BTO Research Report No. 405

Waterways Breeding Bird Survey: preliminary analyses of mammal data 1998-2003

Authors

Stuart E. Newson, David G. Noble & John H. Marchant

A report by the British Trust for Ornithology
under contract to the Joint Nature Conservation Committee

June 2005

WBBS is funded by the Environment Agency. Mammal monitoring within the WBBS is part of a wider suite of schemes looking at the changing fortunes of our mammal populations. These schemes are coordinated through the Tracking Mammals Partnership.

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

Stuart E. Newson, David G. Noble & John H. Marchant

Waterways Breeding Bird Survey: preliminary analyses of mammal data 1998-2003

BTO Research Report No. 405

Published in April 2005 by the British Trust for Ornithology
The Nunnery, Thetford, Norfolk IP24 2PU, UK

ISBN 1-904870-41-4

CONTENTS

Page No.

LIST OF TABLES

Page No.

TABLES

LIST OF FIGURES AND APPENDICES

Page No.

FIGURES

APPENDICES

1. EXECUTIVE SUMMARY

1. The Waterways Breeding Bird Survey (WBBS) was introduced in 1998 in collaboration with the Environment Agency's R&D Programme. Although primarily introduced as a counterpart of the Breeding Bird Survey, to monitor riparian bird species and populations, WBBS observers also record the mammals that they see as they walk their survey stretch or determine their presence by other means. Although summaries of the WBBS mammal data are included in the annual reports, there have been no attempts to calculate population trends. In this report we assess the effectiveness of the WBBS for monitoring UK mammal populations in riparian habitat, particularly specialist riparian species such as Water Vole, American Mink and Otter that are not currently monitored reliably on annual and national basis by any survey.

2. Preliminary analyses of WBBS data for 1998-2003 for the three riparian species, Water Vole, American Mink and Otter demonstrate that at the present levels of survey effort, there is sufficient power to detect a 48% change in presence of these species on WBBS stretches. Whilst this is quite low, a relatively small increase in surveyed stretches can result in a large increase in power to detect change in presence. For example, with 300 WBBS stretches, the power would allow an 33% decline in their presence on WBBS stretches to be detected, whilst with 700 stretches, a 25% decline in these species should be detectable. Additional power to detect change in these species could be obtained through combining WBBS with BBS data for these species, although the level of additional power obtained would not be useful in isolation unless combined with an increase in survey effort. It is unlikely that trends at a Government Office region, Country or by Environmental Zone could be produced for these species.

3. Analyses of sightings data for non-riparian species suggest that the populations of Brown Hare, Rabbit, Roe Deer and Grey Squirrel along waterways could be monitored by the WBBS. However, trends in habitat that borders waterways may not be representative of overall UK trends. Two species, Rabbit and Roe Deer, show significant population changes between 1998 and 2002. WBBS and BBS show a similar declining trend in Rabbit abundance and an increasing trend in Roe Deer abundance during this period.

4. In addition to producing national trends in relative abundance from count data, waterway-specific trends for Brown Hare, Rabbit and Grey Squirrel were produced for England, for Rabbit and Grey Squirrel in the westerly and easterly lowlands of England/Wales (zones 1 & 2) and for Brown Hare in the easterly lowlands of England/Wales (zone 1). There has been a significant decline in Rabbit in England and in the easterly and westerly lowlands of England/Wales during the period 1998 to 2003. However, these may not be representative of trends from all habitats.

5. For species that are not counted in sufficient numbers on WBBS stretches to assess change in abundance, there is potential for monitoring their change in presence. In this report we produce trends for Red Fox, Hedgehog, Mole, Brown Rat, Badger, Stoat and Weasel. For the most widely reported species, Mole and Red Fox, recorded on 30-50% of stretches, a decline of about 23-33% should be detectable. Hedgehog, Brown Rat, Badger, Stoat and Weasel were recorded on 10-15% of stretches, and would need to decline by 48-58% before a significant decline in the species were detected. The data collected since 2002 on the criteria for recording the presence of mammal species will need to be explore further to assess the reliability of trends produced from monitoring the change in presence on WBBS stretches. Trends for species such as Brown Rat, Stoat and Weasel should perhaps be treated with caution for this reason.

6. Whilst data for a number of additional species recorded by the WBBS are insufficient to calculate indices of abundance or presence/absence, these data may provide important

information on their distribution and relative abundance. WBBS data may be important if combined with data from other surveys, especially for species that are poorly monitored by any existing scheme. Although coverage is likely to vary across surveys, this may be controlled for through the production of interpolated distribution maps.

2. INTRODUCTION

In 1995, the BTO expanded the scope of the national bird-monitoring scheme, the Breeding Bird Survey (BBS) to also record information on British mammals. Uptake of mammal recording by BBS participants was very high, so when the Waterways Breeding Bird Survey (WBBS) was introduced in 1998 to survey riparian habitat with a similar survey methodology to the BBS, mammal recording was introduced concurrently. Recent analyses of the BBS mammal data demonstrate their importance for allowing population change to be monitored on an annual basis for a number of mammal species (see Newson & Noble 2003; 2004).

This report explores the first six years of mammal data collected by WBBS observers (between 1998 and 2003) to assess the effectiveness of the WBBS for monitoring British mammals. Of particular interest is the potential of this survey for producing national trends in relative abundance for Water Vole, American Mink and Otter, which are not reliably monitored on an annual basis by any other survey. We provide an overview of WBBS mammal data collected to date, present preliminary population trends for mammal species monitored in sufficient numbers, and outline approaches for future analyses and reporting of these data. In particular we examine whether it is possible to produce trends for English Government Office Regions, Countries or Environmental Zones, which cover the range of environmental conditions that we find in Great Britain, and explore the use of presence information to monitor change in populations of species such as Badger and Mole which are rarely observed, but leave obvious signs of their presence. Distribution maps based on mammal presence on WBBS stretches are presented to illustrate species distributions.

3. METHODS

3.1 Selection of survey sites

The WBBS uses a random sampling design, allowing WBBS results to be treated as representative of waterways across the UK. For this, 2x2 km squares (tetrads) were initially selected at random from all 2x2 km squares that make up the National Grid, discarding squares with no waterway running through them. The tetrad was chosen as the most appropriate scale at which to select waterways, because a high proportion of 1 km squares held no waterway and larger squares of 5x5 km or larger frequently held more than one waterway, raising the problem of which waterway should be chosen. Important to the sampling, and following interpretation is a clear definition of what we mean by waterways. Waterways here includes rivers, canals, stretches that could be defined as both river and canal, and various ditches and drains of 6.5 m wide or more as shown by double blue lines on Ordnance Survey (OS) 1:25,000 pathfinder/Explorer/Outdoor Leisure maps. All non-linear water features are ignored and rivers are considered to finish at the normal tidal limit, shown as 'NTL' on OS maps.

For each randomly selected waterway, a map is prepared showing the boundaries of the random tetrad and the selected waterway is identified on the map with a highlighter. The survey is coordinated at BTO headquarters through a network of volunteer Regional Organisers who are responsible for the volunteer observers in their region and whose job it is to match each site to an observer. The start and end points of the survey within the highlighted length of waterway are not pre-set, but are left to up to the observer to determine, although it is required that a whole number of 500 m transects are surveyed. This flexibility allows for any access problems to be overcome in the majority of cases, and a survey route set up that can be revisited on a long-term basis.

In addition to random stretches, since 1999 the WBBS has included a number of non-random stretches chosen because there was Waterways Bird Survey (WBS) bird data available for these. These stretches differ from the random stretches in their geographical distribution, and could be biased towards sites that are richer in birds and mammals. For further details on the selection of WBBS stretches see Marchant & Coombes (2004).

3.2 WBBS fieldwork methods

The methodology of the WBBS is derived from that of the Breeding Bird Survey (BBS), in which two bird/mammal recording visits are made, termed 'early' and 'late'. The early visit is made between April and mid-May and the second at least four weeks later between mid-May and the end of June (Noble *et al*. 2004). WBBS visits are timed to start at between 0600 and 0700 hours. Visits during heavy rain, strong winds or poor visibility are discouraged. The transect route is divided into up to ten sections of fixed length (500 m). The transect section length of 500 m was chosen to be comparable with data collected through the Environment Agency's River Habitat Survey (RHS) and is different from the BBS which is divided into 200 m transect sections. A further difference from the BBS is that transects are not a fixed 2 km, but are of variable length, up to a maximum of 5 km (ten 500 m sections).

During each visit, all mammals detected from the transect line (i.e. following the waterway) during the two bird counts are counted and recorded. Unlike the WBBS bird data, data for mammals are recorded within a single distance category. Habitat is recorded for each 500 m transect section according to an established system, common to a range of BTO schemes (Crick 1992), whilst mammals are recorded at the entire stretch rather than 500 m transect level.

In order to collect information on widespread but seldom seen species such as Mole and Badger, observers are asked to record the presence of mammal species on the basis of counts of live and dead animals, counts made on any additional visits to the stretch, from field signs (e.g. tracks, droppings, molehills) or known to be present that season from local knowledge (e.g. from a gamekeeper or

landowner). Prior to 2002, observers did not record the method or methods by which the species was known to be present, while since 2002 observers have been asked to record this information.

3.3 Temporal trends in abundance

For species where counts of live animals are made, the maximum number of each species of mammal sighted over the two visits (early and late) was determined for each WBBS stretch in each year from 1998 to 2003. Survey work was severely affected by foot-and-mouth restrictions in 2001, resulting in a heavy bias towards particular areas of the country in this year. For this reason, we exclude survey data for 2001 from all analyses. Using these data, log-linear Poisson regression was used to model site counts, with site and year effects (ter Braak *et al*. 1994) for the UK, where the year effect is an index of the change in numbers relative to 1998, the first year of the survey. This year, (1998) is set to an arbitrary index value of 1 from which all other years are measured. Counts of animals can violate the assumption of a Poisson distribution, so corrections for over-dispersion are made using the dscale option in SAS (SAS 1996).

As with many long-term surveys these data include many missing values, where a particular site was not surveyed in a particular year. The model is estimated using the observed counts to predict the missing counts and calculate the indices from a full data set, including the observed and predicted counts. The model requires that two points in the time series are available to estimate parameters, so stretches counted in one year only are excluded from the analysis. If the data contain too many missing values, the model parameters cannot be estimated. Because the design of the WBBS is truly random, and unlike the BBS which is stratified by observer coverage, we do not weight annual counts by the inverse of the proportion of each region that is surveyed in that year. However, there is an argument that the inclusion of non-random WBBS sites, based on the location of WBS sites may necessitate a weighting to be devised in the future, perhaps based on the distribution of waterways in the UK.

A complexity in producing mammal trends from WBBS data is that a WBBS stretch may record more mammals, simply because more 500-m transect sections are surveyed. To control for this in the analyses, we include the log of the number of transect sections as an offset variable in the analyses (see Stokes *et al*. 2003 for a further discussion of offsets).

In the analyses of BBS mammal data (Newson & Noble 2004), only results for species occurring on a mean of 40 or more 1 km squares in two or more years of the survey are presented. This cut-off point is based on power analyses by Newson & Noble (2003) and work by Joys *et al*. (2003) on BBS bird data, which showed that at the current level of survey effort, the power would be too small to detect a significant change in the populations of species occurring on fewer squares. However, the WBBS differs from the BBS in that the stretches are longer (average of 7 x 500 m transect sections compared with 10 x 200 m transect sections of the BBS), so the power to detect population change is likely to be greater for the WBBS for the same number of sites surveyed. In this report we relax the 40 sites threshold and present all trends based on 20 or more stretches, but also assess the power of the WBBS to detect specified level of population change in these species at the current level of survey effort.. To examine the significance of the trends here we make a comparison between the first and last years of the survey. Because non-overlapping of 95% confidence intervals highlights significance at the 5% level or more, separate formal analyses to examine differences between indices were not performed.

To explore the possibility of producing regional or landscape-specific population trends, we assess the potential of the WBBS for producing annual indices in the same way as above, where data allowed, for the nine English Government Office Regions and for England, Scotland, Wales and Northern Ireland and for six Environmental Zones of Great Britain, shown graphically in Figures 1 & 2. The six Environmental Zones produced from the CS2000 field survey, are based on combinations of CEH land classes which cover the range of environmental conditions that we find in Great Britain, from the lowlands of the south and east, through to the uplands and mountains of the north and west (Bunce *et al*. 1996). Northern Ireland has its own set of Environmental Zones that have been devised on a different basis to those used

for Great Britain. Because the number of sites surveyed in Northern Ireland is very small, we do not consider the production of separate trends for this region.

3.4 Temporal trends in presence

For species that are not counted in sufficient numbers to examine the change in relative abundance over time, but which leave obvious field signs or which are known to be present along a WBBS stretch, it may be possible to examine the change in presence on surveyed stretches. Species presence is defined here as information demonstrating that the species is present on a WBBS stretch in a particular year. This may include counts of live animals as used in the above analyses, dead animals, field signs (e.g. tracks, scats, mole-hills), local knowledge of presence for that year from a gamekeeper or landowner or live animals seen on additional visits to the stretch during that season.

In response to recommendations made in preliminary analyses of BBS mammal data (see Newson & Noble 2003), a change in the survey form in 2002 asked observers to indicate the primary method or methods by which the species was recorded as being present, this change was also applied to WBBS mammal data. Examining these data for 2002 and 2003 in Table 1, suggests that of species that cannot be monitored through counts of live animals, the sample sizes may allow the change in presence of Red Fox, Hedgehog, Mole, Brown Rat, Badger, Stoat, Weasel, American Mink, Water Vole and Otter on WBBS stretches to be monitored. Although we produce trends for these species, the precision and power to detect population change may be a limiting factor. The power of the WBBS to detect specified levels of change in species presence for these species is examined below.

To examine the change in presence of these species, we model presence/absence as a function of site and year using logistic regression. The year effect here is the relative odds ratio, which is the odds of being present on a particular WBBS stretch in a particular year *relative* to the odds of being present on that stretch in the first year in the time series. The first year in the series is set to an arbitrary value of 1. To illustrate, if in the first year, the probability of being present is 0.2, the probability of being absent is 0.8. The odds of being present would therefore be 0.8/0.2 = 0.25. If, five years later, the probability of being present was 0.8 and the probability of being absent was 0.2, the odds of being present would be 4, and the odds ratio relative to the first year would be 4/0.25 = 16. In these analyses, the year effect is produced relative to the first year in the series, 1998. Acceptably the results of the presence/absence analyses here are not as easy to interpret as the analyses of abundance above. For this reason we also present simple figures in Appendix 1 showing the percentage change in the presence of these species on BBS squares.

3.5 Statistical power

It is important to understand the power with which the scheme is able to detect population change. The number of WBBS stretches surveyed should be large enough to detect a required level of change within a specified time period and avoid too much effort in collecting more data than is needed to meet the objectives of the project. The uniqueness of the WBBS is its potential for monitoring riparian species i.e. Water Vole, American Mink and Otter. Whilst it is useful to have additional trends for terrestrial species to compare with those from other independent surveys, the WBBS is likely to reflect trends in populations of species along waterways, it is important to stress that these may not be representative of trends at a national across-habitat level.

3.5.1 Presence/absence data

We use two approaches to examine the relationship between the power of detecting a specified decline and the starting proportion of occupied sites and sample size. The first approach was to estimate the power to detect a difference between two proportions i.e. two chosen years, with a specified starting proportion (proportion of occupied stretches), population change and sample size, as described in Zar (1999, p. 558-559). This assumes that sites are “unmatched” i.e. independent of one another between years. The chosen starting proportions are 0.70, 0.60, 0.50, 0.40, 0.30, 0.20, 0.10,

0.05 and 0.01 and cover the real proportion of stretches in which different mammal species were recorded during the survey (see Table 2) and population decline is simulated in 5% increments for each of these starting proportions. A sample size of 181 sites is chosen as the mean number of WBBS sites surveyed for mammals between 1998-2003, excluding 2001, in which coverage was severely reduced and coverage biased, due to foot-and-mouth restrictions. In these analyses, we assume that the mean WBBS stretch length does not vary between years. If for example there were a trend towards longer transects being surveyed, this would potentially increase the power of the survey. For 1998-2002 (excluding 2001) the mean number of stretches surveyed is 7. Although we exclude data for 2001 in all analyses here, it is interesting to note that a higher proportion of longer stretches were surveyed in this year (mean of 8 stretches), adding another reason in addition to biased geographical coverage for excluding data for this year (Figure 3).

The second approach is to assume a completely "matched" survey design and to randomly generate artificial mammal presence/absence data with a defined starting proportion of occupied sites (0.70, 0.50, 0.30, 0.20, 0.10, 0.05), a sample size of 181 survey squares, (equivalent to the mean number of stretches surveyed by the WBBS between 1998 and 2003, excluding 2001) and linear decline over a ten year period. A simple GLM with a linear trend was then fitted to these artificial data and the entire process repeated 100 times to generate 100 data sets based on the chosen scenario. The power to detect a pre-determined level of decline under the defined scenario was then determined by testing the significance of the linear time trend term of each replicate and examining the proportion of the 100 replicates in which there was a significant decline at the 5% level, which is used as a measure of statistical power. This approach is very computer intensive, which limits the number of simulations possible, although is probably closer in design to the WBBS in which a relatively large proportion of sites are likely to be resurveyed each year, although there will be some turnover in sites surveyed.

3.5.2 Abundance data

Very similar to the second approach above, a log-linear Poisson regression model was used within a GLM framework to generate artificial species abundance data (100 replicates) with the same proportion of occupied sites, sample size and linear decline as above. A starting mean population size of two on occupied stretches was chosen because it represents the approximate mean number of individuals per WBBS stretch recorded for species for which it may be possible to monitor population change (i.e. Rabbit, Brown Hare, Grey Squirrel and Roe Deer). The power to detect different levels of decline are determined as above for each scenario over a period of 10 years.

3.6 Mapping distribution along waterways

A distribution map is produced for each species recorded on WBBS squares in one or more year of the survey, from information that demonstrates the presence of the species (Appendices 1 & 2). Maps of this type provide useful information on the distribution of species, and are likely to highlight the strongholds of particular species, although the non-random component based on surveyed WBS sites may bias this to some degree towards areas of higher observer density. An alternative method trialed by Newson & Noble (2004) for BBS mammal data to interpolate statistically valid maps of relative abundance is an alternative approach that could be considered for the most abundant species, or adapted to model species presence/absence.

4. RESULTS

Because we are particularly interested in examining the potential of this survey for producing national trends in relative abundance for three Riparian species Water Vole, American Mink and Otter, a simple summary of results for these species is additionally presented in Appendix 2.

4.1 Survey effort and description of WBBS stretches

The distribution of WBBS stretches surveyed for mammals in one or more years between 1998 and 2002 is shown in Figure 4. During this period (excluding 2001), mammal data were collected from a mean of 181 stretches (Table 3). For interpretation, it is useful to have an understanding of the presence of habitat and other features that may be important for particular species. For example, Water Voles may be restricted to rivers of more than 3 m wide, whilst the presence of Brown Hare is likely to be related to the bordering farmland, rather than the waterway itself. The hierarchical habitat recording system devised by Crick (1992) allows a number of important features, which may be related to the presence of particular species to be recorded by the observer. Whilst the primary habitat is recorded as a waterbody with no further detail, the second level of primary habitat provides a more detailed description of the waterway itself (Table 4). This shows that about 70% of WBBS stretches are rivers of more than 3 m wide, whilst about 20% are large canals exceeding 5 m in width. In addition to the habitat, the level of disturbance may be important in determining whether a species is present. Of surveyed WBBS stretches, about 40% are undisturbed, 30% are used for game or coarse fishing purposes, whilst the remaining stretches are used for a number of purposes, including sewage processing, for watersports, boating or industrial use (Table 5). The secondary habitat (e.g. farmland, woodland) may be of greatest interest, particularly for non-riparian species. Examining the breakdown of secondary habitat recorded on WBBS stretches, the majority of stretches fall into one of three habitats. Farmland borders about 45% of WBBS stretches, whilst 15% of stretches border woodland and 20% border human sites - rural, suburban or urban (Table 6).

4.2 Temporal changes in abundance

4.2.1 UK trends

Between 1998 and 2003, observers recorded sightings of a total of 28 mammal species (Table 7). When interpreting this table, it is important to highlight a number of changes to the WBBS mammal survey form, which have influenced the apparent abundance (and presence) on WBBS stretches of some mammal species. Whilst observers have always been asked to record all mammal species sighted or known to be present, the survey form lists a number of the most regularly recorded species with space for recording count and presence information. In 2000, Feral Cat and Sika Deer were added to the standard list of species. The addition of Sika Deer made no difference because this species has yet to be recorded on WBBS stretches, but the inclusion of Feral Cat resulted in an apparent increase in the proportion of stretches reporting this species in 2000.

Temporal trends in abundance based on counts were produced for four species reported on a mean of 20 or more stretches in the UK. These were Brown hare, Rabbit, Roe Deer and Grey Squirrel (Table 8). Because the model requires that a species be recorded in two or more years of the survey, stretches recording the species only once during this period are excluded. This explains the difference in sample size between Tables 7 and 8. Rabbit and Roe Deer showed a significant difference between the first and last years in the series. Whilst the run of years is relatively small in which to establish whether this reveals an underlying trend in abundance or annual fluctuation in abundance, there is a decrease in Rabbit abundance over the entire survey period and an increase in Roe Deer, mainly from 1999.

4.2.2 Country and regional trends

Of the four species for which it was possible to produce trends in abundance at a UK level, data were sufficient to produce regional/country trends for England for three of these species - Brown Hare, Rabbit and Grey Squirrel (Table 9, Table 10). A comparison between the first and last years showed a significant difference in abundance for Rabbit in England.

4.2.3 Environmental zones

In the same way as regional trends were produced, data were examined to determine for which environmental zones of Great Britain there were sufficient data to produce separate species trends (Table 11). Trends could be produced for three mammal species within one or more environmental zone (Brown Hare, Rabbit and Grey Squirrel), trends for which are shown in Table 12. A comparison between the first and last years in the series revealed significant declines between the first and last years for Rabbits in the Westerly and Easterly lowlands of England/Wales (zones 1 & 2) between 1998 and 2003.

4.3 Temporal changes in presence

The number of WBBS stretches reporting the presence of mammals from counts of live animals, as used in the above analyses, dead animals, field signs (e.g. tracks, scats, mole-hills), local knowledge of presence for that year from a gamekeeper or landowner or live animals seen on additional visits to the stretch during that season for all species recorded in 1998-2003 are shown in Table 2. By these means, 34 species were recorded on WBBS stretches over this period. Of the ten species for which we model the change in presence on WBBS stretches (Red Fox, Hedgehog, Mole, Brown Rat, Badger, Stoat, Weasel, American Mink, Water Vole and Otter), the Red Fox, Mole, Brown Rat, Badger, Otter, Water Vole and American Mink show no evidence for a decline over this period. However, there were significant declines in the recording of Stoat, Weasel and Hedgehog on WBBS stretches from 1998 to 2003 (Table 13, Figure 6). For comparison with the odds ratio plots for these species in Figure 6, Appendix 3 shows the proportion of sites recording presence in each year from 1998 to 2003.

4.4 Statistical power

4.4.1 Presence/absence data

The first approach, assuming an “unmatched” survey design, is summarised in Figure 7 for the current survey coverage of 181 WBBS stretches. From this figure it is possible to examine the approximate level of decline that could be detected between two years for species surveyed by the WBBS, with an ‘optimistic’ power of 60%.

For Rabbit, which was recorded on about 70% of stretches surveyed it should be possible to detect a 16% decline between two years, whilst for Mole, Red Fox, Grey Squirrel and Brown Hare recorded on 30-50% of stretches, a decline of about 23-33% should be detectable. For Roe Deer, which was recorded on about 25% of stretches, it should be possible to detect a decline of about 37%, Whilst Hedgehog, Red Deer, Brown Rat, Badger, Stoat and Weasel recorded on 10-15 of stretches, declines of about 48-58% would need to occur before these were detected.

For the majority of species recorded on 5% or fewer of WBBS stretches surveyed, it is unlikely that a decline in the presence of these species would be detected until their populations decline by 75% or more. Realistically, it is unlikely that the WBBS will be able to reliably monitor populations of these species in the future.

The three riparian species (Water Vole, American Mink and Otter), were recorded on about 15% of stretches. Whilst the detection rate of these species is high relative to BBS, the power to detect a decline in the populations of these species with the current level of survey effort would require these

species to decline by about 48% for a decline to be detected. Increasing the number of WBBS stretches surveyed will enable a smaller decline in these species to be detected. In order to determine the optimum level of coverage needed to detect a biologically important level of decline, we examine the influence of hypothetically doubling the number of stretches to 362, and further increasing coverage to 500, 750, 1000, 1500, 2000, 2500 and 3000 stretches (Figure 8). This shows that if the survey effort were to be increased to 750 stretches, it should be possible to detect a 25% decline in these three species, whilst if 1500 stretches were surveyed a decline of about 18% should be detectable. An important point demonstrated in the figure, is that above 1500 stretches, extra effort results in very little extra power to detect a decline.

An alternative or perhaps additional approach that could be considered would be to combine WBBS and BBS data for riparian species, i.e. Water Vole, Otter and American Mink. The location of WBBS stretches and BBS squares reporting the presence of these species is shown in Figure 9 and number and proportion of total sites surveyed (WBBS + BBS) is shown in Table 14. With this level of coverage and using the mean proportion of sites reporting the presence of these species (which is about 2% of total sites surveyed), the populations of these species would need to decline by about 43% for a decline to be detected (Figure 10). Without BBS data, about a 48% decline would be detectable, so the effort of combining these data sets, with the current level of coverage of both surveys, suggests that the advantages of doing this would be relatively small, unless this is combined with an increase in number of WBBS stretches surveyed.

Results of the second approach assuming a "matched" survey design i.e. the same 181 WBBS stretches surveyed over a ten-year period are summarized in Table 15. These simulations show that it should be possible to detect a 50% decline over a 10-year period for species occurring on as few as 20% of stretches surveyed i.e. Brown Hare, Rabbit, Grey Squirrel, Red Fox, Roe Deer and Mole. It should also be possible to detect a 25% decline for species occurring on at least 50% of stretches surveyed (Rabbit and Mole). There is insufficient power to detect a 25% decline for species occurring on fewer than 50% of stretches. These simulations also suggest that it is unlikely that there would be enough power to detect a 10% decline over a ten-year period for any species, even for the Rabbit, with a starting presence of about 70% of stretches surveyed.

4.4.2 Abundance data

Results of simulations using log-linear Poisson regression models to examine the power to detect changes in abundance are shown in Table 16 for a "matched" survey design. These suggest that it should be possible to detect a 50% decline in abundance over a 10-year period for species occurring on as few as 10% of stretches surveyed i.e. Brown Hare, Rabbit, Grey Squirrel, Red Fox and Roe Deer. It should also be possible to detect a 25% decline for species occurring on 50% or more of stretches surveyed (Rabbit only), with a power of about 94%. As with the presence simulations, it is unlikely that a 10% decline in abundance would be detected over the ten-year period for any species.

4.5 Comparing trends from the WBBS and BBS

Because the WBBS is designed to monitor waterways and bordering habitat, national trends for non-riparian species based on WBBS data are unlikely to be representative of those over the entire UK landscape. However, it is still interesting to see how these compare with trends produced through the BBS.

Figure 11 compares WBBS and BBS temporal trends in relative abundance at a UK scale for four species, Rabbit, Brown Hare, Grey Squirrel and Roe Deer. BBS mammal data for 2003 is not available at the time of writing for use, so trends are compared up during the period of overlap from 1998 to 2002. For both surveys we interpolate an index value for 2001, because data for this year for are likely to be biased due to the effect of foot-and-mouth disease on coverage.

Trends in relative abundance of Rabbit and Roe Deer in both surveys are very similar during the period of overlap; with Rabbit showing a continued decline during the period (1998-2002 and Roe Deer increased. Grey Squirrel are also well matched, whilst trends for Brown Hare are very different. On BBS squares, hares have remained relatively stable, whilst on WBBS stretches, hares increased, at least from 1999.

5. DISCUSSION & CONCLUSIONS

5.1 The effectiveness of the WBBS for monitoring riparian species at a national level

An advantage of the waterways-stratified design of WBBS is its potential for monitoring riparian species, in particular Water Vole, American Mink and Otter, which are not reliably monitored on an annual basis by any other survey. However, with the current level of coverage (on average 181 WBBS stretches surveyed per year), the power to detect population change (in relative abundance or presence) is small. Using counts of Water Vole, American Mink and Otter, which are recorded on 5% or less of visits to WBBS stretches (see summary of coverage in Appendix 4), the populations of these species would need to decline by about 80-100% over a ten year period for a significant decline to be detected. Because of the higher proportion (15%) of WBBS stretches reporting the presence of Water Vole, American Mink and Otter based upon a combination of live animals, dead animals, field signs, local knowledge and additional visits, the power to detect a change is greater than using count data and therefore provides greater potential for monitoring change in these species. Using presence/absence data and with the current level of survey effort, a 48% decline in presence on WBBS stretches would need to occur for a significant decline in these species to be identified

Increasing the number of WBBS stretches would increase the power to detect population decline in Water Vole, American Mink and Otter, but it is essential to know the additional survey effort that would be required to be able to detect a 'useful' level of decline without putting in extra effort that results in little gain in power. Analyses to determine the effect of increasing coverage on power to detect changes in abundance found that with 750 WBBS stretches, a 25% decline in Water Vole, American Mink and Otter would be detectable, whilst increasing this to 1500 stretches would allow a 18% decline to be detected.

An alternative method for effectively boosting the number of sites monitoring riparian species, and hence power to detect declines, might be to combine WBBS and BBS data for these species. This is feasible where the species are restricted to the waterways stratification in the WBBS design (and absent elsewhere) and hence data are comparable. Whilst the proportion of BBS squares with records of Water Vole, American Mink and Otter is much smaller than the proportion of WBBS stretches reporting these species, the larger number of BBS sites would allow a 43% decline in these species to be detected if used in combination with WBBS data, compared with a 48% decline using WBBS data only. Although combining WBBS and BBS data for these species results in little additional power on its own, it may be particularly effective if done in conjunction with increased WBBS survey effort. The analytical difficulties in combining BBS and WBBS data are not discussed here, but would require a weighting system that allows for the differences in sampling design (stratified random versus random).

5.2 Which additional species might we be able to monitor through the WBBS at a national level?

It is interesting to have waterways-specific trends for non-riparian species for comparison with trends derived from other surveys. However, because the WBBS reflects trends in populations of species along waterways that may not be the same as overall trends, it would not be advisable to compare trends without considering this bias.

In this report we present trends in abundance based on counts from WBBS stretches for four species (Brown Hare, Rabbit, Roe Deer and Grey Squirrel) occurring on a mean of 20 or more WBBS stretches. We did not produce trends for rarer species because there were insufficient data, and hence very little power to detect changes in the populations of these species. Simulations assuming a "matched" survey design (i.e. same squares surveyed each year) suggests that it should be possible to detect a 50% decline in the abundance of these species over a 10-year period. For the Rabbit, reported on about 50% of WBBS stretches, a 25% decline over 10-year period should be detectable. The

significant increase in Roe Deer and the significant decline in Rabbit between 1998 and 2003, were similar to the results from analyzing BBS mammal records over roughly the same period.

For species that are not counted in sufficient numbers on WBBS sites to assess change in abundance over time, there is potential for monitoring their change in presence based on recording a combination of live animals, dead animals, field signs (tracks, scats, mole-hills), local knowledge of presence for that year from a gamekeeper or landowner, or animals seen on additional visits to the stretch during that season. Excluding species recorded on fewer than 20 WBBS stretches annually, we produce trends for Red Fox, Hedgehog, Mole, Brown Rat, Badger, Stoat and Weasel. For Mole and Red Fox recorded on 30-50% of stretches, a decline of about 23-33% should be detectable, whilst Hedgehog, Red Deer, Brown Rat, Badger, Stoat and Weasel recorded on 10-15% of stretches, would need to decline by 48-58% before a significant decline was detected. Obviously, the reliability of trends produced from monitoring the change in presence on WBBS stretches depends on the reliability of the data. Of all categories for the recording of species presence, the category of local knowledge that season obtained from gamekeepers/landowners is perhaps the most dubious. Trends in the change in presence of Stoats, Weasels and Brown Rat would be based largely on data of that type, as seen in the breakdown of record types for 2002 and 2003, and should be treated with caution.

5.3 What species might be able to monitor at a regional, country or landscape level?

As discussed above, trends produced on a regional, country or landscape level may be representative of trends along waterways, but not necessarily overall trends. At current WBBS coverage, it is not possible that reliable trends could be produced at an English Government Office Region level for any species of British mammal, whilst at a country level it is possible to produce trends for Brown Hare, Rabbit and Grey Squirrel, at least for England. Examining the data for producing trends for Environmental Zones, suggests that it may be possible to produce trends for Rabbit and Grey Squirrel in the westerly and easterly lowlands of England/Wales (zones 1 & 2) and for Brown Hare in the easterly lowlands of England/Wales (zone 1). There is evidence of a significant decline in Rabbits in England and in the Easterly and Westerly Lowlands of England/Wales during the period 1998 to 2003.

5.4 What useful information might be gained for scarce or highly localised species?

For species for which indices of abundance using counts or presence could not be calculated, the WBBS may nevertheless provide important information on their distribution. These data could be combined with data from other surveys, especially for species that are poorly monitored by existing surveys. Although coverage is likely to vary between surveys, this bias could be controlled for in the production of interpolated maps, as has been examined in relation to BBS mammal data (Newson & Noble 2004).

5.5 Improvement in mammal monitoring through the WBBS

There have been a number of changes to the WBBS (and BBS) mammal recording form since the introduction of this survey in 1998. In 2000, there was a change to clarify what the presence should include, making it clearer that this should include the recording of dead animals, information from personal communication with landowners/gamekeepers and stating specifically on the survey form examples of signs including mole-hills and Badger latrines. These changes may have increased the number of records in these categories. Feral/domestic cat and Sika Deer (which is yet to be recorded on WBBS stretches) were added to the survey form in 2000, resulting in an apparent increase in the presence of cat on WBBS stretches from 2000. A further change to the survey form in 2002 asked observers to specify the criteria for recording presence, i.e. whether presence was from live animals, dead animals, field signs, local knowledge of presence for that year from a gamekeeper or landowner or live animals seen on additional visits to the square during that season. The change to the survey form in 2002 was intended to provide more detail and should in principle have had little influence on the rate of recording of presence, but this will have to investigated with more years of the new data.

Although these changes have improved the quality of the data and our ability to interpret trends produced from these data, they also highlight the importance of continuity in the WBBS survey form unless there is a very strong argument for changing it.

As discussed earlier, one of the greatest potential values of the WBBS is its potential for monitoring riparian species, in particular Water Vole, American Mink and Otter. At the current level of coverage, the power to detect population change in these species is small. Whilst there has been an increasing number of stretches being surveyed in recent years, increasing the power to detect change, survey effort would need to increase to 300 stretches per year to allow a 33% decline to be detected. To detect declines in these riparian specialists of 25% or less, effort would need to be increased to 750-1500 stretches, which is unlikely to be obtained.

ACKNOWLEDGEMENTS

This work is funded by the Joint Nature Conservation Committee (JNCC) under the supervision of Dr Jessa Battersby. We are grateful to Steve Freeman for statistical advice. The WBBS is supported by the Environment Agency's R&D programme. We also acknowledge the financial support of Anglian Water, British Waterways, Northumbrian Water, Essex & Suffolk Water, Severn Trent Water, Thames Water and Welsh Water. BBS is funded by the BTO, JNCC (on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Environment and Heritage Service in Northern Ireland), and the RSPB. The BTO relies heavily on volunteers to collect the data used in these analyses. We are very grateful to all observers who have contributed data to these analyses, and to the BTO's Regional Representatives.

REFERENCES

Bunce, R. G. H., Barr, C. J., Clarke, R. T., Howard, D.C. & Lowe, A. M. J. 1996. The ITE Merlewood Land Classification. *Journal of Biogeography* **23**, 625-634.

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

Joys, A.C., Noble, D.G. & Baillie, S.R. 2003. *Evaluation of species coverage and precision using the BBS indexing method*. BTO Research Report No. 317. BTO, Thetford.

Marchant, J.H. & Coombes, R.H. 2004. *Waterways Breeding Bird Survey progress report for 2002-03*. A report to the Environment Agency. BTO Research Report 357. BTO, Thetford.

Newson, S.E. & Noble, D.G. 2003. *Preliminary analyses of Breeding Bird Survey (BBS) mammal data*. BTO Research Report No. 321. BTO, Thetford.

Newson, D.G. & Newson, S.E. 2004. *Analyses of Breeding Bird Survey mammal data 1995-2002*. BTO Research Report, First Draft. BTO, Thetford.

Noble, D.G., Newson, S.E., Baillie, S.R., Raven, M.J. & Gregory, R.D. 2004. Recent changes in UK bird populations measured by the Breeding Bird Survey. *Bird Study*, in press.

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

Stokes, M.E., Davis, C.S. & Koch, G.G. 2003. *Categorical Data Analysis Using the SAS System*, Second Edition. Cary, NC: SAS Institute Inc.

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

Zar, J.H. 1999. *Biostatistical Analysis*. Fourth Edition. Prentice Hall.

Table 1. The number (and percentage) of WBBS stretches recording the presence of mammals recorded in 2002 and 2003 from counts of live animals, dead animals, field signs, local knowledge of presence for that year from a gamekeeper or landowner, or live animals seen on additional visits to the stretch that season.

Species	Live animals		Dead animals		Field signs		Local knowledge		Live animals additional visits	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Hedgehog	0	6 (2.7)	2 (1)	5 (2.3)	3 (1.5)	2 (0.9)	6 (3.1)	14 (6.3)	9 (4.6)	5 (2.3)
Mole	3 (1.5)	0	4 (2)	2 (0.9)	96 (49)	93 (42.1)	14 (7.1)	14 (6.3)	1 (0.5)	3 (1.4)
Shrew sp	2 (1)	2 (0.9)	2 (1)	4 (1.8)	0	0	0	0	0	0
Water shrew	0	0	0	1 (0.5)	0	0	0	0	0	1 (0.5)
Rabbit	106 (54.1)	123 (55.7)	2 (1)	0	12 (6.1)	18 (8.1)	9 (4.6)	13 (5.9)	17 (8.7)	16 (7.2)
Brown Hare	45 (23)	49 (22.2)	0	0	0	2 (0.9)	4 (2)	4 (1.8)	9 (4.6)	12 (5.4)
Mountain Hare	2 (1)	3 (1.4)	0	0	2 (1)	2 (0.9)	3 (1.5)	3 (1.4)	0	1 (0.5)
Red Squirrel	5 (2.6)	3 (1.4)	0	0	1 (0.5)	0	2 (1)	2 (0.9)	2 (1)	3 (1.4)
Grey Squirrel	57 (29.1)	76 (34.4)	1 (0.5)	1 (0.5)	6 (3.1)	3 (1.4)	11 (5.6)	10 (4.5)	22 (11.2)	16 (7.2)
Bank Vole	1 (0.5)	0	0	0	1 (0.5)	0	0	0	2 (1)	0
Field Vole	0	0	0	1 (0.5)	0	0	0	0	1 (0.5)	0
Water Vole	8 (4.1)	7 (3.2)	0	0	4 (2)	2 (0.9)	8 (4.1)	4 (1.8)	7 (3.6)	4 (1.8)
Wood Mouse	0	1 (0.5)	0	0	0	0	0	0	1 (0.5)	1 (0.5)
House Mouse	1 (0.5)	0	0	0	0	0	0	0	0	0
Brown Rat	4 (2)	6 (2.7)	2 (1)	2 (0.9)	3 (1.5)	1 (0.5)	11 (5.6)	6 (2.7)	3 (1.5)	5 (2.3)
Common Dormouse	0	0	0	0	1 (0.5)	0	0	0	0	0
Red Fox	23 (11.7)	22 (10)	1 (0.5)	0	29 (14.8)	27 (12.2)	22 (11.2)	30 (13.6)	21 (10.7)	19 (8.6)
Pine Marten	0	1 (0.5)	0	0	0	0	2 (1)	0	0	0
Stoat	4 (2)	9 (4.1)	0	1 (0.5)	0	0	11 (5.6)	12 (5.4)	7 (3.6)	9 (4.1)
Weasel	4 (2)	1 (0.5)	0	0	1 (0.5)	0	7 (3.6)	13 (5.9)	5 (2.6)	5 (2.3)
American Mink	1 (0.5)	7 (3.2)	0	1 (0.5)	4 (2)	4 (1.8)	11 (5.6)	14 (6.3)	5 (2.6)	10 (4.5)
Badger	0	1 (0.5)	3 (1.5)	3 (1.4)	21 (10.7)	28 (12.7)	14 (7.1)	12 (5.4)	4 (2)	5 (2.3)
Otter	3 (1.5)	1 (0.5)	1 (0.5)	0	13 (6.6)	12 (5.4)	16 (8.2)	16 (7.2)	3 (1.5)	4 (1.8)
Wild Cat	0	0	0	0	0	0	1 (0.5)	0	0	0
Feral/Domestic Cat	20 (10.2)	23 (10.4)	0	0	1 (0.5)	1 (0.5)	7 (3.6)	13 (5.9)	11 (5.6)	17 (7.7)
Red Deer	16 (8.2)	13 (5.9)	0	0	3 (1.5)	3 (1.4)	3 (1.5)	4 (1.8)	3 (1.5)	2 (0.9)
Sika Deer	0	0	0	0	1 (0.5)	0	1 (0.5)	0	1 (0.5)	0
Fallow Deer	1 (0.5)	3 (1.4)	0	0	2 (1)	1 (0.5)	0	1 (0.5)	0	1 (0.5)
Roe Deer	31 (15.8)	32 (14.5)	1 (0.5)	2 (0.9)	10 (5.1)	7 (3.2)	10 (5.1)	9 (4.1)	20 (10.2)	10 (4.5)
Reeves's Muntjac	2 (1)	4 (1.8)	0	0	3 (1.5)	2 (0.9)	0	1 (0.5)	1 (0.5)	1 (0.5)
Feral Goat	2 (1)	1 (0.5)	0	0	0	0	0	1 (0.5)	0	0

Table 2. The number of WBBS stretches recording the presence of mammals on WBBS stretches in 1998 to 2003 from counts of live animals, as used in the above analyses, dead animals, field signs (e.g. tracks, scats, mole-hills), local knowledge of presence for that year from a gamekeeper or landowner or live animals seen on additional visits to the stretch during that season (percentage of total WBBS stretches surveyed in shown in parentheses). Note that data for 2001 is excluded from the analyses due to a bias in survey coverage caused by the outbreak of foot-and-mouth disease in this year.

	Year					
Species	1998	1999	2000	2001	2002	2003
Hedgehog	24 (15.5)	36 (20.8)	33 (20.9)	8 (17.4)	17 (8.7)	31 (14)
Mole	56 (36.1)	99 (57.2)	91 (57.6)	19 (41.3)	113 (57.7)	109 (49.3)
Shrew sp	40 (25.8)	42 (24.3)	35 (22.2)	10 (21.7)	4 (2)	5 (2.3)
Water shrew	0	0	0	0	0	2 (0.9)
Daubenton's Bat	0	0	1 (0.6)	0	0	0
Pipistrelle Bat	2 (1.3)	0	0	0	0	0
Long-eared Bat	1 (0.6)	0	0	0	0	0
Rabbit	101 (65.2)	125 (72.3)	113 (71.5)	30 (65.2)	135 (68.9)	149 (67.4)
Brown Hare	43 (27.7)	57 (32.9)	45 (28.5)	17 (35)	56 (28.6)	62 (28.1)
Mountain Hare	9 (5.8)	7 (4)	5 (3.2)	2 (4.3)	7 (3.6)	7 (3.2)
Red Squirrel	5 (3.2)	7 (4)	5 (3.2)	1 (2.2)	8 (4.1)	7 (3.2)
Grey Squirrel	61 (39.4)	75 (43.4)	74 (46.8)	21 (45.7)	88 (44.9)	99 (44.8)
Bank Vole	0	2 (1.2)	1 (0.6)	0	4 (2)	0
Field Vole	0	0	2 (1.3)	0	1 (0.5)	1 (0.5)
Water Vole	19 (12.3)	27 (15.6)	19 (12)	9 (19.6)	23 (11.7)	15 (6.8)
Wood Mouse	0	1 (0.6)	1 (0.6)	0	1 (0.5)	2 (0.9)
House Mouse	0	0	0	0	1 (0.5)	0
Brown Rat	18 (11.6)	32 (18.5)	28 (17.7)	6 (13)	19 (9.7)	19 (8.6)
Common Dormouse	0	1 (0.6)	0	0	1 (0.5)	0
Red Fox	57 (36.8)	76 (43.9)	79 (50)	22 (47.8)	84 (42.9)	88 (39.8)
Pine Marten	2 (1.3)	2 (1.2)	1 (0.6)	1 (2.2)	2 (1)	1 (0.5)
Stoat	22 (14.2)	38 (22)	26 (16.5)	6 (13)	21 (10.7)	31 (14)
Weasel	17 (11)	21 (12.1)	16 (10.1)	4 (8.7)	15 (7.7)	19 (8.6)
American Mink	15 (9.7)	37 (21.4)	35 (22.2)	6 (13)	19 (9.7)	33 (14.9)
Badger	27 (17.4)	31 (17.9)	32 (20.3)	7 (15.2)	36 (18.4)	41 (18.6)
Otter	18 (11.6)	22 (12.7)	21 (13.3)	1 (2.2)	31 (15.8)	31 (14)
Wild Cat	0	0	0	0	1 (0.5)	0
Feral/Domestic Cat	0	0	35 (22.2)	14 (30.4)	36 (18.4)	52 (23.5)
Red Deer	13 (8.4)	20 (11.6)	15 (9.5)	7 (15.2)	22 (11.2)	18 (8.1)
Sika Deer	0	0	0	0	1 (0.5)	0

	Year					
Species	1998	1999	2000	2001	2002	2003
Fallow Deer	5 (3.2)	2 (1.2)	2 (1.3)	1 (2.2)	3 (1.5)	6 (2.7)
Roe Deer	28 (18.1)	44 (25.4)	36 (22.8)	10 (21.7)	58 (29.6)	52 (23.5)
Reeves's Muntjac	5 (3.2)	13 (7.5)	12 (7.6)	2 (4.3)	4 (2)	8 (3.6)
Feral Goat	1 (0.6)	1 (0.6)	1 (0.6)	0	2 (1)	2 (0.9)

Table 3. The number of WBBS stretches surveyed for mammals in each year of the survey. Note that coverage in 2001 was severely reduced as a result of an outbreak of foot-and-mouth disease.

	1998	1999	2000	2001	2002	2003
Stretches surveyed	155	173	158	46	196	221

Table 4. Description of WBBS stretches surveyed between 1998 and 2003.

	1998	1999	2000	2001	2002	2003
Lake/unlined reservoir	0	1 (0.6)	0	0	1 (0.5)	0
Stream (less than 3m wide)	12 (7.7)	12 (6.9)	8 (5.1)	5 (10.9)	16 (8.2)	25 (11.3)
River (more than 3m wide)	70 (45.2)	120 (69)	114 (72.2)	21 (45.7)	149 (76)	155 (70.1)
Ditch with water (less than 2m wide)	0	0	0	0	0	1 (0.5)
Small canal (2-5m wide)	16 (10.3)	12 (6.9)	10 (6.3)	4 (8.7)	3 (1.5)	3 (1.4)
Large canal (more than 5m wide)	57 (36.8)	29 (16.7)	26 (16.5)	16 (34.8)	27 (13.8)	37 (16.7)

Table 5. Nature of human disturbance on WBBS stretches surveyed between 1998 and 2003.

	1998	1999	2000	2001	2002	2003
Undisturbed/disused	52 (33.5)	64 (36.8)	61 (38.6)	18 (39.1)	87 (44.4)	93 (42.1)
Water sports (sailing etc)	3 (1.9)	3 (1.7)	2 (1.3)	1 (2.2)	2 (1)	2 (0.9)
Angling (coarse or game)	28 (18.1)	35 (20.1)	31 (19.6)	6 (13)	27 (13.8)	39 (17.6)
Coarse angling	18 (11.6)	25 (14.4)	24 (15.2)	13 (28.3)	21 (10.7)	26 (11.8)
Game fishing	4 (2.6)	13 (7.5)	10 (6.3)	0	19 (9.7)	14 (6.3)
Industrial activity	4 (2.6)	2 (1.1)	2 (1.3)	0	2 (1)	2 (0.9)
Sewage processing 'rural'	0	1 (0.6)	1 (0.6)	0	2 (1)	3 (1.4)
Other disturbance (specified)	6 (3.9)	9 (5.2)	9 (5.7)	2 (4.3)	10 (5.1)	16 (7.2)
Boat traffic relatively light	13 (8.4)	6 (3.4)	6 (3.8)	4 (8.7)	8 (4.1)	7 (3.2)
Boat traffic medium to heavy	2 (1.3)	1 (0.6)	1 (0.6)	1 (2.2)	2 (1)	3 (1.4)
Not recorded	25 (16.1)	15 (8.6)	11 (7)	1 (2.2)	16 (8.2)	16 (7.2)

Table 6. Secondary habitat bordering WBBS stretches surveyed between 1998 and 2003.

Secondary habitat	1998	1999	2000	2001	2002	2003
Woodland	22 (14.2)	25 (14.4)	22 (13.9)	5 (10.9)	36 (18.4)	47 (21.3)
Scrubland	3 (1.9)	4 (2.3)	3 (1.9)	2 (4.3)	5 (2.6)	8 (3.6)
Semi-natural grassland / marsh	6 (3.9)	15 (8.6)	13 (8.2)	4 (8.7)	17 (8.7)	20 (9)
Heathland & bogs	8 (5.2)	8 (4.6)	6 (3.8)	4 (8.7)	11 (5.6)	8 (3.6)
Farmland	71 (45.8)	82 (47.1)	82 (51.9)	16 (34.8)	92 (46.9)	99 (44.8)
Human sites	38 (24.5)	34 (19.5)	27 (17.1)	12 (26.1)	25 (12.8)	31 (14)
Coastal	2 (1.3)	2 (1.1)	1 (0.6)	0	1 (0.5)	1 (0.5)
Inland rock	1 (0.6)	0	0	0	0	0
Not recorded	4 (2.6)	4 (2.3)	4 (2.5)	3 (6.5)	9 (4.6)	7 (3.2)

Table 7. The number of WBBS stretches recording counts of mammals on WBBS stretches between 1998 and 2003 (percentage of total WBBS stretches surveyed in shown in parentheses). Note that data for 2001 is excluded from the analyses due to a bias in survey coverage caused by the outbreak of foot-and-mouth disease in this year. Species for which we produce annual trends in relative abundance are highlighted in bold.

	Year					
Species	1998	1999	2000	2001	2002	2003
Hedgehog	2 (1.3)	2 (1.2)	0	1 (2.2)	0	7 (3.2)
Mole	4 (2.6)	5 (2.9)	4 (2.5)	2 (4.3)	5 (2.6)	3 (1.4)
Shrew sp	15 (9.7)	4 (2.3)	3 (1.9)	0	2 (1)	2 (0.9)
Water shrew	0	0	0	0	0	1 (0.5)
Pipistrelle Bat	1 (0.6)	0	0	0	0	0
Rabbit	86 (55.5)	95 (54.9)	80 (50.6)	20 (43.5)	103 (52.6)	122 (55.2)
Brown Hare	32 (20.6)	31 (17.9)	33 (20.9)	12 (26.1)	45 (23)	49 (22.2)
Mountain Hare	6 (3.9)	3 (1.7)	2 (1.3)	0	2 (1)	3 (1.4)
Red Squirrel	1 (0.6)	3 (1.7)	1 (0.6)	0	5 (2.6)	3 (1.4)
Grey Squirrel	50 (32.3)	45 (26)	42 (26.6)	12 (26.1)	58 (29.6)	77 (34.8)
Bank Vole	0	0	1 (0.6)	0	1 (0.5)	0
Water Vole	10 (6.5)	11 (6.4)	7 (4.4)	1 (2.2)	8 (4.1)	7 (3.2)
Wood Mouse	0	0	0	0	0	1 (0.5)
House Mouse	0	1 (0.6)	0	0	1 (0.5)	0
Brown Rat	5 (3.2)	4 (2.3)	3 (1.9)	1 (2.2)	4 (2)	6 (2.7)
Red Fox	17 (11)	16 (9.2)	11 (7)	4 (8.7)	25 (12.8)	24 (10.9)
Pine Marten	0	0	1 (0.6)	0	0	1 (0.5)
Stoat	3 (1.9)	8 (4.6)	3 (1.9)	1 (2.2)	4 (2)	9 (4.1)
Weasel	3 (1.9)	1 (0.6)	1 (0.6)	1 (2.2)	4 (2)	1 (0.5)
American Mink	3 (1.9)	4 (2.3)	0	1 (2.2)	1 (0.5)	7 (3.2)
Badger	1 (0.6)	1 (0.6)	1 (0.6)	0	1 (0.5)	2 (0.9)
Otter	5 (3.2)	2 (1.2)	1 (0.6)	0	4 (2)	1 (0.5)
Feral/Domestic Cat	0	0	18 (11.4)	4 (8.7)	20 (10.2)	24 (10.9)
Red Deer	8 (5.2)	11 (6.4)	9 (5.7)	4 (8.7)	16 (8.2)	13 (5.9)
Fallow Deer	2 (1.3)	2 (1.2)	1 (0.6)	1 (2.2)	1 (0.5)	3 (1.4)
Roe Deer	15 (9.7)	18 (10.4)	19 (12)	6 (13)	30 (15.3)	33 (14.9)
Reeves's Muntjac	1 (0.6)	1 (0.6)	6 (3.8)	0	2 (1)	4 (1.8)
Feral Goat	1 (0.6)	1 (0.6)	1 (0.6)	0	2 (1)	1 (0.5)

Table 8. UK temporal trends in relative abundance for 4 mammal species for the period 1998-2003. 95% confidence intervals are shown in brackets. Indices are measured relative to the year 1998, which is set to one. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index value here for 2001 as the mean of the surrounding years. An asterisk denotes a significant difference between the first and last years of the survey at the 5% level or more. A visual representation of temporal trends in abundance are shown in Figure 5.

		Year					
Species	*n*	1998	1999	2000	2001	2002	2003
Rabbit*	98	1	0.81 (0.67-0.97)	0.80 (0.66-0.96)	0.75 (0.62-0.90)	0.69 (0.57-0.84)	0.62 (0.51-0.76)
Brown Hare	38	1	0.59 (0.46-0.76)	0.65 (0.49-0.86)	0.86 (0.67-1.05)	1.06 (0.82-1.38)	0.95 (0.73-1.24)
Grey Squirrel	54	1	0.60 (0.45-0.80)	0.62 (0.47-0.82)	0.63 (0.46-0.85)	0.64 (0.48-0.84)	0.92 (0.71-1.20)
Roe Deer*	23	1	0.71 (0.50-1.00)	1.13 (0.81-1.56)	1.35 (0.98-1.86)	1.57 (1.14-2.16)	1.99 (1.46-2.73)

Table 9. Mean number of WBBS stretches reporting counts of each species by region and country over the period 1998-2003, excluding 2001 in which foot-and-mouth disease severely affected coverage. Species / region combinations for which it should be possible to produce annual trends in relative abundance are highlighted in bold.

Species	E. of England	E. Midlands	London	NE England	NW England	SE England	SW England	W. Midlands	Yorks & Humber	England	Scotland	Wales	N. Ireland
Hedgehog	0	0	0	1	0	0	0	0	0	2	0	0	0
Mole	1	0	0	1	0	0	0	1	0	4	0	0	0
Shrew sp	0	0	0	1	1	0	0	1	0	4	1	0	0
Rabbit	8	9	1	7	16	9	10	9	7	75	15	7	0
Brown Hare	6	5	0	2	6	3	3	1	4	30	6	2	0
Mountain Hare	0	0	0	0	0	0	0	0	0	0	3	0	0
Red Squirrel	0	0	0	0	1	0	0	0	0	1	2	0	0
Grey Squirrel	3	5	3	2	7	6	7	8	3	44	2	9	0
Water Vole	0	3	0	1	1	1	1	1	0	8	0	0	0
Brown Rat	1	1	0	0	0	1	0	0	0	3	0	1	0
Red Fox	1	2	1	1	2	3	2	2	1	14	3	1	0
Stoat	0	1	0	1	1	0	0	0	1	4	1	0	0
Weasel	0	1	0	0	0	0	0	0	0	2	0	0	0
American Mink	0	0	0	0	0	0	1	0	0	2	1	0	0
Badger	0	0	0	0	0	0	0	0	0	1	0	0	0
Otter	0	0	0	0	1	0	0	0	0	1	1	0	0
Feral/Domestic Cat	1	1	1	0	3	1	1	1	0	10	0	2	0
Red Deer	0	0	0	0	0	0	0	0	0	0	11	0	0
Fallow Deer	1	0	0	0	0	0	1	0	0	2	0	0	0
Roe Deer	3	0	0	2	2	2	4	0	2	14	8	0	0
Reeves's Muntjac	1	0	0	0	0	1	0	0	0	3	0	0	0
Feral Goat	0	0	0	0	0	0	0	0	0	0	1	0	0

Table 10. Regional temporal trends in relative abundance for 3 mammal species for the period 1998-2003. 95% confidence intervals are shown in brackets. Indices are measured relative to the year 1998, which is set to one. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index here for 2001. An asterisk denotes a significant difference between the first and last years of the survey at the 5% level.

		Year					
Species	*n*	1998	1999	2000	2001	2002	2003
ENGLAND							
Rabbit*	95	1	0.81 (0.66-0.99)	0.80 (0.65-0.98)	0.75 (0.62-0.90)	0.69 (0.56-0.85)	0.62 (0.50-0.78)
Brown Hare	36	1	0.57 (0.43-0.76)	0.67 (0.49-0.91)	0.89 (0.69-1.18)	1.11 (0.84-1.48)	1.00 (0.75-1.35)
Grey Squirrel	52	1	0.56 (0.40-0.79)	0.69 (0.50-0.94)	0.64 (0.44-0.92)	0.59 (0.43-0.83)	1.15 (0.86-1.54)

Table 11. Mean number of WBBS stretches recording counts of each mammal species in each of the six environmental zones. The six Environmental Zones are based on combinations of CEH land classes which cover the range of environmental conditions that we find in Great Britain, from the lowlands of the south and east, through to the uplands and mountains of the north and west (Bunce *et al*. 1996). Species/zone combinations for which we produce annual trends in relative abundance are highlighted in bold. See Figure 2 for a description of environmental zones.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Hedgehog	0	1	1	0	0	0
Mole	2	1	0	0	0	0
Shrew sp	1	3	1	0	0	0
Rabbit	**34**	**37**	12	6	2	7
Brown Hare	**19**	11	3	2	1	3
Mountain Hare	0	0	0	0	0	3
Red Squirrel	0	0	0	1	0	1
Grey Squirrel	**18**	**27**	8	2	0	0
Water Vole	3	3	2	0	0	0
Brown Rat	2	2	1	0	0	0
Red Fox	7	7	1	2	0	1
Stoat	2	2	1	0	0	1
Weasel	1	1	0	0	0	0
American Mink	1	1	0	0	0	0
Badger	0	1	0	0	0	0
Otter	1	1	0	0	0	0
Feral/Domestic Cat	3	7	2	0	0	0
Red Deer	0	0	0	0	2	9
Fallow Deer	1	1	0	0	0	0
Roe Deer	8	6	1	6	1	2
Reeves's Muntjac	2	0	0	0	0	0
Feral Goat	0	0	0	0	0	1

Table 12. Temporal trends in relative abundance for 3 mammal species for the period 1998-2003 within the six environmental zones in Great Britain where there is sufficient data. The six Environmental Zones are based on combinations of CEH land classes which cover the range of environmental conditions that we find in Great Britain, from the lowlands of the south and east, through to the uplands and mountains of the north and west (Bunce *et al*. 1996). 95% confidence intervals are shown in brackets. Indices are measured relative to the year 1998, which is set to one. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index here for 2001. An asterisk denotes a significant difference between the first and last years of the survey at the 5% level or more.

		Year					
Species	*n*	1998	1999	2000	2001	2002	2003
Rabbit							
Zone 1*	34	1	0.89 (0.65-1.21)	0.87 (0.64-1.20)	0.82 (0.69-1.13)	0.77 (0.54-1.06)	0.69 (0.48-0.97)
Zone 2*	37	1	0.78 (0.55-1.11)	0.72 (0.50-1.03)	0.72 (0.50-1.02)	0.71 (0.50-1.00)	0.65 (0.46-0.91)
Brown Hare							
Zone 1	19	1	0.70 (0.43-1.14)	0.68 (0.42-1.11)	1.03 (0.65-1.61)	1.37 (0.88-2.11)	0.92 (0.59-1.47)
Grey Squirrel							
Zone 1	18	1	0.49 (0.31-0.78)	0.66 (0.44-0.99)	0.66 (0.43-1.01)	0.65 (0.42-1.03)	1.01 (0.68-1.51)
Zone 2	27	1	0.62 (0.39-0.98)	0.58 (0.36-0.94)	0.61 (0.38-0.98	0.64 (0.40-1.02)	0.96 (0.62-1.48)

Table 13. Change in the odds of being present on WBBS stretches (see methods for temporal trends in presence) for 9 mammal species for the period 1998-2003. 95% confidence intervals are shown in brackets. Odds are measured relative to the year 1998, which is set to one. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index here for 2001.

		Year					
Species	*n*	1998	1999	2000	2001	2002	2003
Hedgehog*	28	1	0.25 (0.06-0.97)	0.19 (0.04-0.78)	0.10 (0.10-0.10)	0.01 (0.00-0.03)	0.04 (0.01-0.20)
Mole	94	1	0.61 (0.17-2.14)	0.90 (0.26-3.20)	0.67 (0.67-0.67)	0.43 (0.12-1.58)	0.50 (0.14-1.82)
Water Vole	20	1	2.80 (0.81-9.66)	3.06 (0.85-11.01)	1.69 (1.69-1.69)	0.31 (0.07-1.33)	1.04 (0.28-3.90)
Brown Rat	23	1	2.77 (1.17-6.52)	3.19 (1.28-7.97)	3.77 (3.77-3.77)	4.34 (1.70-11.10)	2.02 (0.81-5.06)
Red Fox	77	1	1.17 (0.49-2.80)	1.87 (0.76-4.59)	1.47 (1.47-1.47)	1.06 (0.43-2.61)	1.05 (0.43-2.58)
Stoat *	27	1	0.83 (0.15-4.42)	0.48 (0.09-2.60)	0.31 (0.31-0.31)	0.14 (0.02-0.82)	0.17 (0.03-0.95)
Weasel *	18	1	1.46 (0.41-5.23)	0.65 (0.18-2.35)	0.54 (0.54-0.54)	0.43 (0.11-1.67)	0.15 (0.03-0.64)
American Mink	28	1	0.19 (0.03-1.16)	0.44 (0.07-2.70)	0.47 (0.47-0.47)	0.49 (0.09-2.83)	0.38 (0.06-2.28)
Badger	33	1	1.36 (0.44-4.17)	0.56 (0.17-1.81)	0.35 (0.35-0.35)	0.15 (0.04-0.53)	0.44 (0.14-1.45)
Otter	25	1	1.84 (0.58-5.83)	2.10 (0.63-6.98)	1.38 (1.38-1.38)	0.66 (0.18-2.34)	0.59 (0.17-2.07)

Table 14. The combined number of WBBS stretches and BBS squares recording the presence and sightings of riparian species (Water Vole, American Mink and Otter) from counts of live animals, as used in the above analyses, dead animals, field signs (e.g. tracks, scats, mole-hills), local knowledge of presence for that year from a gamekeeper or landowner or live animals seen on additional visits to the stretch/square during that season (percentage of total BBS/WBBS sites surveyed in shown in parentheses). Note that data for 2001 is excluded here and would be from any analyses due to a bias in survey coverage caused by the outbreak of foot-and-mouth disease in this year. BBS mammal data for 2003 is not yet available, so we do not calculate the total proportion of sites reporting these species in this year.

	Year				
Species	1998	1999	2000	2002	2003
COUNT					
Water Vole	26 (1.2)	46 (2.1)	30 (1.5)	27 (1.3)	22 (1.0)
American Mink	5 (0.2)	5 (0.2)	60 (0.3)	10 (0.5)	10 (0.5)
Otter	8 (0.4)	3 (0.1)	5 (0.2)	3 (0.1)	14 (0.7)
PRESENCE					
Water Vole	43 (2.0)	51 (2.3)	37 (1.8)	36 (1.8)	28 (1.3)
American Mink	25 (1.2)	46 (2.1)	63 (3.1)	44 (2.2)	78 (3.6)
Otter	32 (1.5)	30 (1.4)	39 (1.9)	47 (2.3)	46 (2.2)

Table 15. Results of a simulation-based study to examine the power of simple GLMs to detect different rates of decline in the presence of a species on 181 WBBS survey stretches. Each set of simulations consists of 100 replicates, where the power is the percentage of replicates in which a decline was detected with a significance level of α=0.05 (likelihood-ratio test).

Number of years	% Stretches detected		Overall decline	Power
	Start	End		
10	0.70	0.35	50%	100%
10	0.70	0.53	25%	94%
10	0.70	0.63	10%	15%
10	0.50	0.25	50%	100%
10	0.50	0.38	25%	64%
10	0.50	0.45	10%	16%
10	0.30	0.15	50%	95%
10	0.30	0.23	25%	31%
10	0.30	0.27	10%	10%
10	0.20	0.10	50%	83%
10	0.20	0.15	25%	18%
10	0.20	0.18	10%	9%
10	0.10	0.05	50%	42%
10	0.10	0.08	25%	12%
10	0.10	0.09	10%	9%
10	0.05	0.03	50%	25%
10	0.05	0.04	25%	13%
10	0.05	0.05	10%	6%

Table 16. Results of a simulation-based study to examine the power of log-linear Poisson regression to detect different rates of decline in the abundance of a species on 181 WBBS survey stretches, assuming a mean of one animal per stretch where present. Each set of simulations consists of 100 replicates, where the power is the percentage of replicates in which a decline was detected with a significance level of α=0.05 (likelihood-ratio test).

Number of years	% Stretch detected		Overall decline	Power
	Start	End		
10	0.50	0.25	50%	100%
10	0.50	0.38	25%	66%
10	0.50	0.45	10%	14%
10	0.30	0.15	50%	100%
10	0.30	0.23	25%	37%
10	0.30	0.27	10%	9%
10	0.20	0.10	50%	99%
10	0.20	0.15	25%	27%
10	0.20	0.18	10%	11%
10	0.10	0.05	50%	76%
10	0.10	0.08	25%	13%
10	0.10	0.09	10%	11%
10	0.05	0.03	50%	36%
10	0.05	0.04	25%	11%
10	0.05	0.05	10%	3%

Figure 1. English Government Office Regions and Country boundaries used in the regional analyses.

Figure 2. The six Environmental Zones of Great Britain used in the analyses of landscape types.

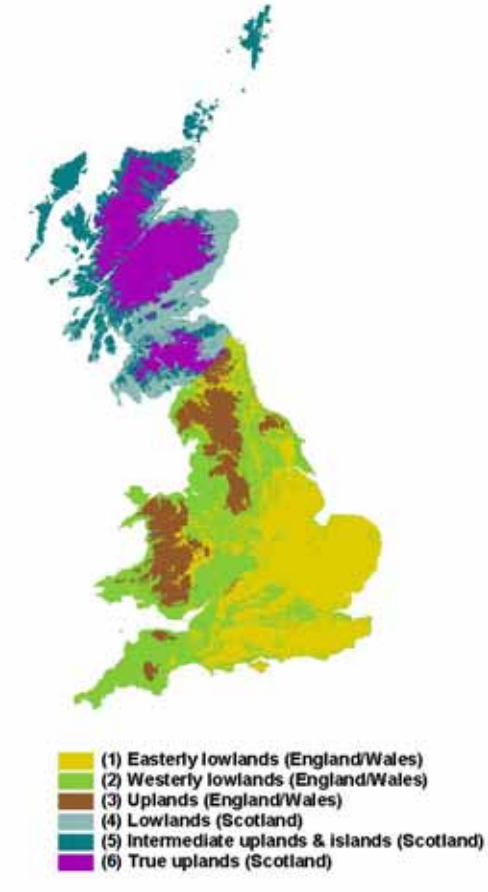


Figure 3. Proportion of WBBS stretches with different numbers of surveyed 500 m transect sections.

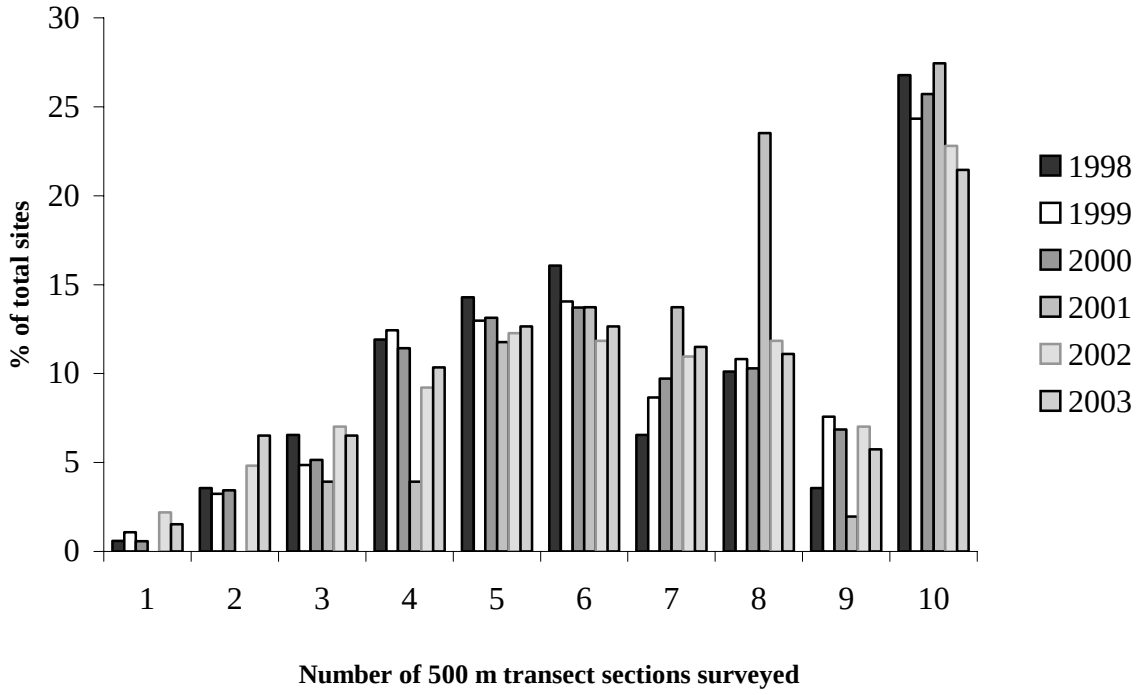
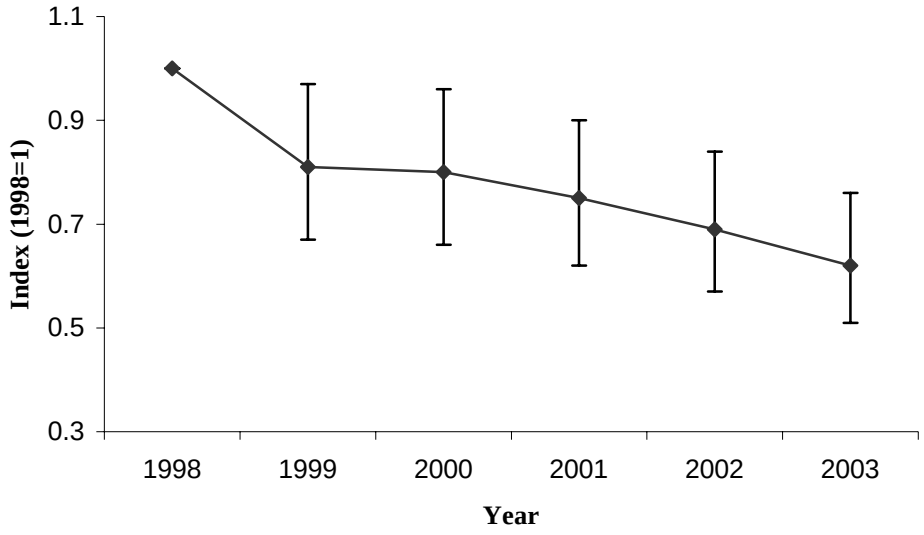


Figure 4. Distribution of WBBS stretches surveyed in one or more year between 1998-2003.

Figure 5. Temporal trends in relative abundance at a UK scale for 4 mammal species for the period 1998-2003. Indices are measured relative to the year 1998, which is set to 1. The error bars represent 95% confidence intervals of the WBBS indices. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index here for 2001. The raw data is additionally presented in Table 8.

a) Rabbit



b) Brown Hare

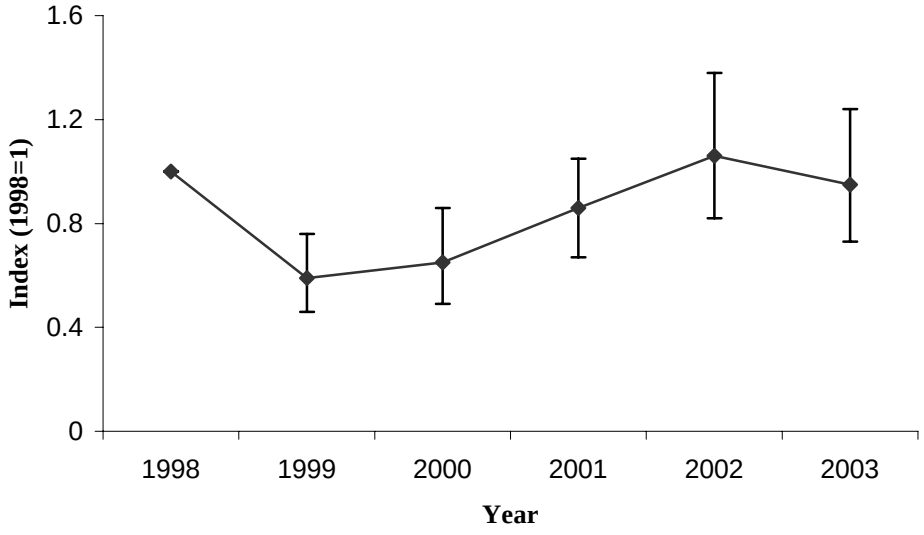
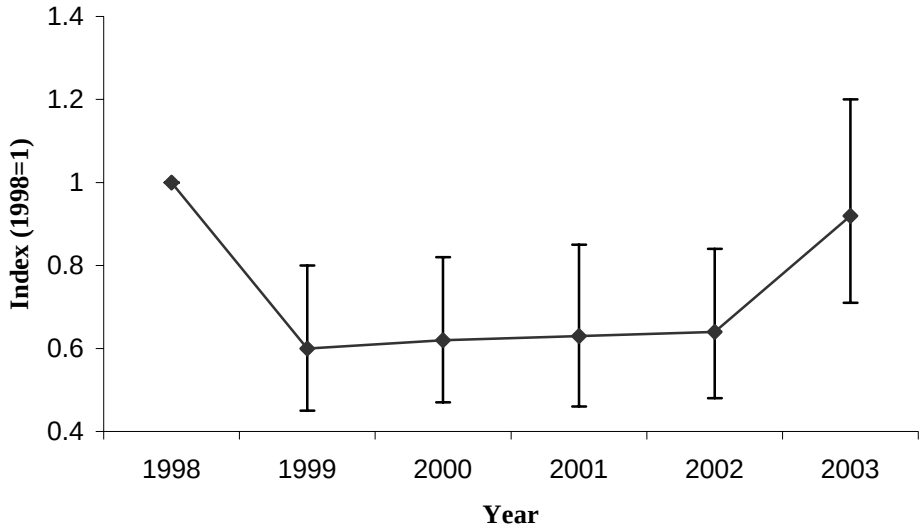


Figure 5 (continued)

c) Grey Squirrel



d) Roe Deer

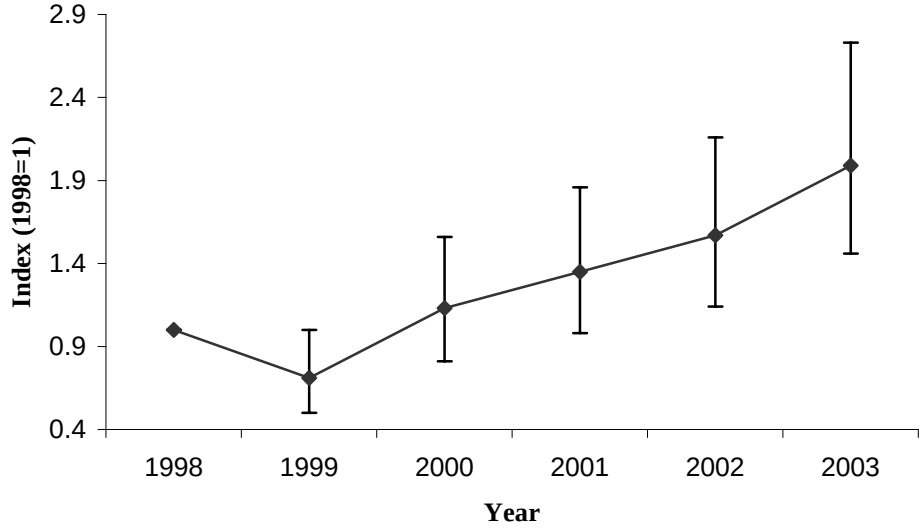
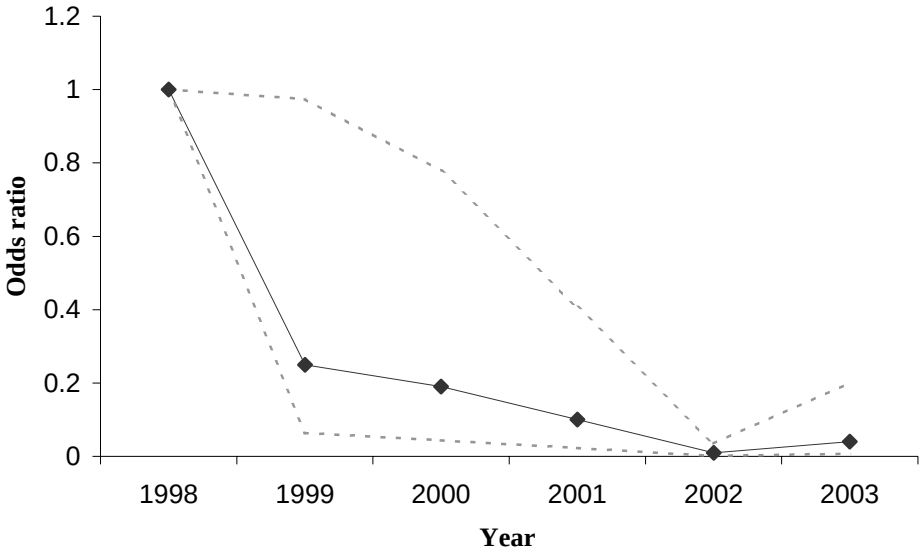


Figure 6. Temporal trends in the presence at a UK scale of 10 mammal species on WBBS stretches for the period 1998-2003 for Red Fox, Mole, Hedgehog, Brown Rat, Badger, Stoat, Weasel, Water Vole, American Mink and Otter. Indices are measured relative to the first year in the series, which is set to 1. The error bars represent 95% confidence intervals of the WBBS indices. We exclude data for 2001 from the analyses due to the influence of foot-and-mouth disease in this year. The raw trends are additionally presented in Table 13.

a) Hedgehog



b) Mole

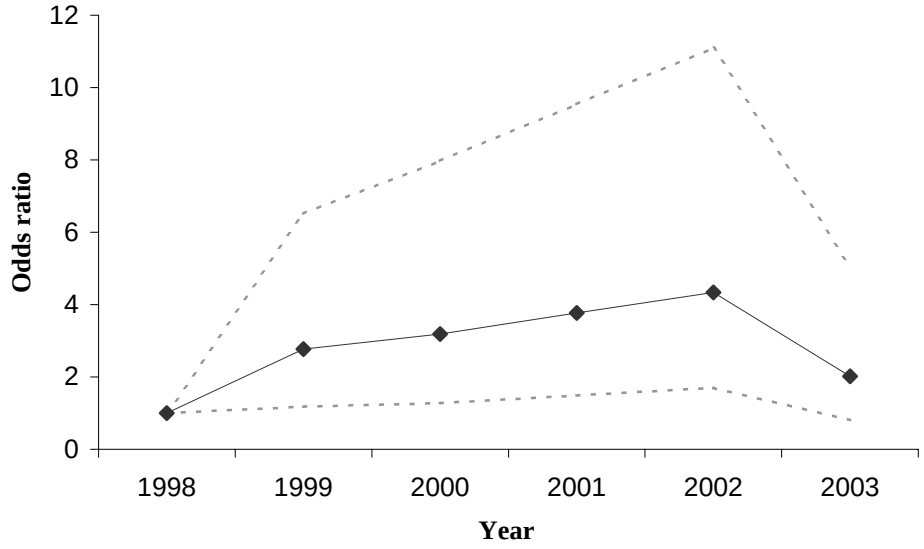
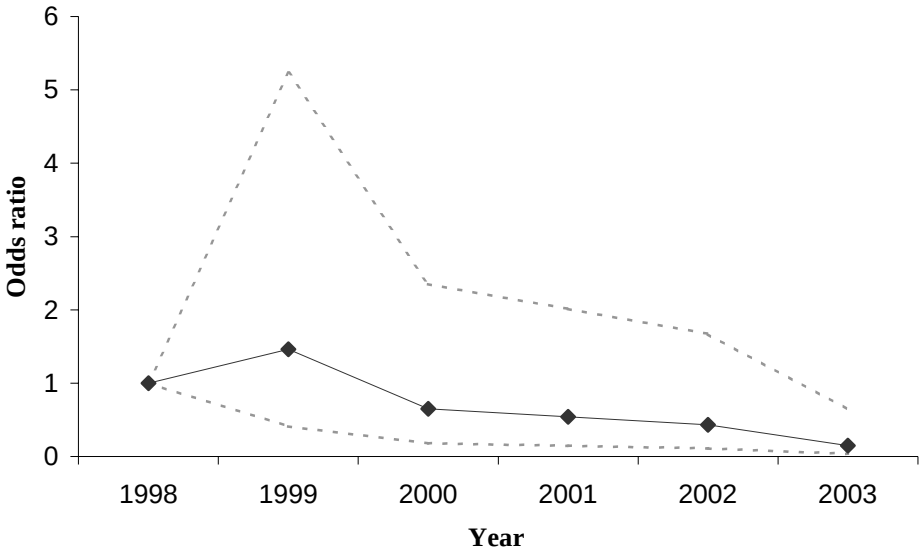


Figure 6 (continued)

c) Water Vole



d) Brown Rat

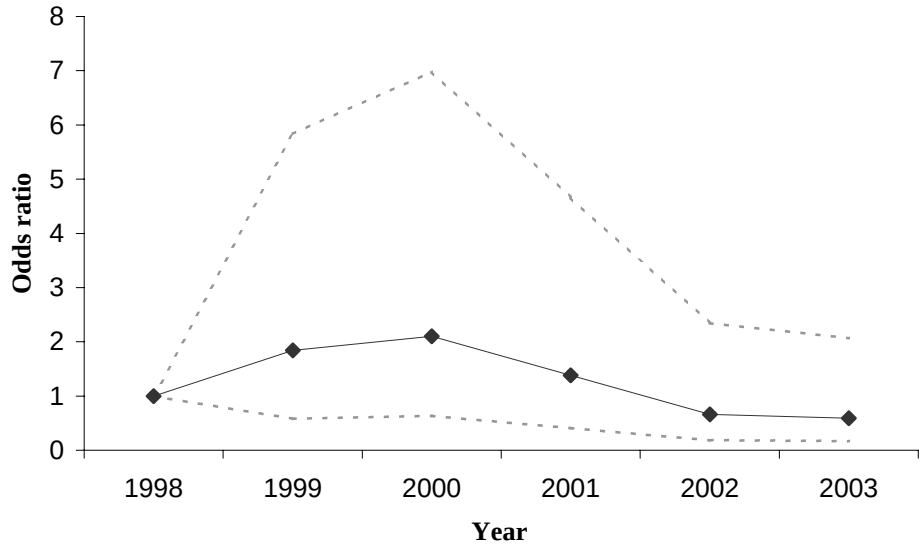
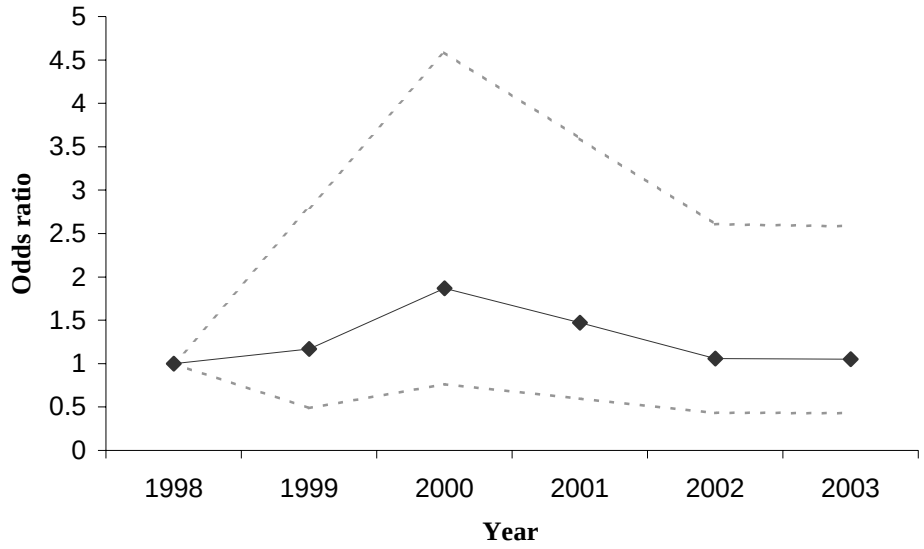


Figure 6 (continued)

e) Red Fox



f) Stoat

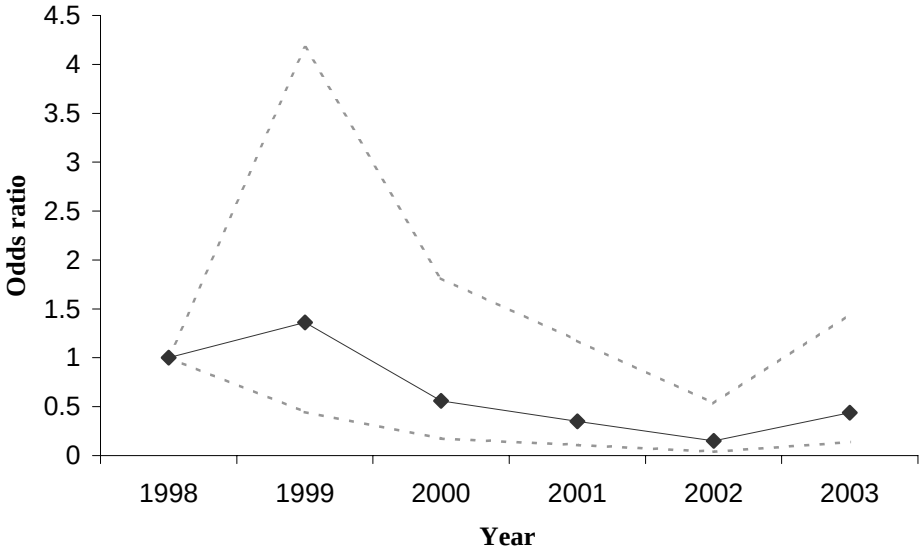
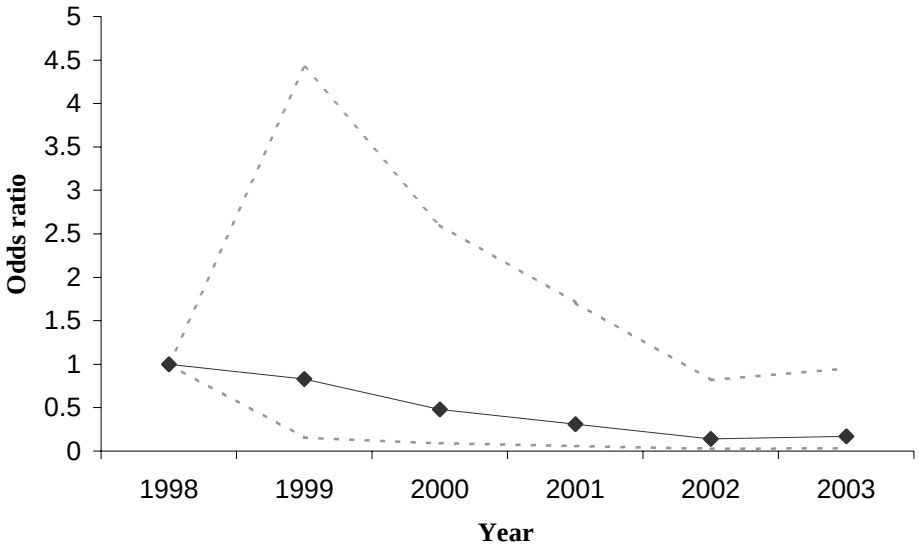


Figure 6 (continued)

g) Weasel



h) American Mink

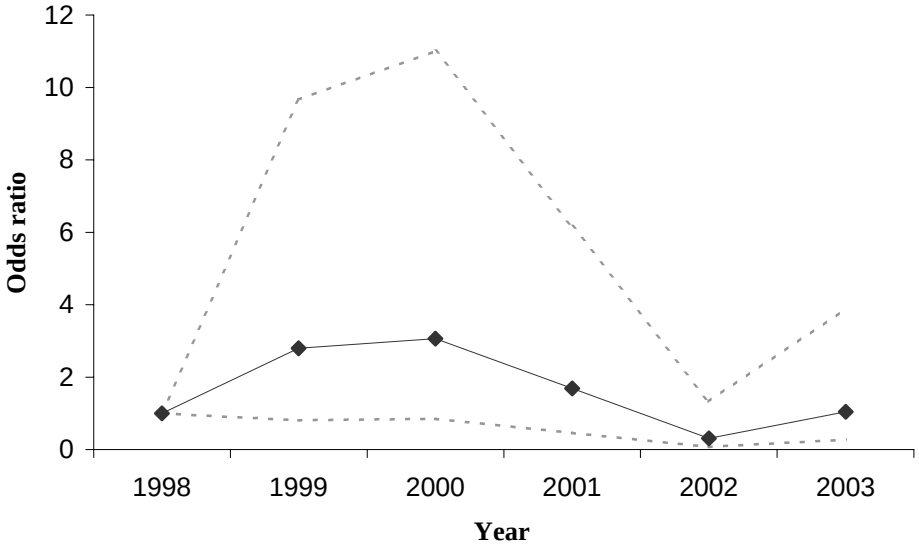
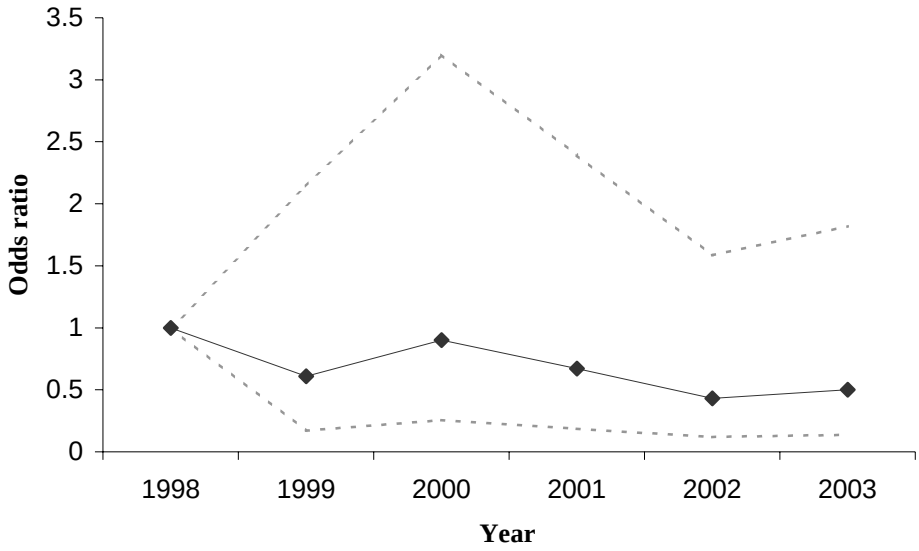


Figure 6 (continued)

i) Badger



j) Otter

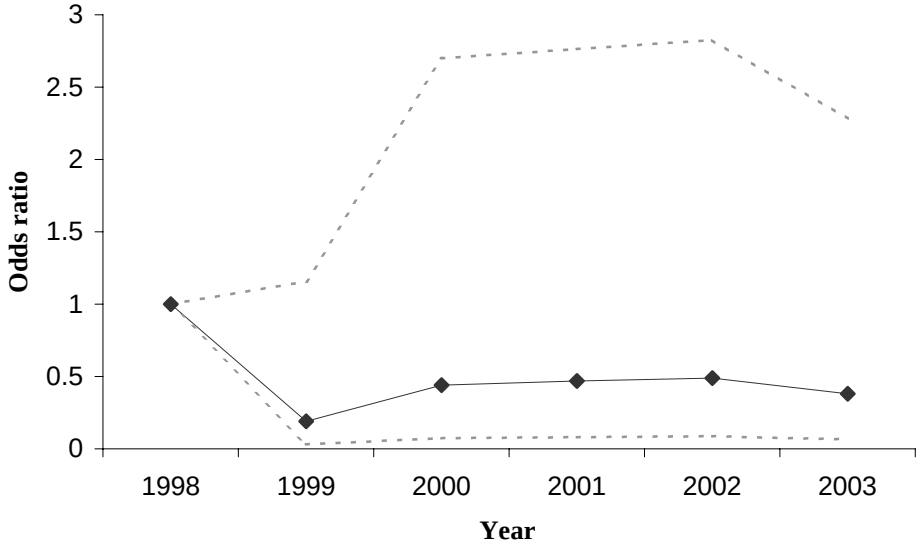


Figure 7. Power for detecting different levels (%) decline with different starting proportions, i.e. percent presence on 181 WBBS sites surveyed.

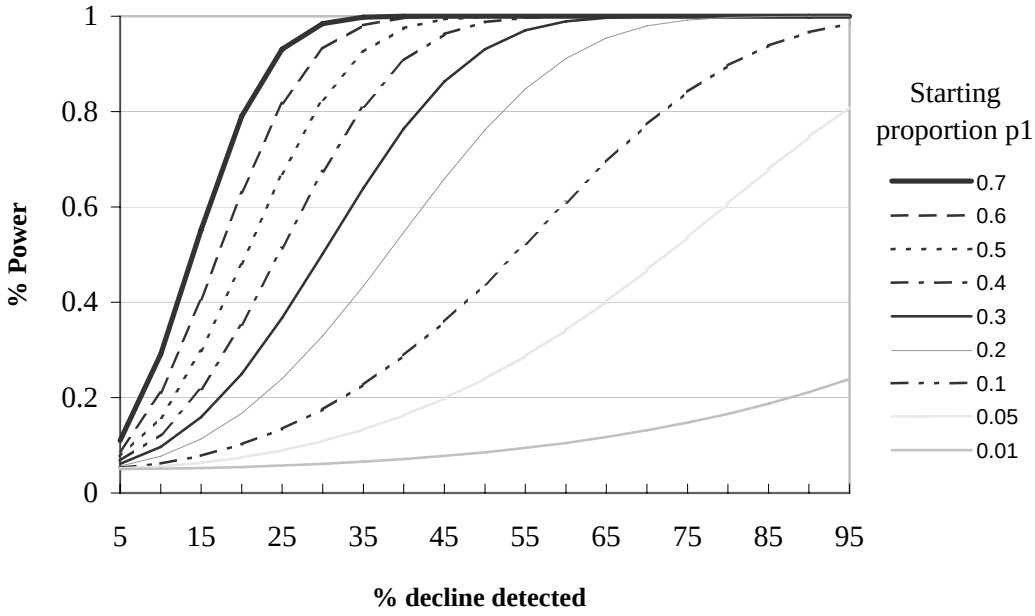


Figure 8. Power for detecting different levels (%) decline with different levels of survey coverage (number of WBBS stretches surveyed) and a starting proportion of 0.15, equivalent to the proportion of stretches recording the presence of Water Vole, American Mink and Otter.

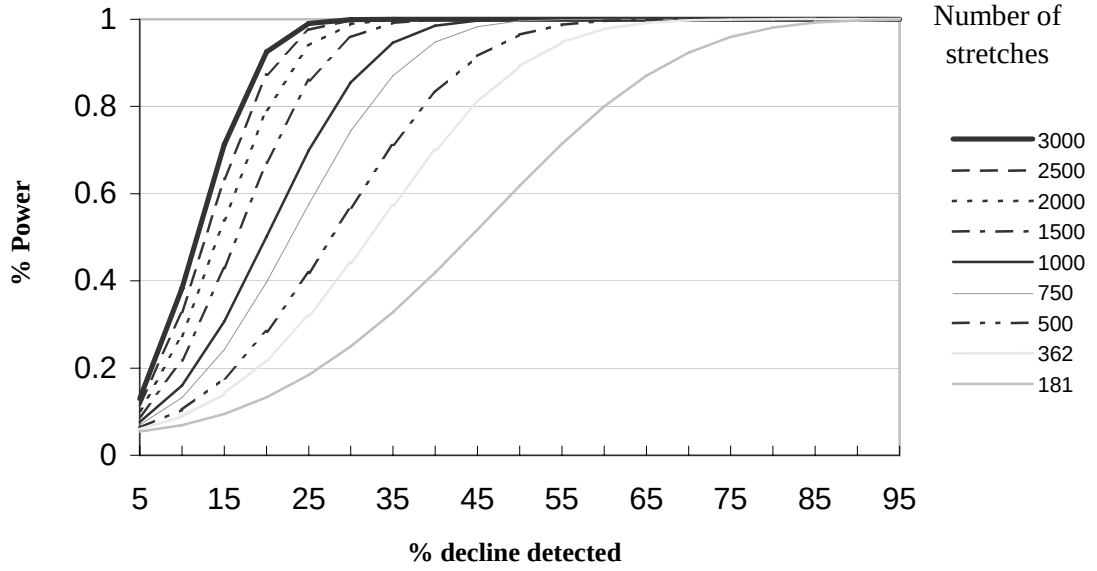


Figure 9. Presence of riparian mammal species recorded on WBBS stretches and BBS squares in the UK during the period 1998-2003. BBS = open circles, WBBS = closed circles.

a) Water Vole

b) American Mink

Figure 9 (continued)

c) Otter

Figure 10. Power for detecting different levels (%) decline with different starting proportions, i.e. percent presence on a theoretical 2100 WBBS and BBS sites surveyed combined.

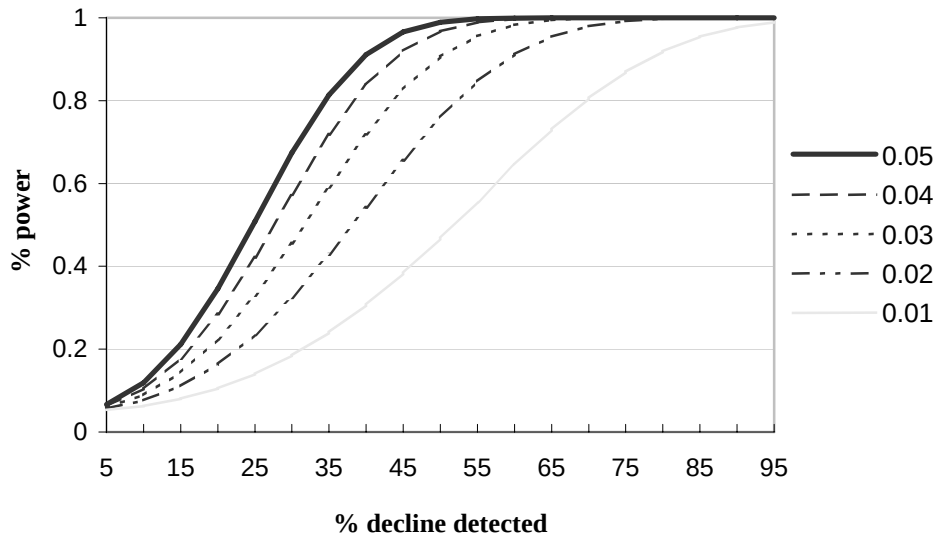
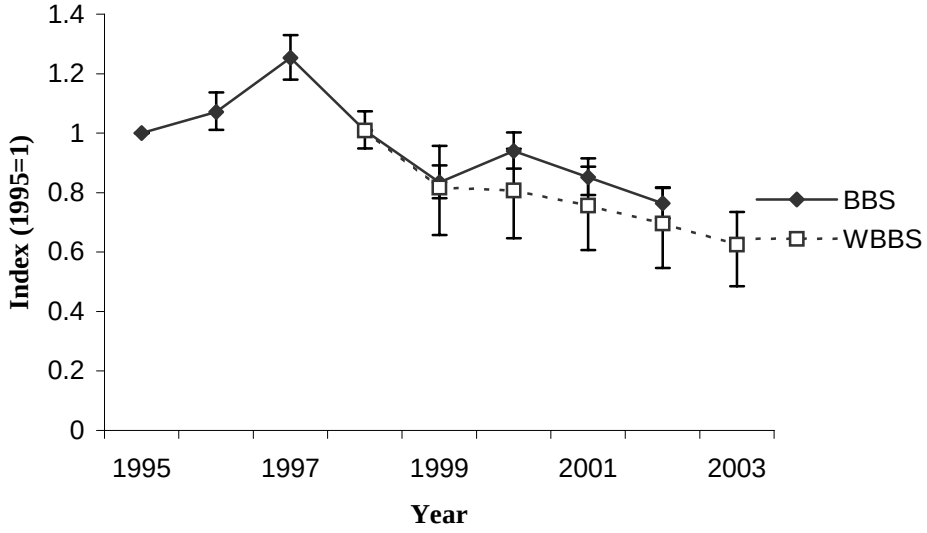


Figure 11. Comparison of WBBS and BBS temporal trends in relative abundance at a UK scale for Rabbit, Brown Hare, Grey Squirrel and Roe Deer. Indices are measured relative to the year 1995 for the BBS, which is set to 1 and the WBBS is set to the BBS index value in 1998. The error bars represent 95% confidence intervals of the WBBS and BBS indices. Although we exclude data for 2001 from the analyses due to foot-and-mouth disease, we interpolate an index here for 2001 for both surveys.

a) Rabbit



b) Brown Hare

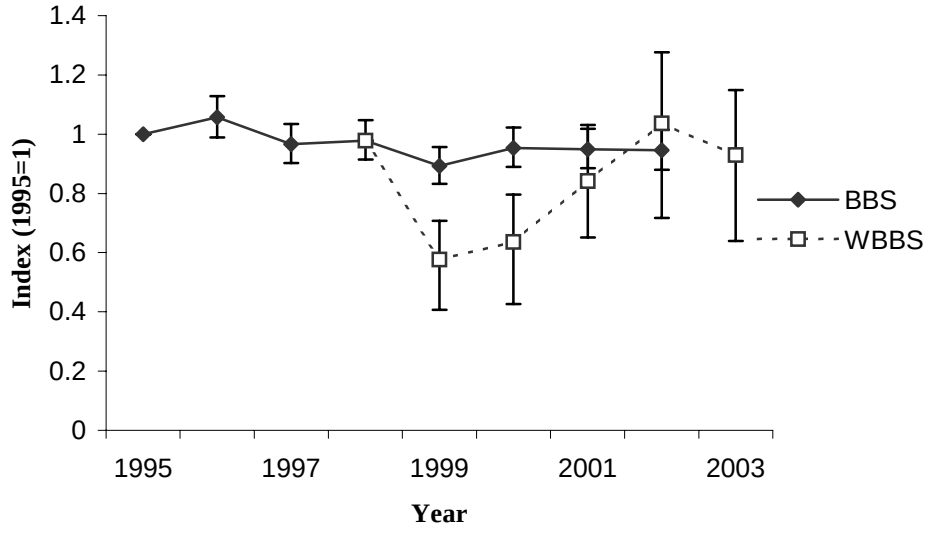
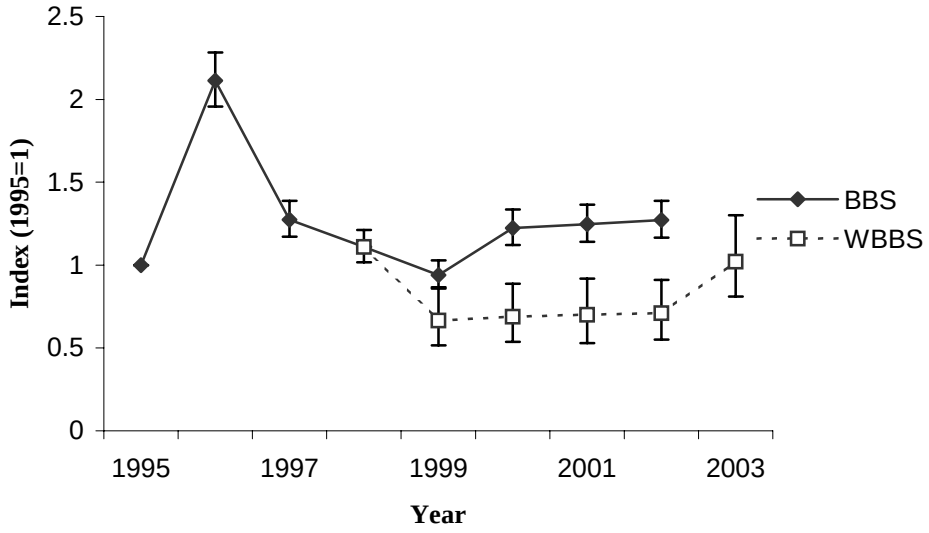
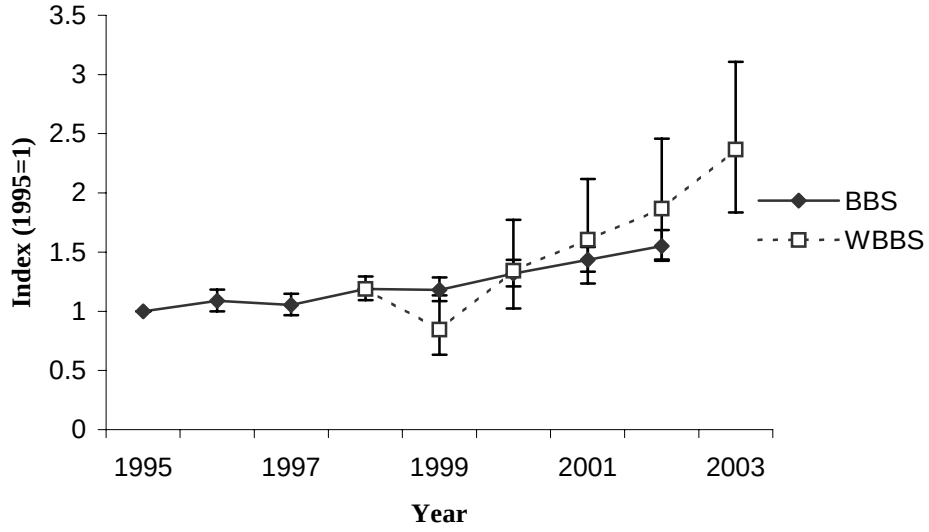


Figure 11 (continued)

c) Grey Squirrel



d) Roe Deer



Appendix 1. Presence of commonly recorded mammal species recorded on WBBS stretches in the UK during the period 1998-2003.

a) Hedgehog

b) Mole

c) shrew species

d) Rabbit

e) Brown Hare

f) Grey Squirrel

Appendix 1 (continued)

g) Water Vole

h) Brown Rat

i) Red Fox

j) Stoat

k) Weasel

l) American Mink

Appendix 1 (continued)

m) Badger

p) Red Deer

n) Otter

q) Roe Deer

o) Feral/Domestic Cat

r) Reeves's Muntjac

`

Appendix 2. Presence of mammal species recorded on fewer than 10 WBBS stretches in the UK during the period 1998-2003

a) Water Shrew

b) Daubenton's Bat

c) Pipistrelle Bat

d) Long-eared Bat

e) Mountain Hare

f) Red Squirrel

Appendix 2 (continued)

g) Bank Vole

h) Field Vole

i) Wood Mouse

j) House Mouse

k) Common Dormouse

l) Pine Marten

Appendix 2 (continued)

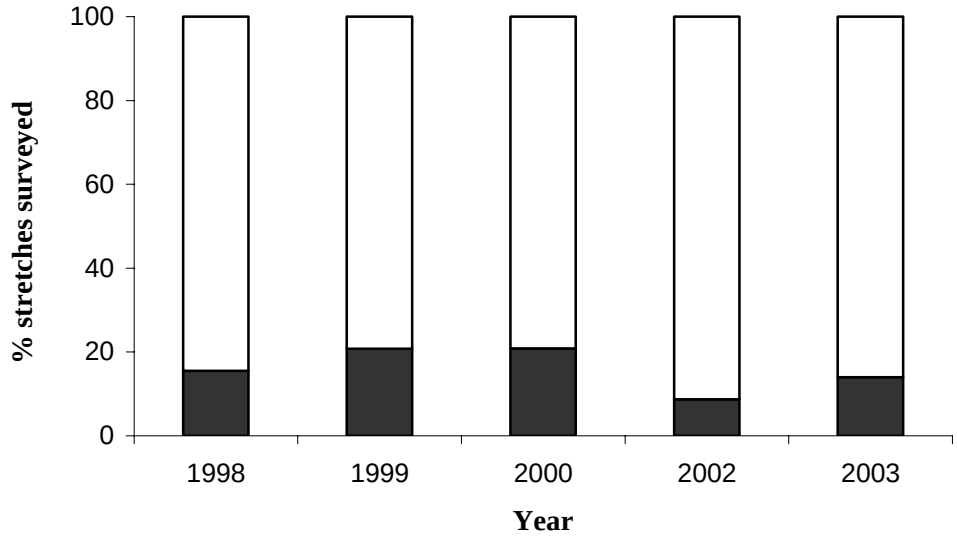
m) Wild Cat

n) Sika Deer

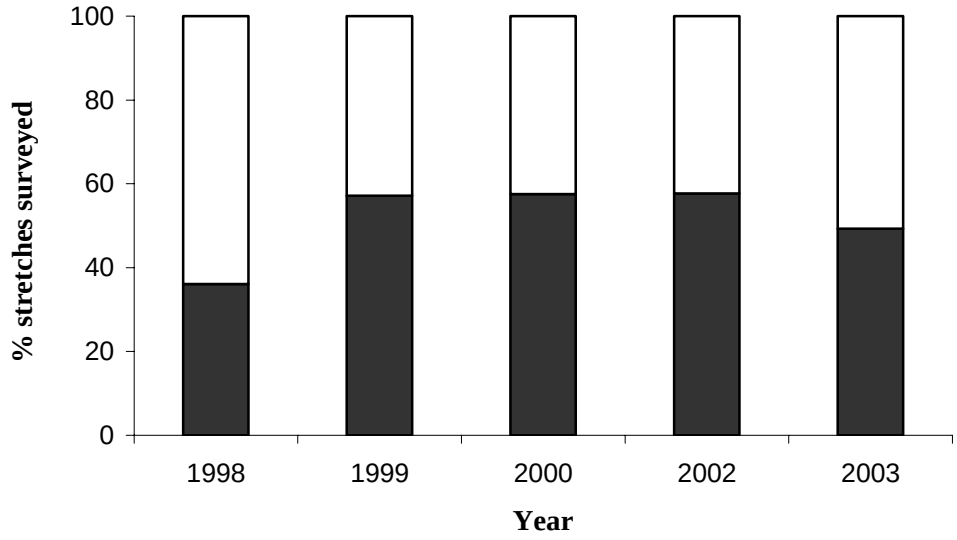
o) Fallow Deer

Appendix 3. The change in the percentage of squares reporting the presence of each of ten mammal species in the UK on WBBS stretches for the period 1998-2003. Formal analyses is carried out to examine the change in presence based on the change in odds ratio.

a) Hedgehog

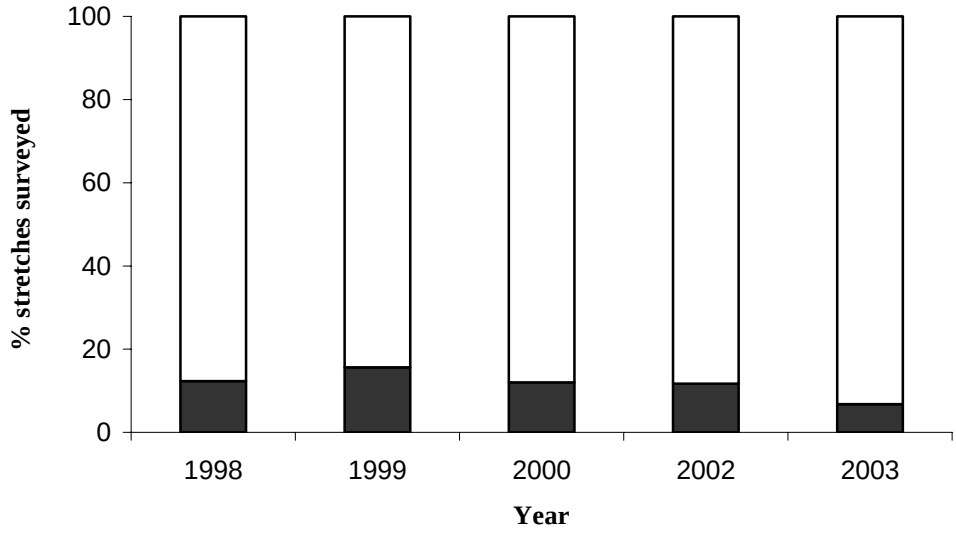


b) Mole

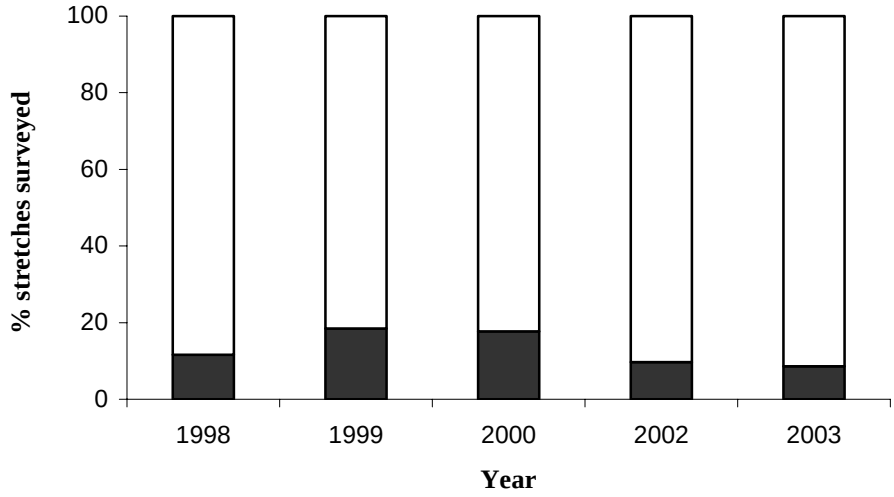


Appendix 3 (continued)

c) Water Vole

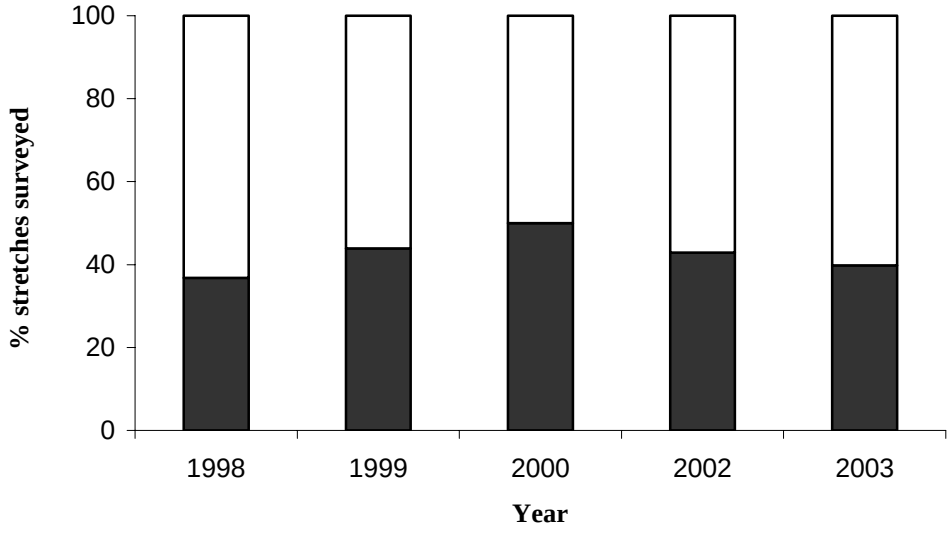


d) Brown Rat

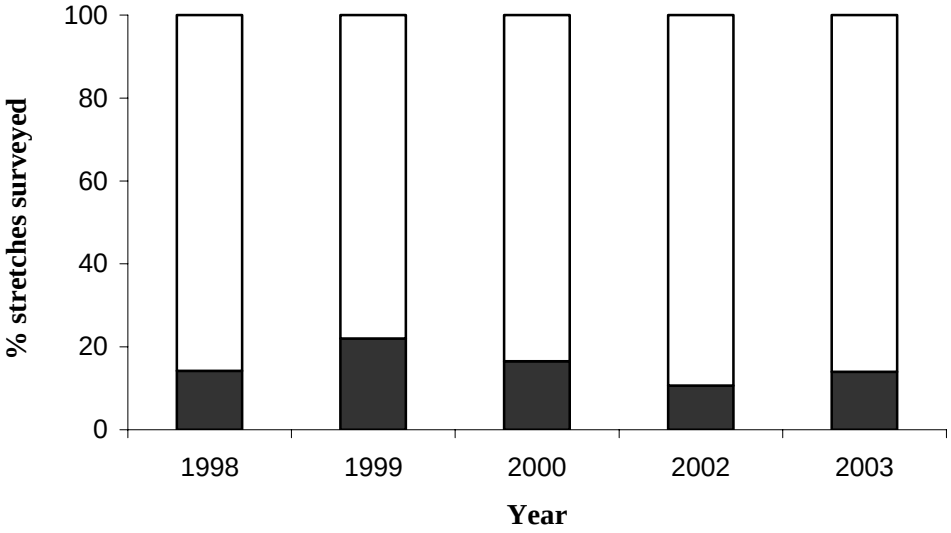


Appendix 3 (continued)

e) Red Fox

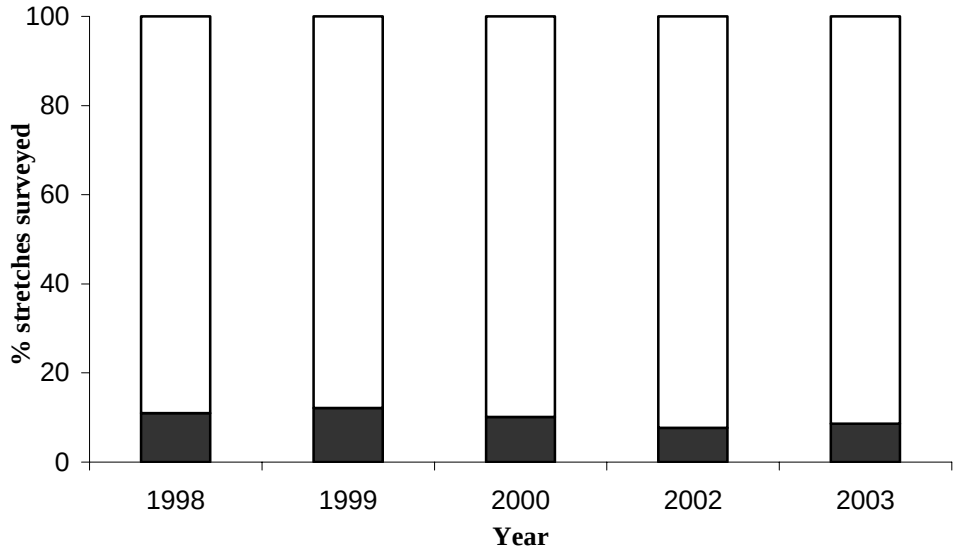


f) Stoat

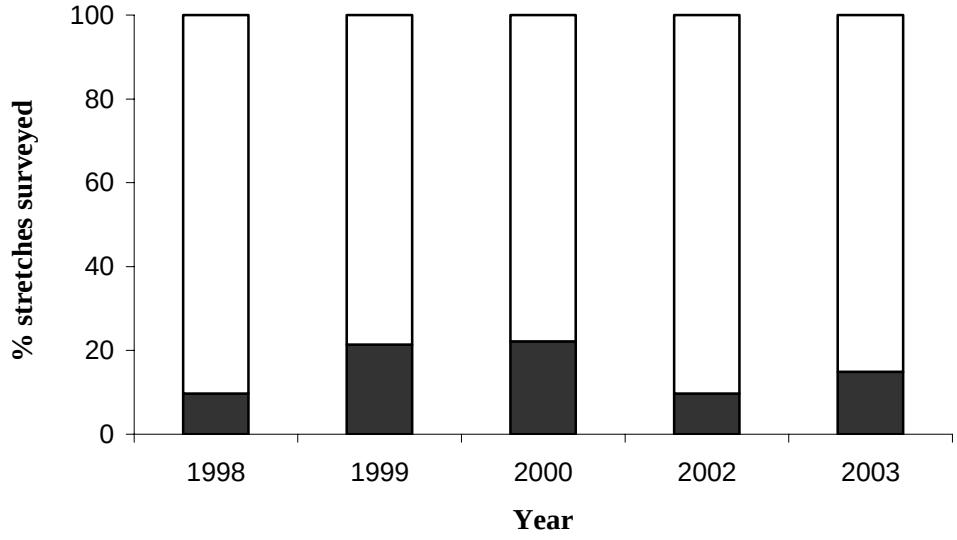


Appendix 3 (continued)

g) Weasel

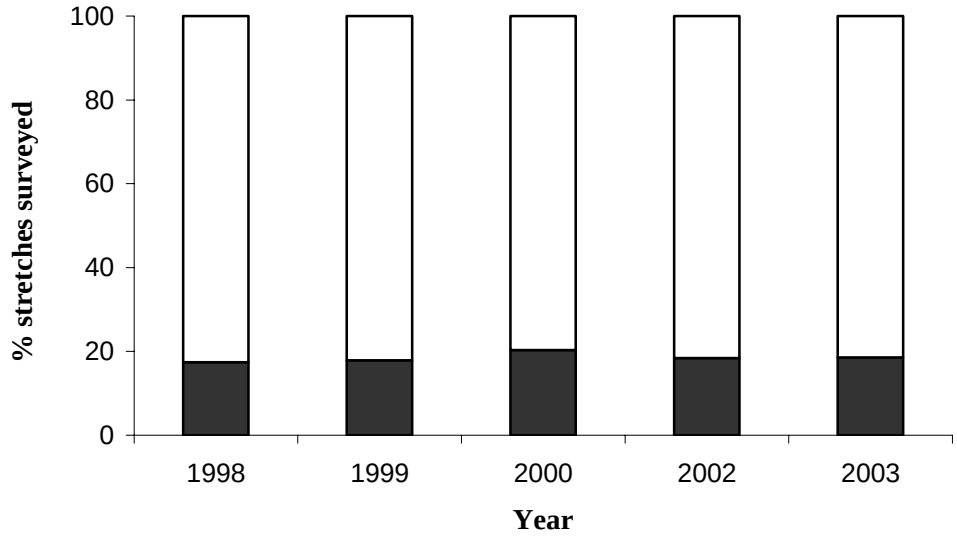


h) American Mink

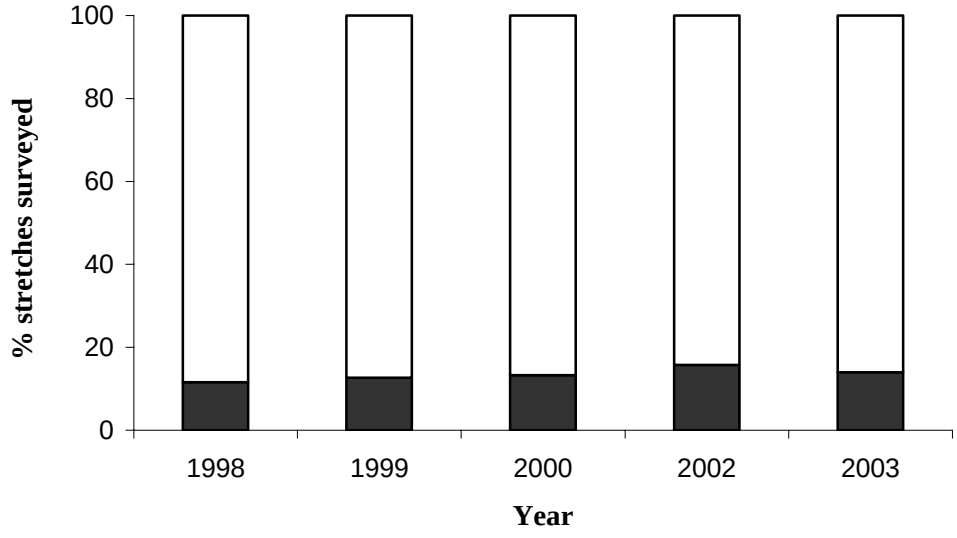


Appendix 3 (continued)

i) Badger



j) Otter



Appendix 4. Riparian species: Water Vole, Otter and American Mink

Summary

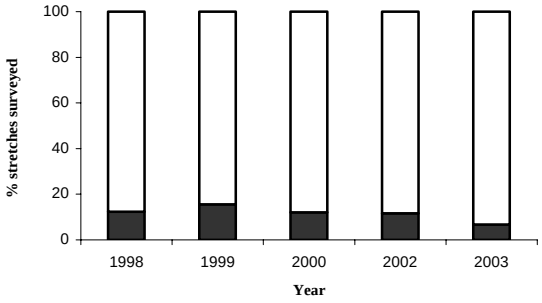
Power to detect change in relative abundance from counts for these species is small. To be detected these species would need to decline by 80-100% over ten years.

Power to detect change in presence (combination of live animals, dead animals, field signs, local knowledge and additional visits) would allow a 48% decline to be detected over ten years. Perhaps unsurprisingly considering the number of years of data, there was no significant change in presence of these species between 1998 and 2003 (P >0.05).

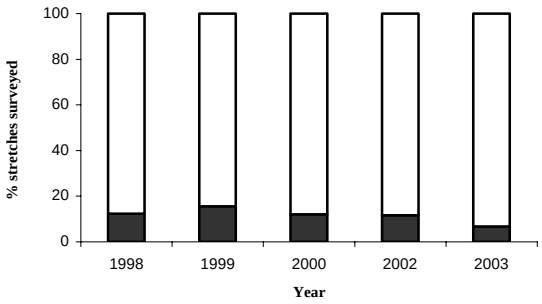
A relatively small increase in the number stretches would result in a large increase in power to detect change in presence (e.g. a 33% decline detected with 300 stretches and 25% decline with 700 stretches). Whilst the potential of combining BBS and WBBS presence data for these species was considered, in isolation it would result in little additional power to detect change.

Change in percent WBBS stretches reporting presence
Key Black = present: White = absent (species not recorded)

a) Water Vole



b) American Mink



c) Otter