counts of the 5 most common gull species in BBS 1994-1997. Vertical line represents counts of greater than ten.**

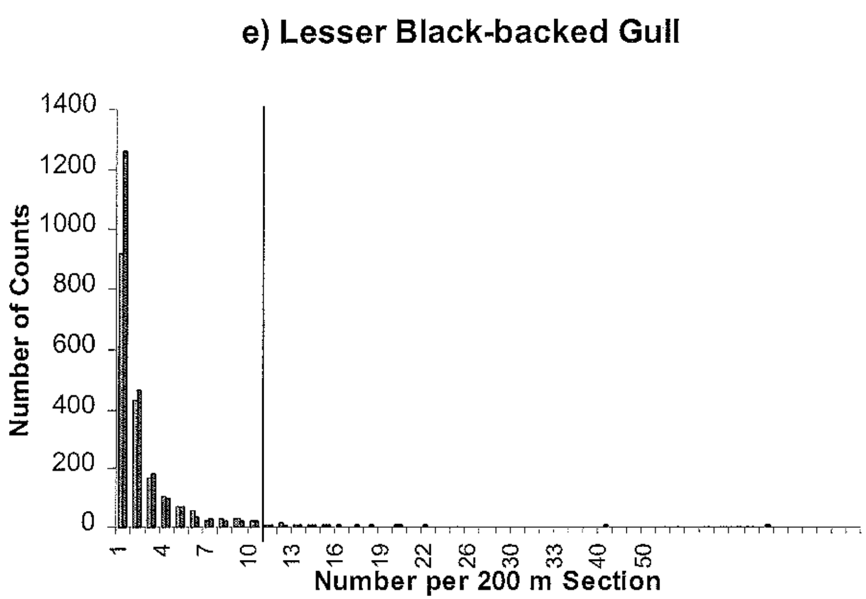


Figure 3.3.5 (Contd.)

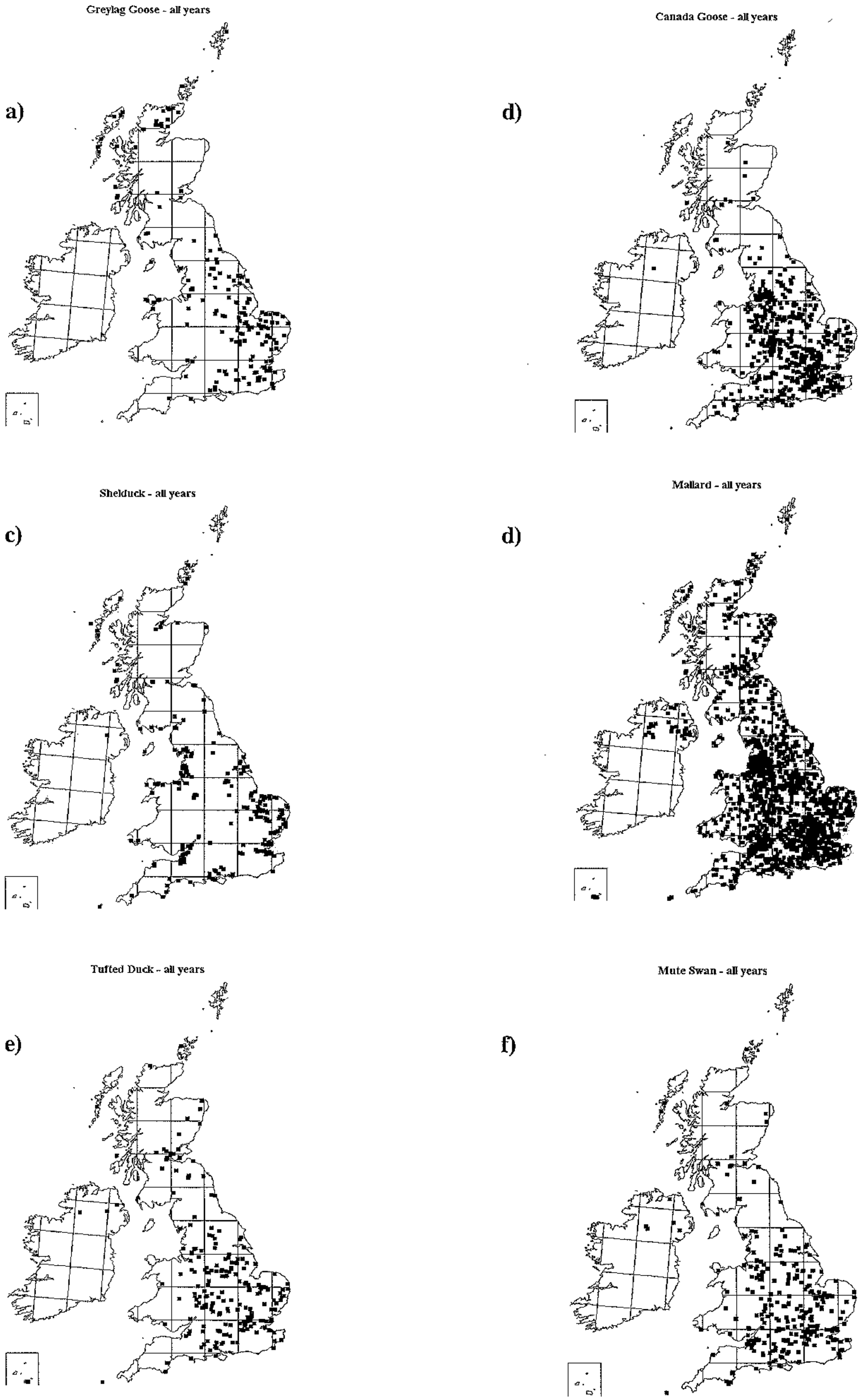


Figure 3.3.6 Distribution of BBS squares where the 6 commonest wildfowl species were encountered 1994-1997.

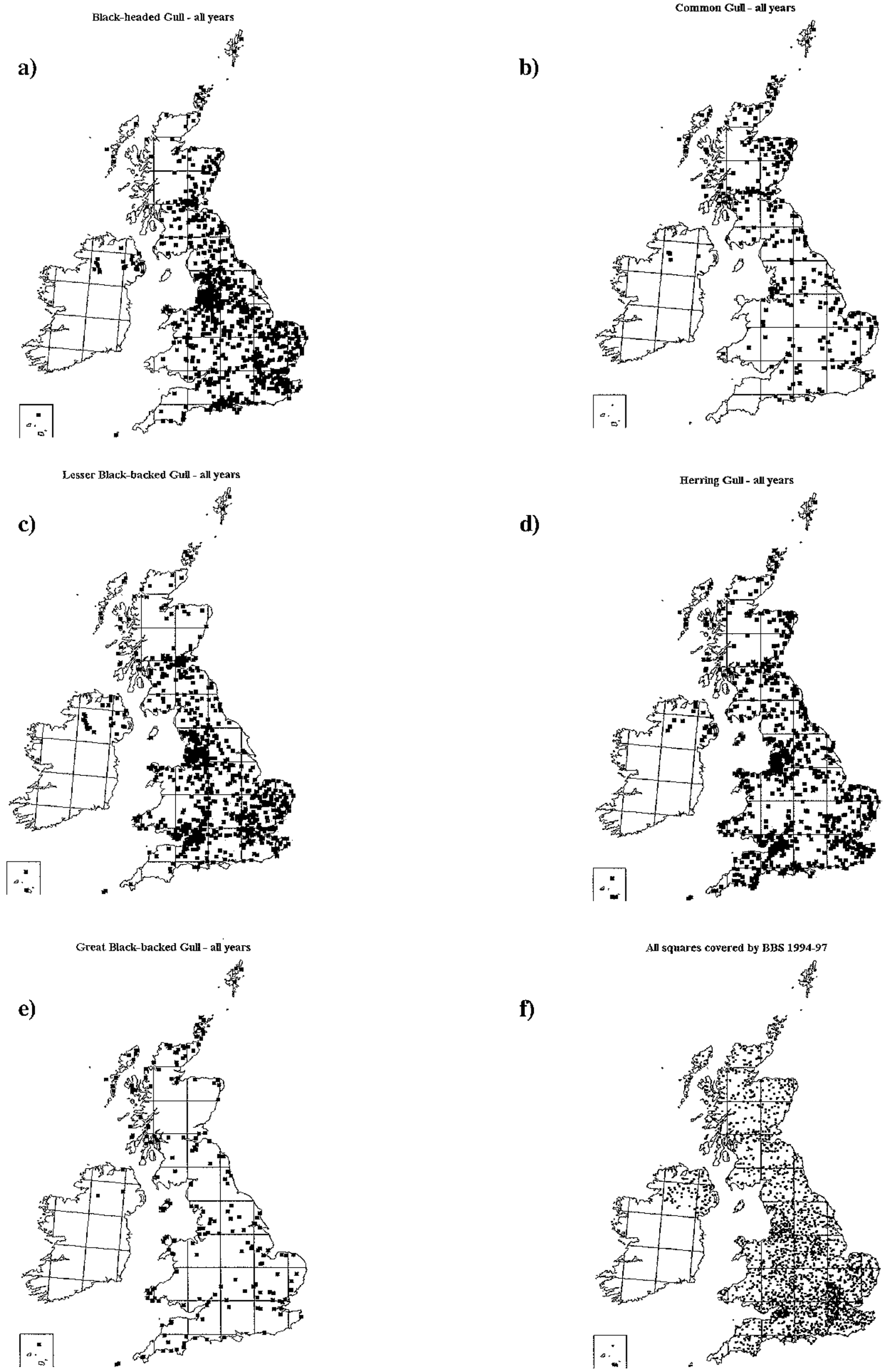


Figure 3.3.7 **Distribution of BBS squares where the 5 commonest Gull species were encountered. Map f) is the distribution of all BBS 1km squares 1994-97.**

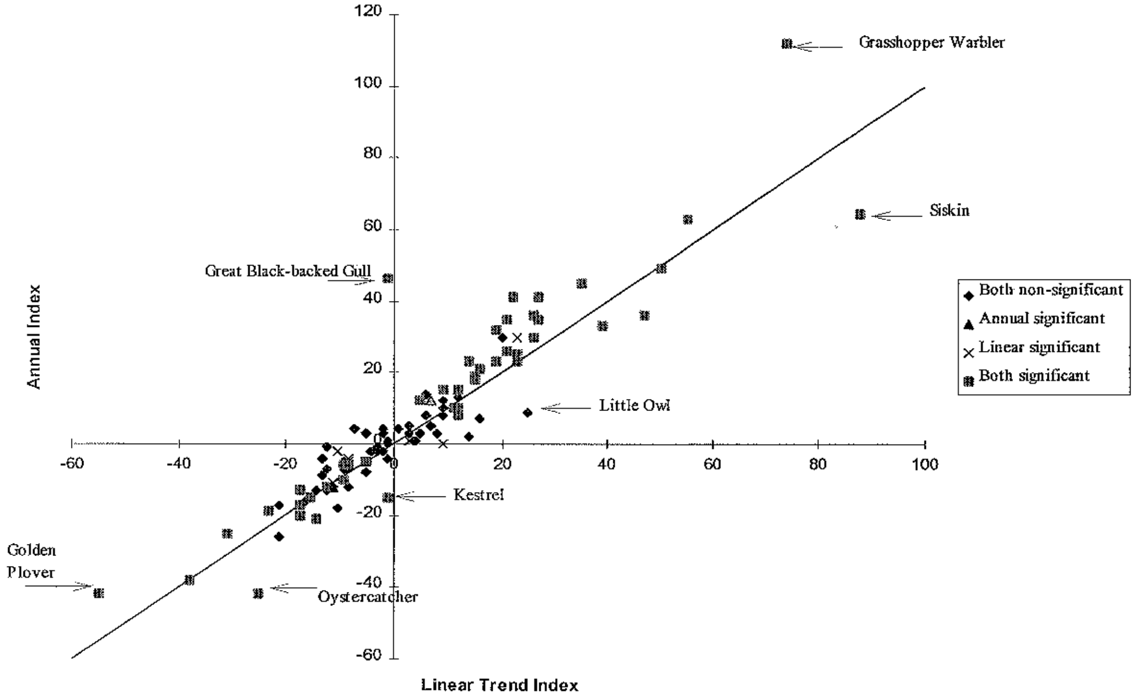


Figure 3.4.1 The relationship between population changes beteween 1994 and 1997 as derived from an annual and a linear trend model.

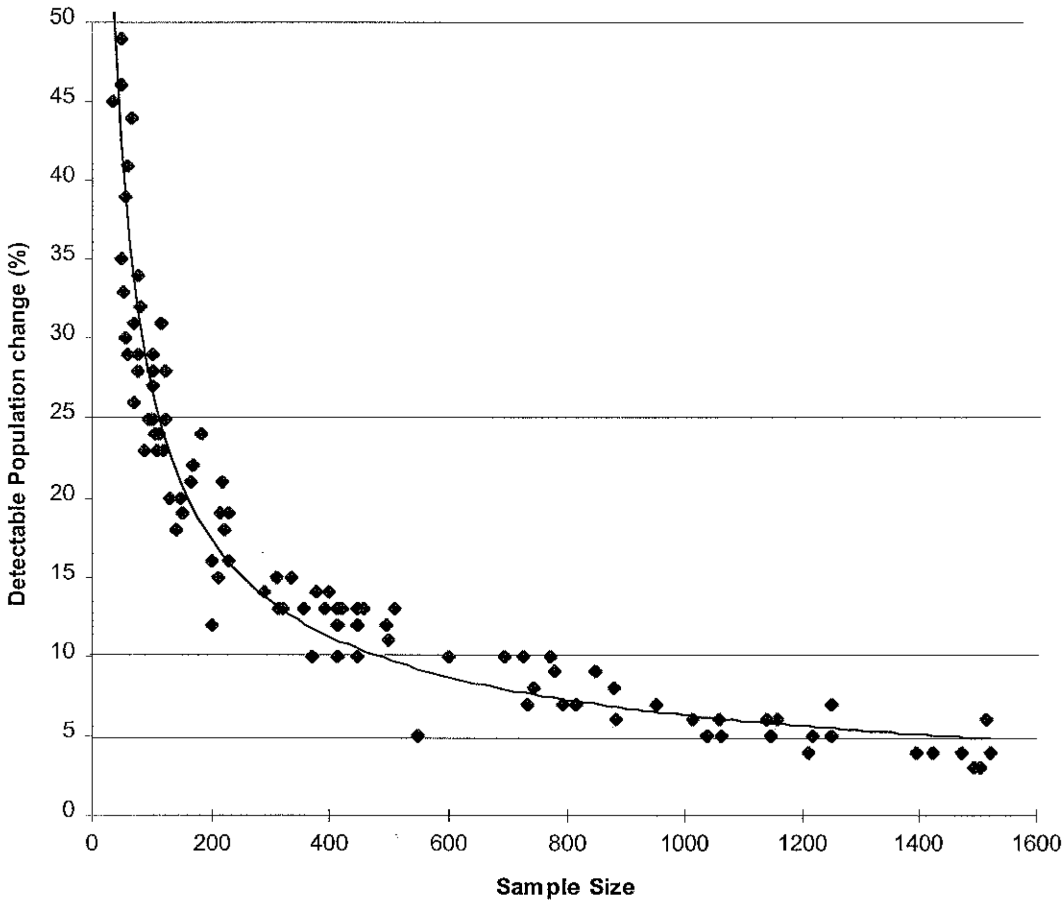


Figure 3.4.2 **The relationship between detectable population change (%) between 1994 and 1997, and sample size for the 100 most common species (in 1997 BBS). This is based on a standard site x year model. Sample = mean number of squares reporting counts over all years.**

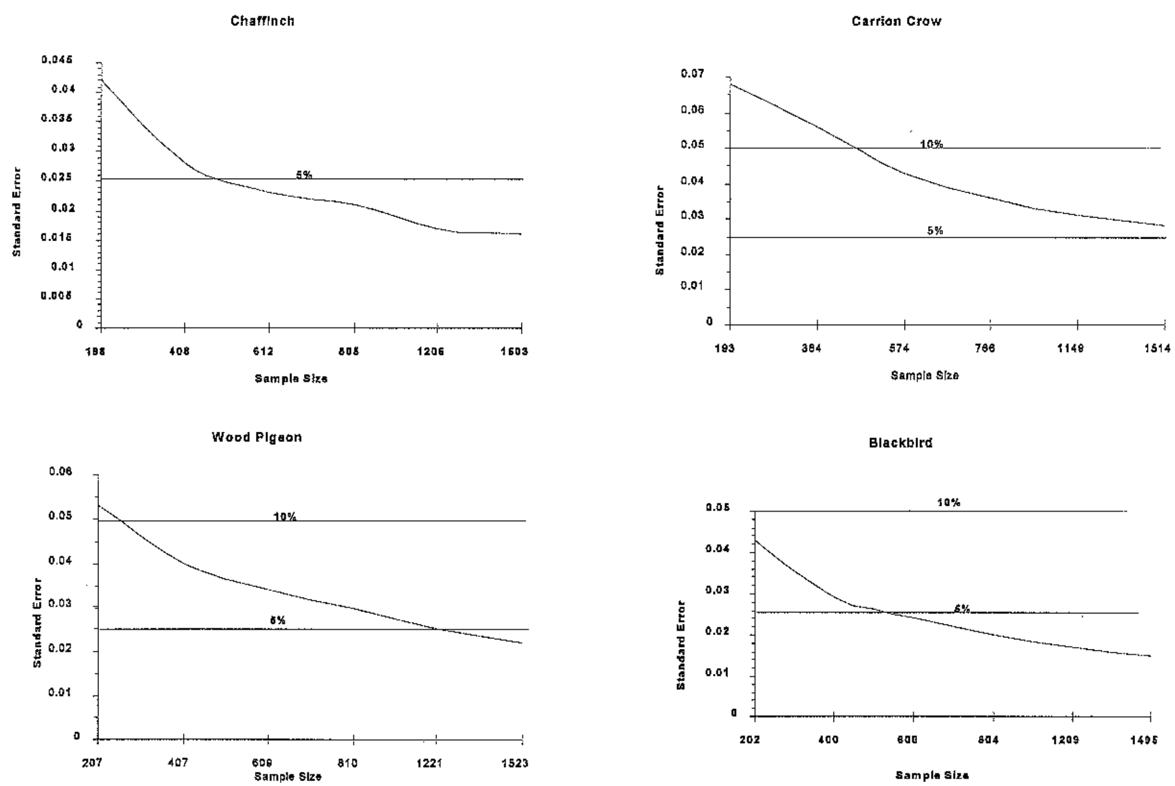
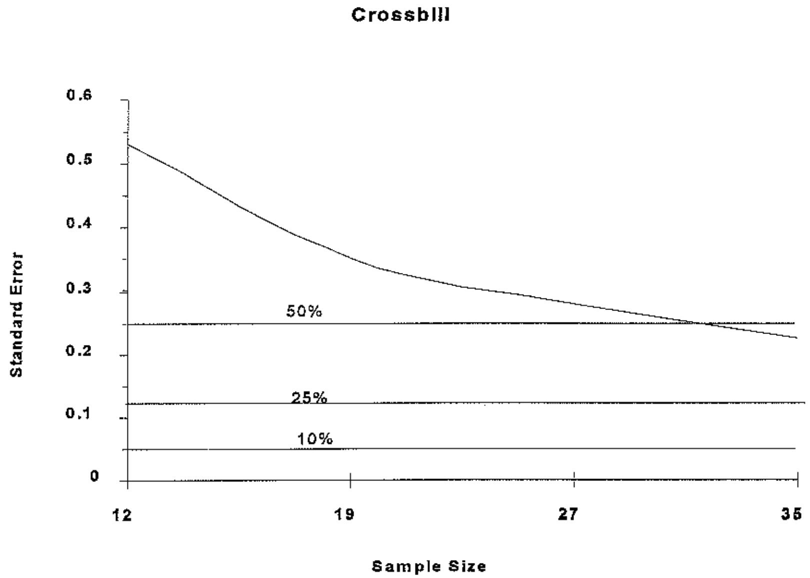
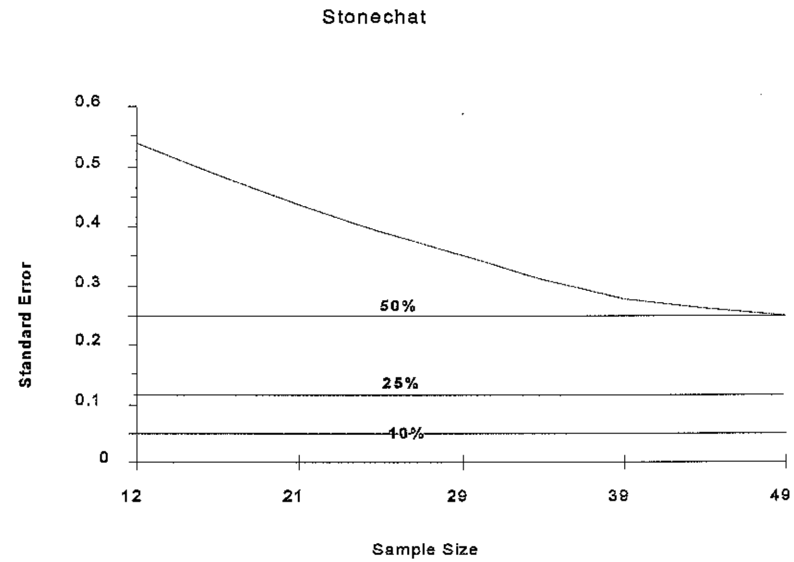


Figure 3.4.3 Relationship between the standard error of the 1994 to 1997 change measure and minimum detectable population change for 4 common species (Chaffinch, Carrion Crow, Wood Pigeon and Blackbird). This is based on a standard site x year model.





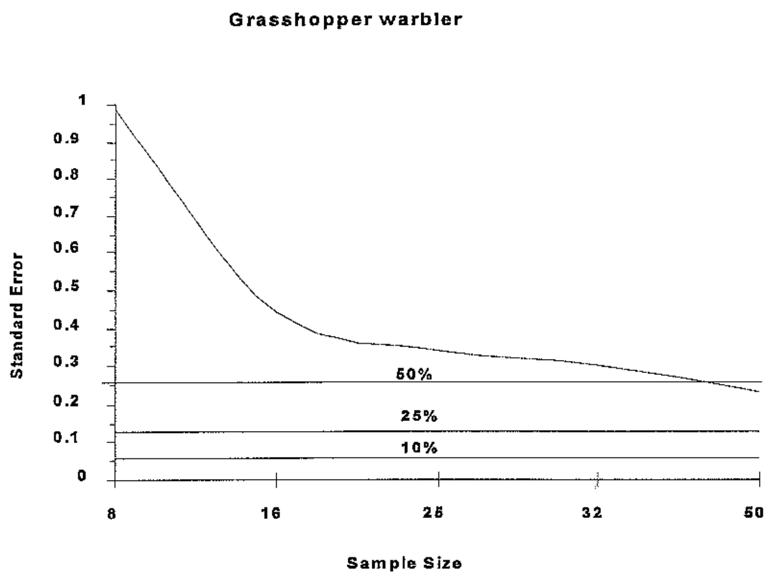


Figure 3.4.4 **Relationship between the standard error of the 1994 to 1997 change measure and minimum detectable population change for 11 less common species. This is based on a standard site x year model.**

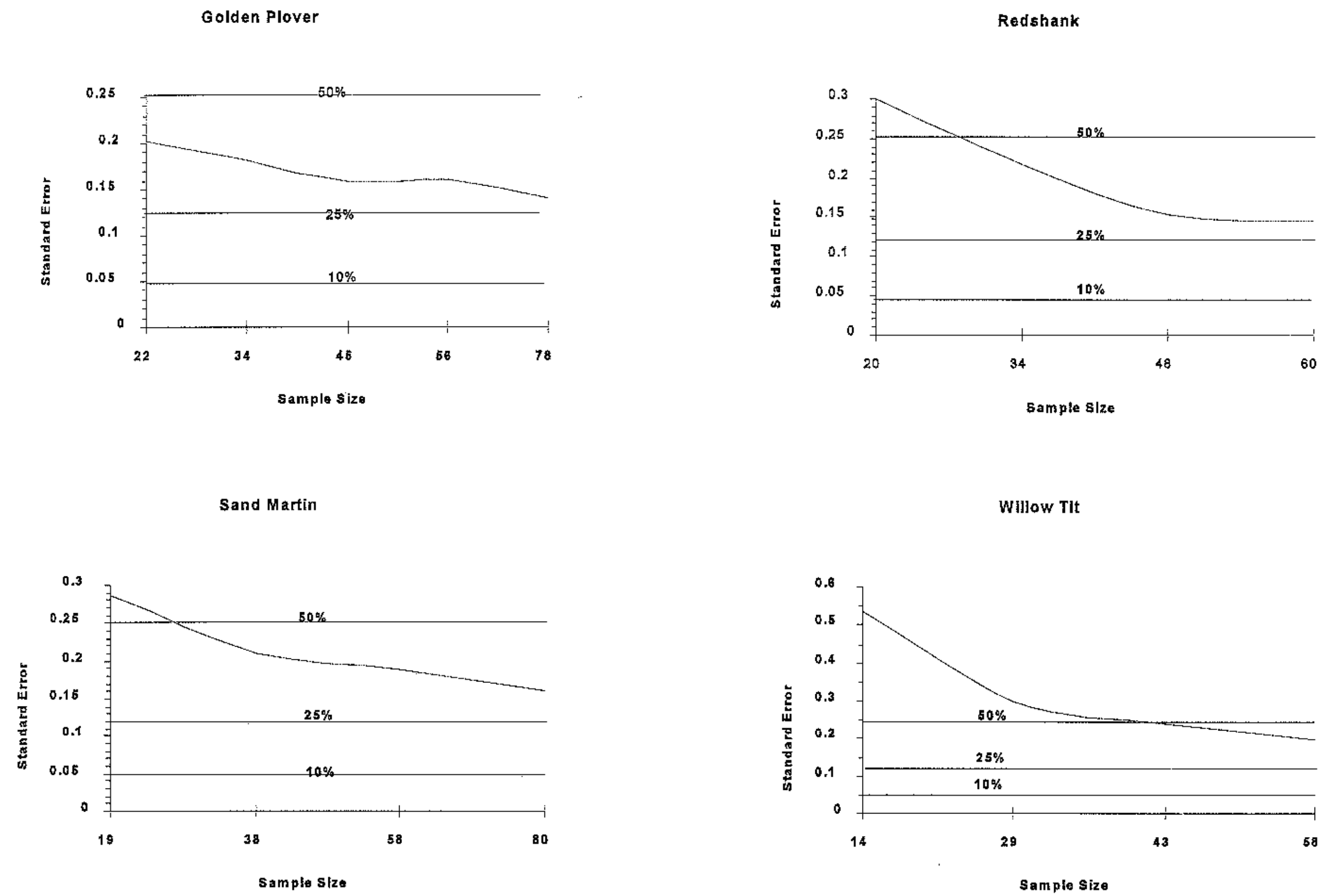


Figure 3.4.4 (Contd.)

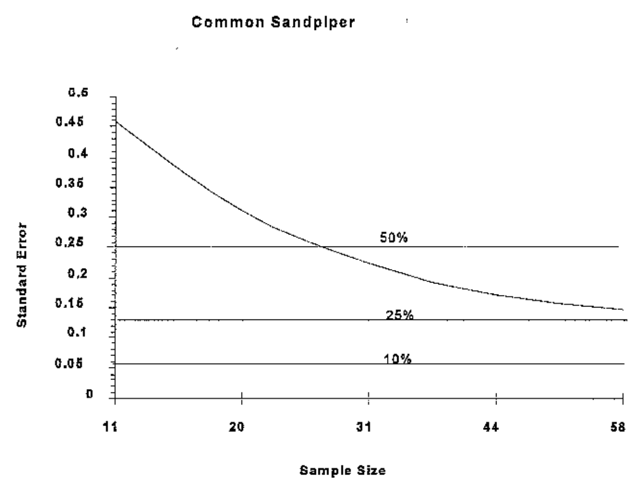
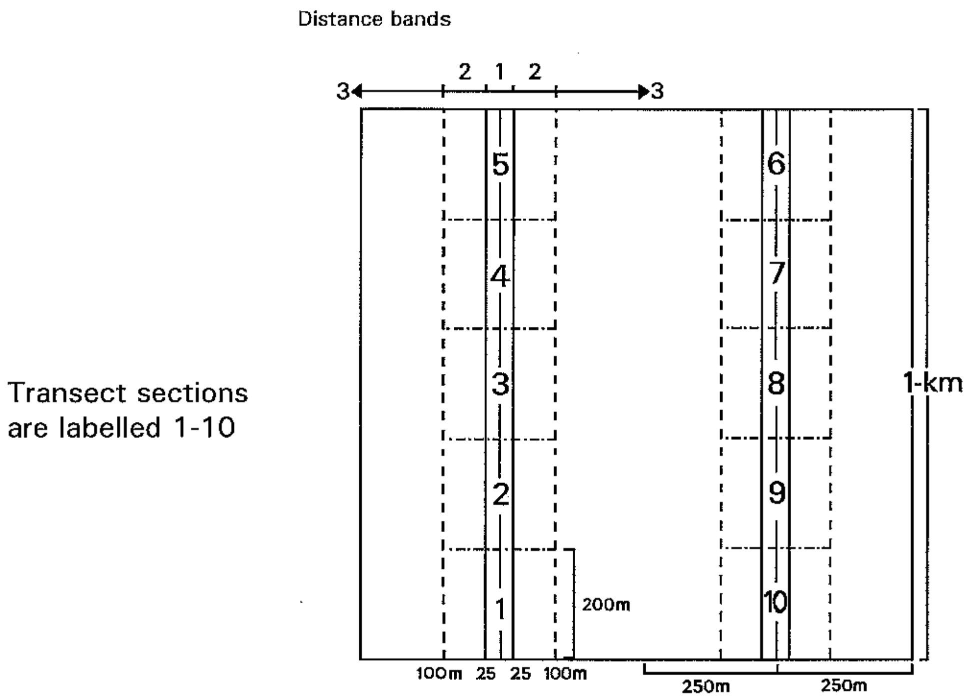


Figure 3.4.4 (Contd.)

Appendix 1 **Data recording ideal transect line used during BBS bird surveys. Large square represents the OS unit square. 2 km transects comprise two 500m parallel routes, 500m apart, subdivided into ten 200m sections. 1, 2 & 3 are the 3 terrestrial distance categories, along with flying birds, recorded for each square. (BBS Instructions 1998).**



Appendix 2 **BBS weather conditions classification scheme. (BBS Instructions 1998).**

Cloud cover	Rain	Wind	Visibility
0 - 33% = 1	None = 1	Calm = 1	Good = 1
33 - 66% = 2	Drizzle = 2	Light = 2	Moderate = 2
66 - 100% = 3	Showers = 3	Breezy = 3	Poor = 3

Appendix 3 BBS Species Codes

1.	B.	Blackbird
2.	BC	Blackcap
3.	BF	Bullfinch
4.	BH	Black-headed Gull
5.	BT	Blue Tit
6.	BZ	Buzzard
7.	C.	Carrion Crow
8.	CA	Cormorant
9.	CB	Corn Bunting
10.	CC	Chiffchaff
11.	CD	Collared Dove
12.	CG	Canada Goose
13.	CH	Chaffinch
14.	CK	Cuckoo
15.	CM	Common Gull
16.	CO	Coot
17.	CR	Crossbill
18.	CS	Common Sandpiper
19.	CT	Coal Tit
20.	CU	Curlew
21.	D.	Dunnock
22.	FP	Feral Pigeon
23.	G.	Green Woodpecker
24.	GB	Great Black-backed Gull
25.	GC	Goldcrest
26.	GG	Great Crested Grebe
27.	GH	Grasshopper Warbler
28.	GJ	Greylag Goose
29.	GL	Grey Wagtail
30.	GO	Goldfinch
31.	GP	Golden Plover
32.	GR	Greenfinch
33.	GS	Great Spotted Woodpecker
34.	GT	Great Tit
35.	GW	Garden Warbler
36.	H.	Grey Heron
37.	HG	Herring Gull
38.	HM	House Martin
39.	HS	House Sparrow
40.	J.	Jay
41.	JD	Jackdaw
42.	K.	Kestrel
43.	L.	Lapwing
44.	LB	Lesser Black-backed Gull
45.	LI	Linnet
46.	LO	Little Owl
47.	LR	Redpoll
48.	LT	Long-tailed Tit
49.	LW	Lesser Whitethroat
50.	M.	Mistle Thrush
51.	MA	Mallard
52.	MG	Magpie
53.	MH	Moorhen
54.	MP	Meadow Pipit
55.	MS	Mute Swan
56.	MT	Marsh Tit
57.	NH	Nuthatch
58.	OC	Oystercatcher
59.	P.	Grey Partridge
60.	PH	Pheasant
61.	PW	Pied Wagtail
62.	R.	Robin
63.	RB	Reed Bunting
64.	RG	Red Grouse
65.	RK	Redshank
66.	RL	Red-legged Partridge
67.	RN	Raven
68.	RO	Rook
69.	RT	Redstart
70.	RW	Reed Warbler
71.	S.	Skylark
72.	SC	Stonechat
73.	SD	Stock Dove
74.	SF	Spotted Flycatcher
75.	SG	Starling
76.	SH	Sparrowhawk
77.	SI	Swift
78.	SK	Siskin
79.	SL	Swallow
80.	SM	Sand Martin
81.	SN	Snipe
82.	ST	Song Thrush
83.	SU	Shelduck
84.	SW	Sedge Warbler
85.	TC	Treecreeper
86.	TD	Turtle Dove
87.	TO	Tawny Owl
88.	TP	Tree Pipit
89.	TS	Tree Sparrow
90.	TU	Tufted Duck
91.	W.	Wheatear
92.	WC	Whinchat
93.	WH	Whitethroat
94.	WO	Wood Warbler
95.	WP	Woodpigeon
96.	WR	Wren
97.	WT	Willow Tit
98.	WW	Willow Warbler
99.	Y.	Yellowhammer
100.	YW	Yellow Wagtail