British Trust for Ornithology

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Opportunistic Bird Species - Enhancements for the Monitoring of Populations

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CONTENTS

1. EXECUTIVE SUMMARY

1. The control of 13 opportunistic bird species in the interests of health and safety or to prevent damage to agriculture or for the protection of flora and fauna is permitted, under license, by the UK Government. To ensure that the conservation statuses of the species controlled under these licences are not adversely affected by the issue of the licences, the population levels and trends need to be monitored. This is in line with the UK's obligations under the European Community Wild Birds Directive.

2. The Common Birds Census, operated by the British Trust for Ornithology since 1962, provides data on the population trends for nine of the 13 opportunistic species in the United Kingdom. Of these nine species, three increased strongly between 1985 and 1996, three showed modest gains while three showed population decreases. Conservation Vigilance is recommended for Starling and House Sparrow on the basis of their continued decline between 1985 and 1996.

3. The Rook population is not well monitored by the Common Birds Census, owing to its habit of nesting in large colonies that may shift between years. A special survey of Rooks in 1996 estimated that the total UK nesting population in that year was 1.27 million pairs. Comparison with a BTO survey in 1975 suggest an increase of about 40% between 1975 and 1996.

4. The use of CBC data, and in principle any similar data set, has been enhanced by the development of an Alert Level system which can be used to identify population declines of conservation concern. This system is not specific to opportunistic species and should prove to be a valuable tool in wildlife conservation.

5. No opportunistic species raised alerts, but examples are presented of a number of other species which gave evidence of serious decline. Further methods, using different techniques of index estimation and trend smoothing, and the possibility of incorporating life-history traits into alert level criteria, are discussed.

6. The Common Birds Census, and the Breeding Bird Survey which began in 1994, are ongoing projects that are essential to the monitoring of opportunistic species. However, they require long-term funding if they are to continue to provide robust information on population trends of birds in the United Kingdom.

2. INTRODUCTION

The Wildlife and Countryside Act (1981) listed thirteen opportunistic bird species, Lesser Black-backed Gull *Larus fuscus*, Herring Gull *L. argentatus*, Great Black-backed Gull *L. marinus*, Feral Pigeon *Columba livia*, Woodpigeon *C. palumbus*, Collared Dove *Streptopelia decaocto*, Jay *Garrulus glandarius*, Magpie *Pica pica*, Jackdaw *Corvus monedula*, Rook *C. frugilegus*, Carrion Crow *C. corone*, Starling *Sturnus vulgaris* and House Sparrow *Passer domesticus*, under Schedule 2, Part II. Under this legislation as originally enacted, birds of all these species could be controlled at any time. All these species were removed from that schedule, as the actions that were authorised by their listing on that schedule did not meet the detailed derogation requirements of the EC Wild Birds Directive. However, the United Kingdom Government has secured a derogation in respect of these thirteen species under Article 9 of the European Directive on the Conservation of Wild Birds (EC/79/409). Since January 1993 a licensing system has been in operation by which the UK Government can issue a general licence, under section 16 of the Wildlife and Countryside Act, for the taking of these species in the interests of health and safety or to prevent serious damage to livestock and crops, or for the protection of flora and fauna. The derogation entails a responsibility to monitor these species to provide data that indicate their population levels and trends.

The population levels of these opportunistic species are of special interest to birdwatchers and conservationists alike. In particular, several of the corvids have shown long-term changes in population status (Parslow 1973, Marchant *et al.* 1990, Gregory & Marchant 1996). Magpie, and to a lesser extent Carrion Crow, are important predators of eggs and nestlings (Potts 1986, Gooch *et al.* 1991, Groom 1993). It has been suggested that their population increases may have been a cause of parallel declines of open-nesting species, although there is little direct support for this idea (Potts 1986, Gooch *et al.* 1991, Groom 1993). All thirteen species are familiar and widespread birds whose interests sometimes conflict with those of man. There is therefore considerable value in monitoring their status as 'pest species'.

The Common Birds Census (CBC), operated by the British Trust for Ornithology since 1962, is the only source of data on trends in breeding population for the period and species included in this study (Marchant *et al.* 1990). Note that populations of the three gulls are monitored routinely through the Joint Nature Conservation Committee and are not included in this report. We are also unable to report population changes for Feral Pigeon which has generally been omitted from census schemes, although the Breeding Bird Survey has monitored their national populations from 1994 onwards. Most CBC plots are on farmland or in woodland; the data are used to monitor population changes and study fine-scale distribution patterns among birds, particularly in these two types of habitat. Standard reporting of population change covers farmland and woodland, combining plots throughout the United Kingdom; a small number of scarcer species are monitored by combining data from all habitat types. More than thirty years' data on United Kingdom bird populations are now available (see section 3.2).

The CBC forms an invaluable resource for the study of population changes in around 75 bird species. Species for which the CBC can monitor population levels are generally the commonest and most widespread British birds. Among the species previously in Schedule 2, Part II, the gulls and Feral Pigeon, though all with large breeding populations in the United Kingdom, are too scarce in the habitats surveyed by the CBC for monitoring to be possible. Rook, although both numerous and widespread, has not routinely been indexed because of its highly clumped nesting distribution. Rooks are recorded as present during the breeding season on most CBC plots, but only active nests are counted for monitoring purposes. Nesting was reported on between 2% and 12% of plots in 1965-88 (Marchant *et al.* 1990), so that samples of plots available for population indexing have been relatively low. Total counts of nests on CBC plots have, however, been substantial in recent years and sufficient to indicate the population trend over the past decade. The most efficient approach to censusing Rooks is to carry out national surveys based upon a sampling framework and the BTO has conducted three previous surveys of this species. For this reason a new national survey of Rookeries was conducted as part of this contract (see section 4).

This report is organised as follows. The annual monitoring of opportunistic species through the CBC for the period of the contract in reported in section 3. Following a brief introduction and discussion of methods, the results are presented species by species. The chapter concludes with a review of the overall trends of the opportunistic species in the UK. Section 4 summarises the results of the national Sample Census of Rookeries of 1996. Following an introduction and discussion of methods, we describe survey coverage, provide an estimate of the size of the Rook population and make specific comparison with the previous full national survey of 1975.

The fifth and final section presents work on the development of "Alert Levels" for opportunistic species. A novel set of analyses are developed in order to define quantitative criteria and thresholds that identify species in serious population decline. Methods are developed using data from the CBC and applied to a number of common passerines, as well as the opportunistic species, to assess their generality. The strengths and limitations of this approach are discussed in the context of opportunistic species monitoring.

Finally, we acknowledge the many individuals and organisations who have supported the work in a number of different ways. A full list of references is provided.

3. MONITORING OPPORTUNISTIC SPECIES

3.1 Introduction

CBC data were used to produce three interim reports, each covering the most recent ten-year period. The periods covered were 1985-94 (Marchant & Gregory 1995), 1986-95 (Marchant, Wilson & Gregory 1996), and 1987-96 (Marchant, Wilson & Gregory 1997). The results chapter from the most recent of these annual reports is reproduced here, following a methods section that covers the full 12-year period 1985-96.

3.2 Methods

3.2.1 Census methods

CBC observers use the mapping method to gather information each spring and summer on the numbers and distribution of breeding bird territories on plots throughout the United Kingdom (Marchant 1983, Marchant *et al.* 1990). Observers make a series of visits to their plot through the breeding season to record all the birds seen or heard. This information is used to identify clusters of registrations which are taken to represent breeding territories.

CBC plots are classified mostly as either farmland or woodland. A smaller number of 'special' plots are of other habitat types. Farmland plots reflect the general nature of farmland landscapes in that they often contain small areas of woodland. Plots of all three classes may contain or be bordered by houses and gardens.

The numbers and mean areas of census plots during the 12 years 1985-96 are shown in Table 3.2.1.1 for each class of habitat. These are the plots that were available for analysis using the chain index method: some late returns are expected to add to these totals, especially for 1996. The 1996 farmland total represents about 95% of the expected final total, while only a handful of woodland or special plots are certain to arrive. Thus the analysis is based on about 98% of the final results for 1996.

Table 3.2.1.1 **Numbers of CBC plots censused in the United Kingdom during 1985-96, classified by broad habitat type.**

Year	Farmland		Woodland		Special habitats		All habitats combined	
	Number	Mean area (ha)	Number	Mean area (ha)	Number	Mean area (ha)	Number	Mean area (ha)
1985	100	73.4	102	20.4	47	33.6	249	44.2
1986	99	72.7	92	20.0	34	34.3	225	45.3
1987	101	69.8	95	20.9	29	45.9	225	46.1
1988	100	74.4	86	20.1	25	33.9	211	47.5
1989	102	73.2	96	20.8	21	32.2	219	46.3
1990	99	73.3	97	21.6	25	37.3	221	46.5
1991	101	71.7	103	21.6	23	35.4	227	45.3
1992	97	73.6	103	21.8	23	35.4	223	45.7
1993	104	73.8	111	20.7	24	34.0	239	45.2
1994	103	74.0	117	21.3	27	37.1	247	45.0
1995	102	71.0	115	21.1	28	36.6	245	43.7
1996	95	69.6	107	20.7	24	34.4	226	42.7

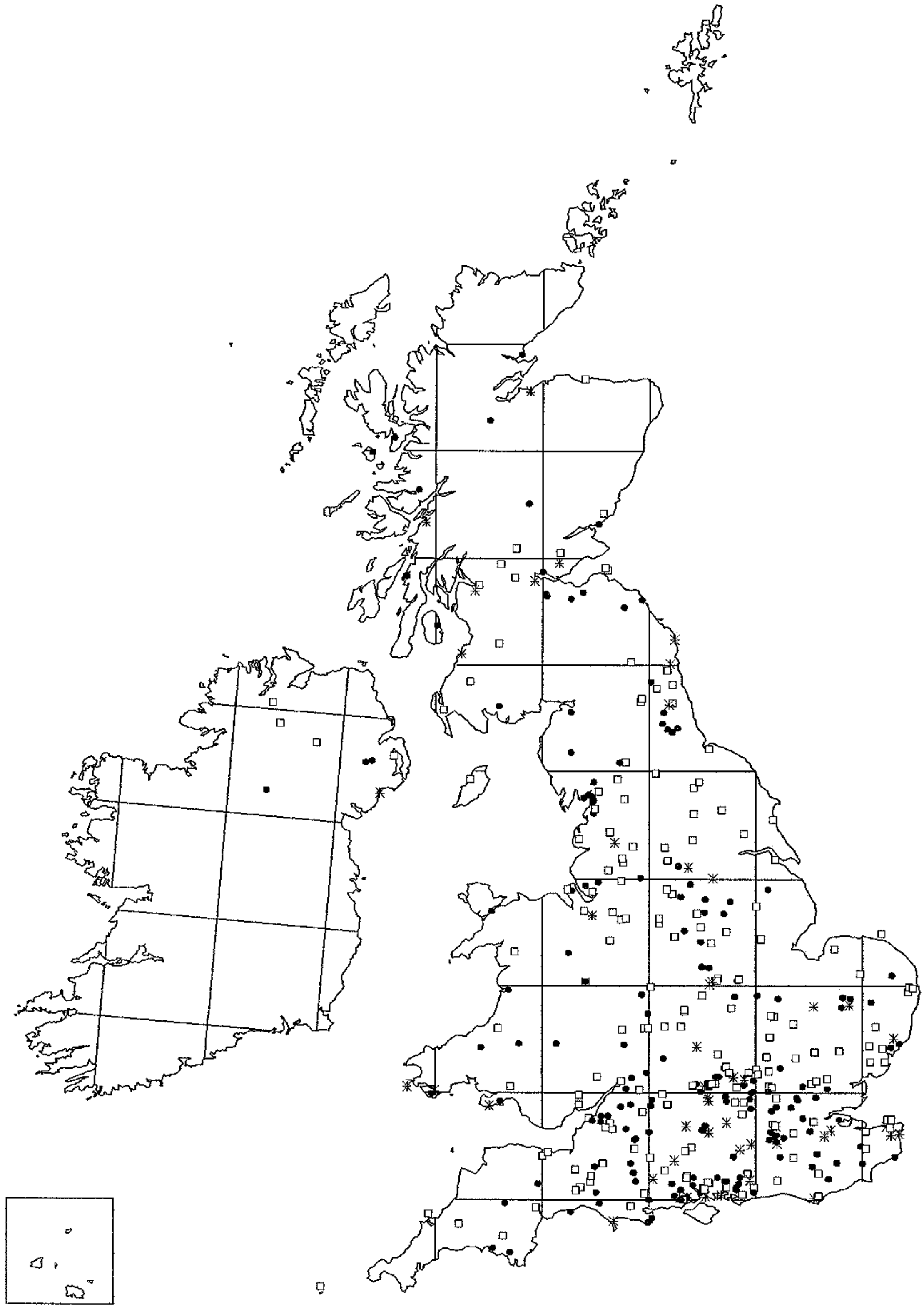
The reduction during the first four years in the number of special plots was the result of a policy decision to concentrate resources more into farmland and woodland. No other major changes in the structure of the all-habitats sample have occurred during this period, despite an annual turnover rate typically in the range 12-15%.

3.2.2 Estimation of population change

Annual population changes have been standardly estimated from the CBC by pairing territory totals on each plot in successive years, using only those plots providing data collected in a comparable way. Estimates of population change between the first and second years of a comparison are calculated from the totals of paired counts across plots. Successive estimates of year-to-year change are converted to long-term trends by the chain index method, in which the values of a population index, set at 100 in an arbitrary datum year, are calculated by applying each annual change successively to the previous value (Marchant *et al.* 1990).

The distribution of the census plots, 407 in total, that contributed to the estimates of percentage change during 1985-96 is plotted in Figure 3.2.2.1. All regions of the United Kingdom were represented except the Northern and Western Isles.

Figure 3.2.2.1 The distribution of Common Birds Census plots contributing data to estimates of percentage change between 1985 and 1996. Habitat categories are shown separately: open squares - farmland; filled circles - woodland; asterisks - special habitats.



3.2.3 Present limitations of the trend data

The population trends presented here are drawn from the only extensive census data set using the best analysis methods that were available throughout the period of the contract. However, neither data nor methods of analysis are the best that could be achieved (Baillie & Marchant 1992, Peach & Baillie 1994, Greenwood *et al.* 1995).

The limitations of the CBC data as measures of United Kingdom population trends were set out by Marchant *et al.* (1990). The most important are the geographical bias of census plots towards the south and east of Britain (Figure 3.2.2.1), the restriction of coverage to farmland and woodland habitats, and the relative shortage of census plots compared to the number that could be achieved using simpler methods to collect the data. These limitations were addressed by BTO and JNCC in the design of methods for a new census scheme, the Breeding Bird Survey (BBS), which began in the spring of 1994 and has just completed its third season. BBS uses random selection of census sites to ensure that sampling is representative both geographically and in terms of habitat.

BBS and CBC are currently running in parallel, so that the monitoring results of the two schemes can be compared.

New methods of assessing trends in CBC data that are expected eventually to supersede the chain index method are now available and have been used in section 5. Section 5 also points the way to further improvements in this area.

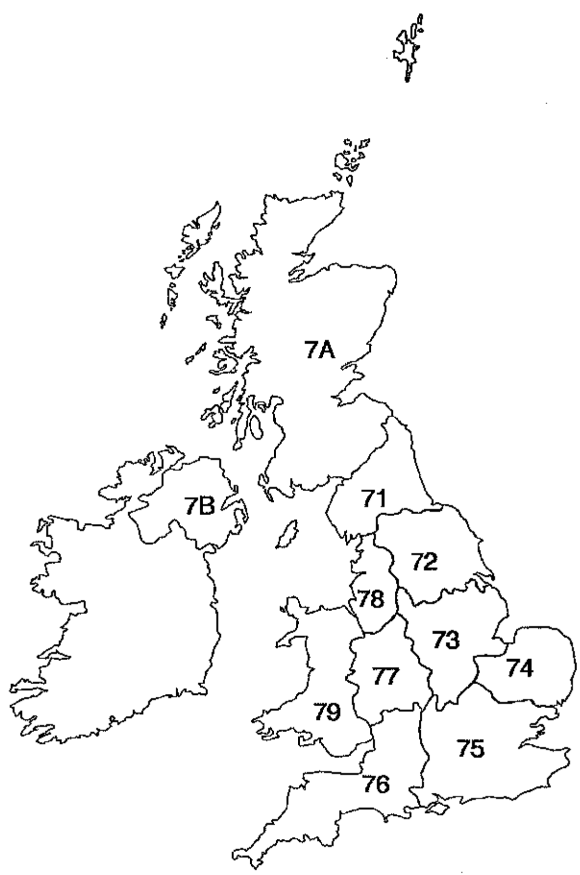
3.3 Results and discussion

The results are discussed first species by species, and then generally.

A regional analysis of trends for all nine species was carried out in 1994, covering the period 1983-93 (Marchant in press). Regions used were the 11 NUTS (Nomenclature of Territorial Units for Statistics) regions of the United Kingdom (Figure 3.3.1). The results of this analysis are summarised under the species headings.

Variation in trends in CBC density across habitats and regions has been analysed by Gregory & Marchant (1996) for four of the corvids, Jay, Magpie, Jackdaw and Carrion Crow, over the same period (1983-93).

Figure 3.3.1 United Kingdom showing level 1 NUTS (Nomenclature of Territorial Units for Statistics) regions of the European Community. Key: 71 North England; 72 Yorkshire/Humberside; 73 East Midlands; 74 East Anglia; 75 Southeast England; 76 Southwest England; 77 West Midlands; 78 Northwest England; 79 Wales; 7A Scotland; and 7B Northern Ireland.



3.3.1 Woodpigeon *Columba palumbus*

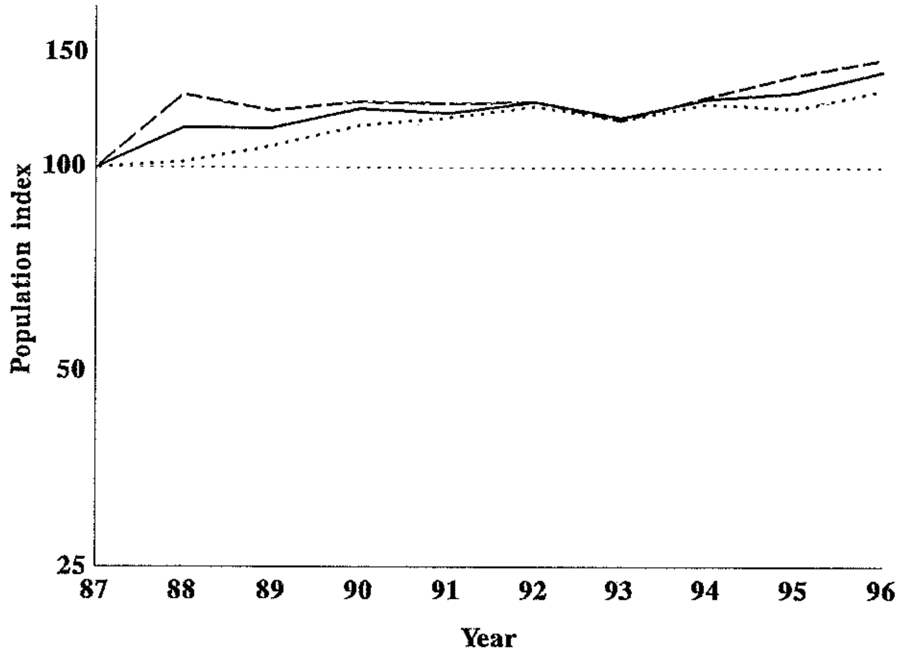


Figure 3.3.1.1 CBC population changes between 1987 and 1996 for Woodpigeon on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

CBC data indicate a steady increase in the population in both farmland and woodland during the last ten years. This is a continuation of the upward trend shown by the CBC since the mid 1970s (Marchant *et al.* 1990). Inglis *et al.* (1990) regarded the acreage of oilseed rape, which has increased since the late 1970s, as an important factor limiting the population.

A regional analysis of trends (Marchant in press) showed significant increases in five regions, but a significant shallow decline in numbers in Scotland.

CBC monitoring of Woodpigeon numbers is of poor quality in relation to other common species, for two main reasons (Marchant *et al.* 1990). First, Woodpigeons have a long breeding season and may nest in any month. Many nest late in the breeding season, after CBC fieldwork has finished for the year. There is evidence that the proportion of breeding attempts occurring within the March-July census period has increased (O'Connor & Shrubb 1986): this would have the effect of biasing the CBC trend towards increase. O'Connor & Shrubb linked the advancing breeding season with changes in farmland management, particularly the switch from spring to autumn sowing which advances the ripening of crops. Second, CBC observers often cannot estimate breeding numbers on plots where Woodpigeons are dense. No data entered the index calculations from such plots. Thus the CBC trends were drawn particularly from plots where density was relatively low, and were based on the assumption that trends on plots of high and low density were similar.

Population trend: Continued increase

Conservation status or concern: Status secure

Table 3.3.1.1 **Population changes for Woodpigeon in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.**

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	777	894	103	**+15***	+7	+24	**115**
	89	884	884	103	**0**	-8	+9	**115**
	90	940	1002	112	**+7**	0	+14	**123**
	91	1005	995	112	**-1**	-7	+6	**121**
	92	1097	1136	121	**+4**	-3	+10	**126**
	93	1183	1123	133	**-5**	-11	+1	**119**
	94	1200	1276	147	**+6**	-1	+14	**127**
	95	1276	1311	151	**+3**	-3	+9	**130**
	96	1247	1336	147	**+7**	0	+15	**140**
Farmland plots	**87**							**100**
	88	366	372	45	**+2**	-8	+12	**102**
	89	402	427	51	**+6**	-9	+22	**108**
	90	475	512	58	**+8**	-2	+19	**116**
	91	485	495	54	**+2**	-7	+12	**119**
	92	534	557	58	**+4**	-6	+15	**124**
	93	592	565	62	**-5**	-13	+5	**118**
	94	573	608	68	**+6**	-4	+19	**125**
	95	644	631	70	**-2**	-10	+6	**123**
	96	583	622	67	**+7**	-5	+20	**131**
Woodland plots	**87**							**100**
	88	331	428	44	**+29***	+16	+43	**129**
	89	395	373	41	**-6**	-16	+6	**122**
	90	381	392	43	**+3**	-8	+16	**126**
	91	419	416	47	**-1**	-9	+9	**125**
	92	427	432	47	**+1**	-8	+11	**126**
	93	489	459	56	**-6**	-14	+2	**118**
	94	494	533	62	**+8**	-4	+21	**128**
	95	498	537	65	**+8**	-1	+18	**138**
	96	582	617	67	**+6**	-3	+16	**146**

3.3.2 Collared Dove *Streptopelia decaocto*

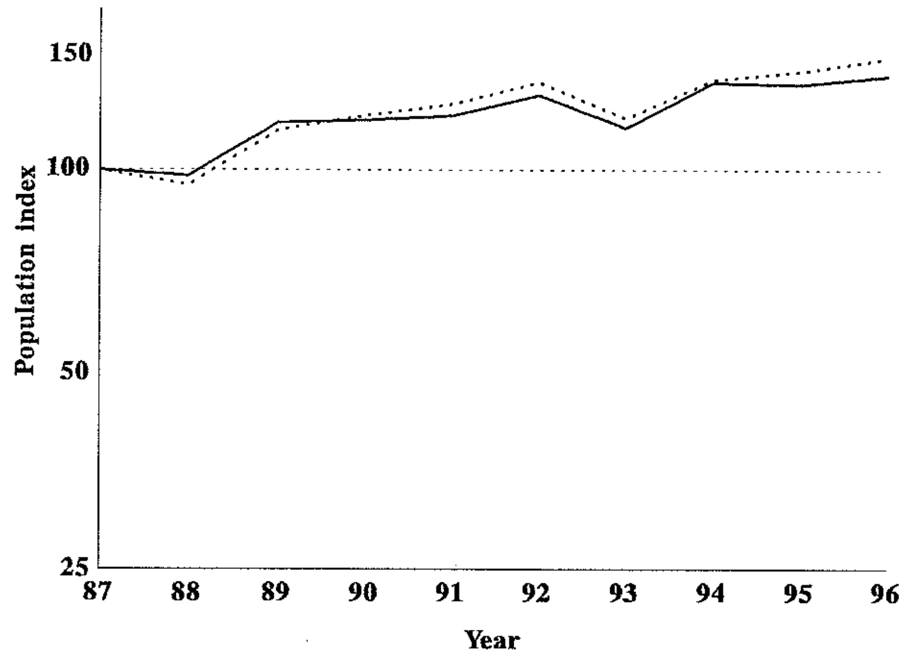


Figure 3.3.2.1 CBC population changes between 1987 and 1996 for Collared Dove on farmland (dotted line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

The spectacular rise in Collared Dove numbers during the first decades of the CBC ended about 1982 (Marchant *et al.* 1990). There was no overall trend in the United Kingdom during the rest of the 1980s but during the 1990s there has been a further steady increase on farmland. The woodland sample size is relatively small and results are therefore presented only for farmland and all habitats combined (Figure 3.3.2.1, Table 3.3.2.1).

A regional analysis for the period 1983-93 found an increase in North England to be the only statistically significant regional trend (Marchant in press).

The CBC is well placed to monitor Collared Dove populations of farmland, where the species is usually associated with farms or homesteads. However, these results may not be representative of the whole population because the species reaches its highest densities in urban and suburban environments.

Population trend: **Renewed shallow increase, following earlier spectacular increase and stability**

Conservation status or concern: **Status secure**

Table 3.3.2.1 Population changes for Collared Dove in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	87							100
	88	178	174	82	-2	-20	+16	98
	89	171	206	82	+20*	+7	+40	118
	90	190	192	83	+1	-13	+16	119
	91	185	188	79	+2	-13	+19	121
	92	204	219	88	+7	-8	+27	130
	93	189	169	80	-11	-24	+5	116
	94	175	205	83	+17*	+4	+33	136
	95	202	200	84	-1	-14	+13	135
	96	167	172	77	+3	-10	+17	139
Farmland plots	87							100
	88	128	122	50	-5	-26	+15	95
	89	122	147	49	+20*	+4	+47	115
	90	131	138	49	+5	-12	+21	121
	91	130	135	47	+4	-14	+28	126
	92	141	153	50	+9	-11	+35	136
	93	134	118	48	-12	-27	+9	120
	94	120	137	52	+14*	0	+33	137
	95	135	139	54	+3	-13	+20	141
	96	117	123	51	+5	-11	+23	148

3.3.3 Jay *Garrulus glandarius*

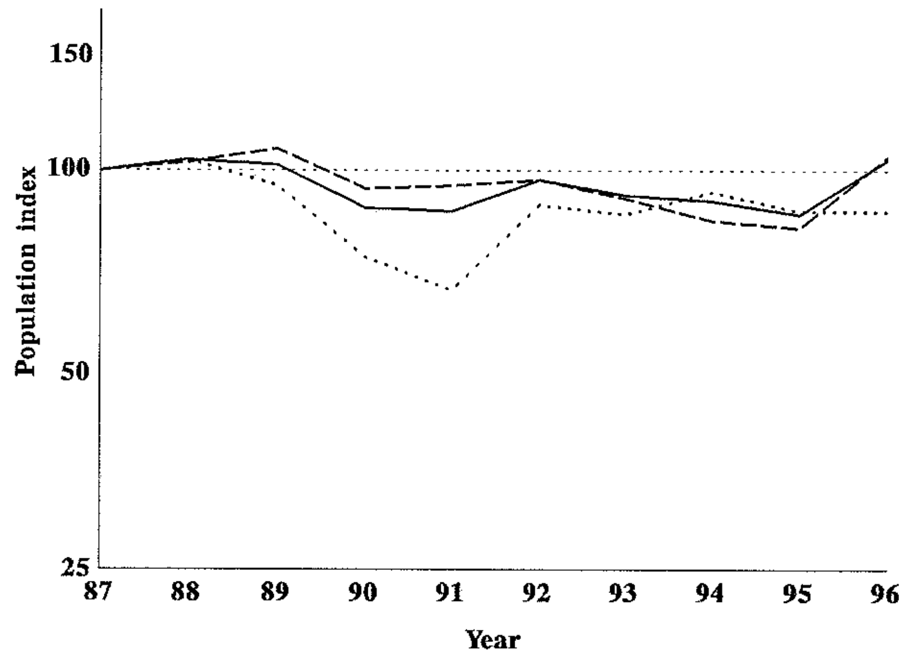


Figure 3.3.3.1 CBC population changes between 1987 and 1996 for Jay on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

Following stability of Jay populations during the 1980s, there was a shallow decrease in numbers on both woodland and farmland CBC plots beginning about 1989. This has now been reversed by a sharp increase in woodland numbers in 1996. The relatively low density on farmland may have been responsible for the apparently greater fluctuation in that habitat. Jays appear to have increased overall during the second half of the twentieth century (Parslow 1973, Marchant *et al.* 1990), although data from the *New Atlas* show a small reduction between 1970 and 1990 in the number of occupied squares (Gibbons *et al.* 1993). There has been, however, some northward extension of the breeding range in Northern Ireland and in Scotland since 1968-72.

Decreases during 1983-93 were statistically significant in East Midlands and West Midlands (Marchant in press).

The increases noted between the Second World War and the 1980s are thought to be to due to reduced control by gamekeepers and to the creation of new woodlands (Prestt 1965, Sharrock 1976, Gibbons *et al.* 1993). Some support for the control argument is provided by the Game Conservancy Trust's National Game Bag Census (NGBC) which shows the numbers of Jays killed on a sample of estates managed for shooting to have fallen between 1961 and 1989 (Tapper 1992). The majority of Jays in this sample are killed in winter, and so not all will be resident birds (S Tapper, pers. comm.). It should be noted first that, like the CBC, the NGBC is not based upon a random sample and, second, that there is no control for differences in keepering effort across estates.

Population trend: Shallow decrease during 1987-96; stable in the longer term

Conservation status or concern: Status secure

Table 3.3.3.1 Population changes for Jay in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	170	176	108	+4	-7	+15	**104**
	89	174	172	107	-1	-10	+9	**102**
	90	186	160	108	-14*	-22	-6	**88**
	91	162	160	108	-1	-10	+8	**87**
	92	179	199	121	+11*	0	+23	**97**
	93	195	185	118	-5	-15	+6	**92**
	94	195	192	123	-2	-11	+9	**90**
	95	194	185	127	-5	-14	+6	**86**
	96	157	189	113	+20*	+8	+34	**104**
Farmland plots	**87**							**100**
	88	47	49	34	+4	-17	+32	**104**
	89	54	49	37	-9	-26	+11	**95**
	90	50	39	32	-22*	-34	-9	**74**
	91	39	35	30	-10	-28	+9	**66**
	92	37	50	36	+35*	+10	+73	**89**
	93	45	43	36	-4	-29	+26	**86**
	94	44	48	36	+9	-14	+44	**93**
	95	45	42	39	-7	-31	+24	**87**
	96	39	39	33	0	-25	+29	**87**
Woodland plots	**87**							**100**
	88	108	111	63	+3	-9	+16	**103**
	89	105	110	60	+5	-7	+18	**108**
	90	123	107	67	-13*	-24	-2	**94**
	91	110	111	68	+1	-10	+12	**95**
	92	121	124	72	+2	-9	+16	**97**
	93	129	121	72	-6	-17	+6	**91**
	94	127	117	75	-8	-18	+4	**84**
	95	123	120	74	-2	-13	+9	**82**
	96	103	132	69	+28*	+14	+46	**105**

3.3.4 Magpie *Pica pica*

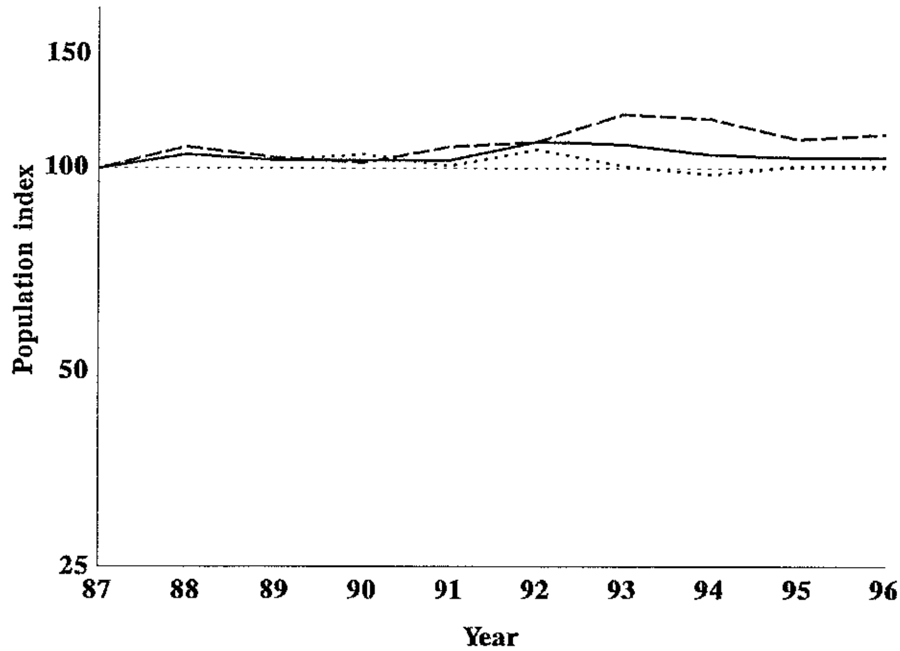


Figure 3.3.4.1 CBC population changes between 1987 and 1996 for Magpie on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

The CBC has documented substantial increases in Magpie populations between 1964 and 1993 (Gregory & Marchant 1996), an increase that has been characterised by an expansion of the population into urban areas. Trends were similar across CBC habitats, although population gains were limited on arable farms. Regional trends were also described by Gooch *et al.* (1991). Population gains in the southeast since 1964 contrast with the recorded declines in parts of eastern England during the late 1950s and early 1960s. The latter were attributed to the removal of hedgerows and to the use of pesticides (Prestt 1965, Parslow 1973, Cooke 1979). There has been a considerable levelling off of the upward trend during the last ten years with overall stability during the 1990s (Figure 3.3.4.1).

Significant upward trends during 1983-93 were confined to England among United Kingdom NUTS regions, but were detected in six of the eight English regions (Marchant in press). Population gains were largest in East Anglia, but Magpie densities are still relatively low in much of eastern England (Gibbons *et al.* 1993, Gregory & Marchant 1996, Marchant in press).

The historical increases in Magpies are believed to stem from reduced levels of control that began at the time of the First World War (Parslow 1973, O'Connor & Shrubb 1986, Tapper 1992). The spread of the breeding range from rural farmland and woodland into suburbia, which is only partly reflected in the CBC data, has contributed to the high rate of increase (Birkhead 1991, Gooch *et al.* 1991). The NGBC has shown a doubling in the number of Magpies killed in Britain between 1961 and 1989, reflecting the population growth (Tapper

1992). In just two more years up to 1991 there was a further doubling in the numbers killed (Tapper & France 1992), but a slight decline in the next two years (S Tapper, pers. comm.). The recent changes are due to the introduction of Larsen traps which represent a remarkably efficient method of trapping breeding Magpies (and Carrion Crows) (Tapper & France 1992). Their recent introduction, however, means that they cannot be responsible for the slowing down of population growth of Magpie (and Carrion Crow) which began in the late 1970s (Gregory & Marchant 1996). Studies of Magpie populations in Sheffield have also shown a reduction in the rate of increase of territorial birds from around 1980, although the numbers of non-territorial birds has continued to increase (Birkhead 1991). The current impact of control measures is difficult to judge but, with the advent of the Larsen trap, it is conceivable that control might limit Magpie numbers.

Links are widely perceived between the increases in Magpies and decreases in open-nesting songbirds. There is evidence from local studies that Magpie predation can reduce Blackbird nesting success to the point where productivity is too low to maintain local populations (Groom 1993). On the national scale, however, Gooch *et al.* (1991) found no decreases in nest success among fifteen species of songbirds that occur alongside Magpies, and no evidence that increases in Magpie numbers were linked with declines in songbird populations.

Population trend: **Now stable after earlier prolonged and widespread increase**

Conservation status or concern: **Status secure**

Table 3.3.4.1 **Population changes for Magpie in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.**

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	474	497	150	+5	-2	+12	**105**
	89	502	493	152	-2	-8	+5	**103**
	90	474	474	152	0	-7	+7	**103**
	91	465	464	149	0	-7	+8	**103**
	92	487	519	150	+7	-1	+14	**110**
	93	511	509	152	0	-7	+7	**109**
	94	539	517	158	-4	-10	+2	**105**
	95	531	530	167	0	-7	+7	**104**
	96	463	463	158	0	-7	+7	**104**
Farmland plots	**87**							**100**
	88	309	324	72	+5	-4	+14	**105**
	89	334	329	80	-2	-9	+7	**103**
	90	294	298	75	+1	-8	+11	**105**
	91	286	276	72	-4	-13	+7	**101**
	92	275	292	66	+6	-4	+17	**107**
	93	293	276	68	-6	-15	+4	**101**
	94	292	282	71	-3	-12	+6	**98**
	95	288	298	75	+3	-6	+14	**101**
	96	267	266	71	0	-10	+10	**101**
Woodland plots	**87**							**100**
	88	124	134	60	+8	-5	+25	**108**
	89	129	124	56	-4	-14	+7	**104**
	90	142	139	62	-2	-11	+7	**102**
	91	137	146	62	+7	-5	+19	**108**
	92	156	159	65	+2	-9	+14	**110**
	93	158	173	67	+9	-2	+23	**121**
	94	179	176	70	-2	-11	+9	**119**
	95	175	164	74	-6	-17	+5	**111**
	96	146	148	70	+1	-10	+15	**113**

3.3.5 Jackdaw *Corvus monedula*

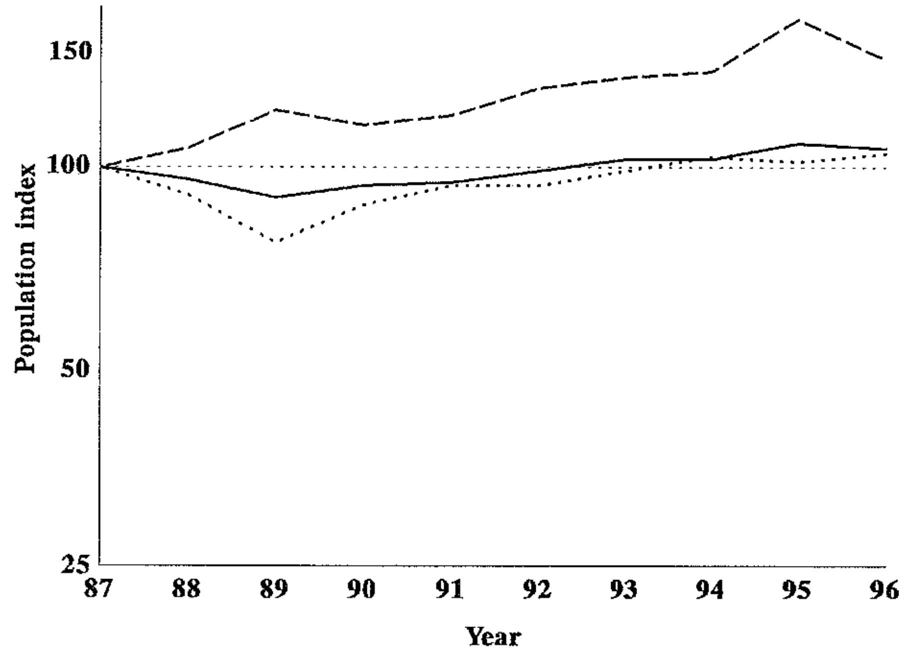


Figure 3.3.5.1 CBC population changes between 1987 and 1996 for Jackdaw on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

The Jackdaw's steady increase in Britain during the twentieth century is perhaps attributable to changing patterns of cultivation (Parslow 1973, O'Connor & Shrubb 1986). During the 1980s, the rate of increase slowed and the farmland and woodland CBC indices changed little between 1982 and 1988 (Marchant *et al.* 1990). During the period 1987 to 1996 there was a renewal of the upward trend, particularly in woodland (Figure 3.3.5.1). In contrast, analysis of CBC densities during 1964-93 found Jackdaw populations to have declined in woodland during that period (Gregory & Marchant 1996).

Jackdaw trends varied across habitats and regions (Gregory & Marchant 1996). Population gains during 1964-93 were most pronounced on grazing farms and in the north and southwest where such farms predominate. Woodland Jackdaws increased only in the north. During 1983-93, regional trends were significantly upward in Scotland and East Anglia, and downward, although based on a small sample, in Yorkshire/Humberside (Marchant in press). Previous studies have raised the importance of grassland as a feeding area for Jackdaws and also the availability of suitable nest sites (O'Connor & Shrubb 1986).

It should be stressed that the aggregated and semi-colonial nesting habit of this species makes census work problematic; in addition, their populations are concentrated in the west of Britain and often in habitats outside the scope of the CBC (Gibbons *et al.* 1993). Atlas data show a contraction of range between 1970 and 1990 (Gibbons *et al.* 1993), and the NGBC shows the number of Jackdaws killed to have fallen between 1961 and 1989 (Tapper 1992).

Population trend: **Increase recently in woodland, otherwise little recent change**

Conservation status or concern: **Status secure**

Table 3.3.5.1 Population changes for Jackdaw in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al*. (1986). Statistically significant changes are marked with an asterisk.

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	267	257	85	**-4**	-18	+16	**96**
	89	292	272	89	**-7**	-15	+2	**90**
	90	272	284	90	**+4**	-7	+18	**94**
	91	266	270	85	**+2**	-11	+16	**95**
	92	290	301	87	**+4**	-10	+19	**99**
	93	307	320	87	**+4**	-6	+16	**103**
	94	348	350	86	**+1**	-9	+13	**103**
	95	327	345	85	**+6**	-5	+17	**109**
	96	348	341	71	**-2**	-14	+13	**107**
Farmland plots	**87**							**100**
	88	183	166	47	**-9**	-26	+18	**91**
	89	185	158	51	**-15***	-25	-4	**77**
	90	156	177	52	**+13**	-1	+32	**88**
	91	148	158	45	**+7**	-6	+20	**94**
	92	171	172	45	**+1**	-17	+22	**94**
	93	198	208	45	**+5**	-8	+19	**99**
	94	205	214	46	**+4**	-8	+21	**104**
	95	194	192	47	**-1**	-14	+15	**102**
	96	184	188	35	**+2**	-14	+26	**105**
Woodland plots	**87**							**100**
	88	69	74	30	**+7**	-14	+38	**107**
	89	74	84	31	**+14**	-3	+32	**122**
	90	86	82	31	**-5**	-24	+11	**116**
	91	89	92	32	**+3**	-20	+39	**120**
	92	83	91	32	**+10**	-17	+38	**132**
	93	90	94	33	**+4**	-15	+31	**137**
	94	96	98	30	**+2**	-15	+26	**140**
	95	92	110	28	**+20**	-1	+44	**168**
	96	146	127	31	**-13**	-27	+10	**146**

3.3.6 Rook *Corvus frugilegus*

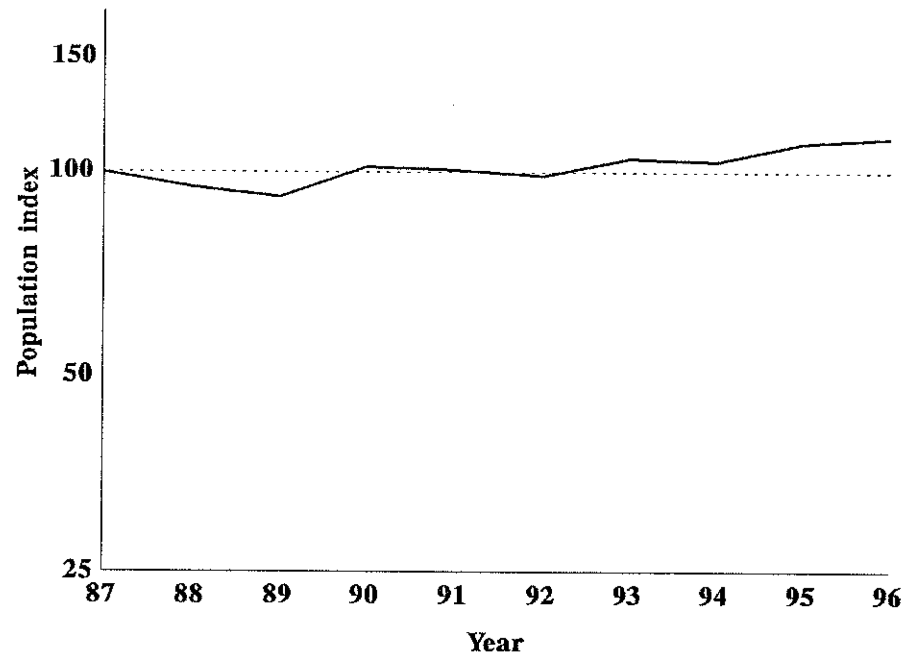


Figure 3.3.6.1 CBC population changes between 1987 and 1996 for Rook in all habitats combined. Index values are relative to 100 in 1987.

The territory mapping method of the CBC is of little use in enumerating the populations of colonial species such as Rooks. Instead, CBC observers make counts of nests in active rookeries. While this species is recorded on most CBC plots, nests were found on only around 10% of plots in 1983-88 (Marchant *et al.* 1990), not enough to maintain an adequate sample. The species has not therefore been monitored routinely by the CBC. However, in the absence of other annual data on national population change, it is of value to produce an estimate of trends using the nests counts from CBC plots. These indicate a small increase between 1987 and 1996 with rather little between-year fluctuation (Figure 3.3.6.1). As these results are based on few plots (Table 3.3.6.1), it is not possible to provide separate indices for farmland and woodland.

A regional analysis during 1983-93 found a significant decrease in West Midlands, although this was based on a small sample of census plots, and a significant increase in the South East (Marchant in press).

Population trend: **Stable or increasing shallowly**

Conservation status or concern: **Status secure**

Table 3.3.6.1 Population changes for Rook in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986).

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	774	733	17	**-5**	-38	+23	**95**
	89	983	957	24	**-3**	-19	+20	**92**
	90	836	926	23	**+11**	-27	+39	**102**
	91	869	856	23	**-2**	-12	+22	**101**
	92	778	762	22	**-2**	-10	+5	**99**
	93	851	904	27	**+6**	-6	+31	**105**
	94	1038	1031	30	**-1**	-9	+16	**104**
	95	791	841	28	**+6**	-5	+18	**111**
	96	899	917	29	**+2**	-12	+20	**113**

3.3.7 Carrion Crow *Corvus corone*

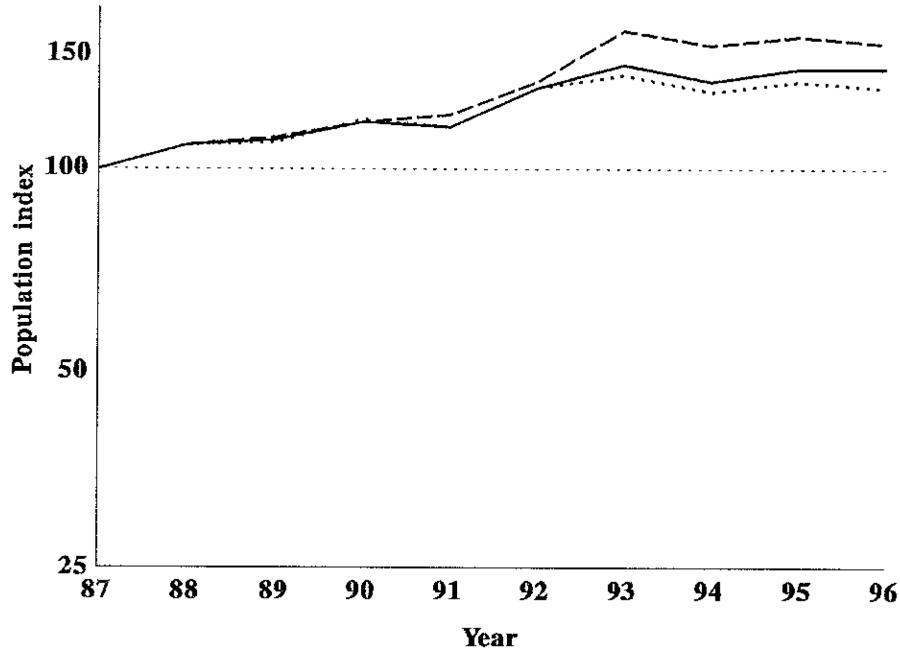


Figure 3.3.7.1 CBC population changes between 1987 and 1996 for Carrion Crow on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

The considerable increase in Carrion Crow numbers during this century mirrors that shown by Magpies, although the rate of increase has generally been slower (Gregory & Marchant 1996). A reduction in persecution has probably contributed to this increase but, as with Magpie, there has also been a change in habits, allowing the population to expand rapidly into suburban and urban areas (Parslow 1973, O'Connor & Shrubb 1986, Tapper 1992). Although the rate of increase had slowed by the 1980s, the upward trend has since picked up again, particularly on farmland (Figure 3.3.7.1).

During 1983-93, increases were remarkably consistent among 11 regions of the United Kingdom (Marchant in press). Significant increases of between 4.3% and 7.2% per annum were found in five of the eight English regions, and in Scotland.

O'Connor & Shrubb (1986) suggested that the general increase in the stocking density of sheep in upland areas, and consequent increase in carrion, may be responsible for the expansion of Carrion Crow and Magpie populations. They showed that Carrion Crows on CBC plots were increasing in counties dominated by cereals and tillage and were stable in sheep-rearing regions. However, Gregory & Marchant (1996) found population gains on both mixed and grazing CBC plots and only a small increase on arable plots. Comparison is difficult because O'Connor & Shrubb assigned all CBC plots in a county to the predominant farmland type in that county, and their period of study was 1962-84 rather than 1964-93. The *New Atlas* shows population densities to be relatively low in much of eastern England (Gibbons *et al.* 1993).

The NGBC has shown no overall change in the number of Carrion Crows killed between 1961 and 1988 (Tapper 1992). This is surprising given the general population increase and perhaps suggests a reduction in effort directed to the control of this species (Tapper 1992). Despite the introduction of Larsen traps, which are equally efficient at capturing territorial Carrion Crows and Magpies, there has been only a small upturn in more recent bag returns (Tapper & France 1992).

CBC results refer to the species as a whole but, in practice, owing to the shortage of plots in northwest Scotland and in Northern Ireland, very few Hooded Crows *Corvus corone cornix* or intermediates were censused. There are no measures of population change among such birds, but it is known that their breeding range contracted further to the north and west during the twenty years between the two BTO breeding bird atlases (Gibbons *et al.* 1993).

Population trend: **Continued strong increase, perhaps less steep than formerly**

Conservation status or concern: **Status secure**

Table 3.3.7.1 Population changes for Carrion Crow in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	380	416	154	**+9***	+2	+18	**109**
	89	429	434	157	**+1**	-6	+9	**111**
	90	410	438	153	**+7**	-1	+15	**118**
	91	430	423	151	**-2**	-9	+6	**116**
	92	431	491	159	**+14***	+5	+23	**133**
	93	508	552	155	**+9***	+1	+17	**144**
	94	537	506	162	**-6***	-11	0	**136**
	95	524	550	168	**+5**	0	+11	**142**
	96	499	496	159	**-1**	-7	+6	**142**
Farmland plots	**87**							**100**
	88	258	281	75	**+9**	0	+20	**109**
	89	292	294	80	**+1**	-9	+11	**110**
	90	268	290	74	**+8**	-2	+18	**119**
	91	284	277	69	**-2**	-12	+8	**116**
	92	271	311	70	**+15***	+2	+28	**133**
	93	334	350	67	**+5**	-6	+16	**139**
	94	336	317	72	**-6**	-12	+2	**131**
	95	331	342	74	**+3**	-3	+10	**136**
	96	303	297	69	**-2**	-10	+7	**133**
Woodland plots	**87**							**100**
	88	97	106	62	**+9**	-5	+26	**109**
	89	107	110	61	**+3**	-10	+19	**112**
	90	115	121	64	**+5**	-11	+22	**118**
	91	116	119	66	**+3**	-13	+18	**121**
	92	124	139	70	**+12**	-3	+28	**136**
	93	142	169	70	**+19***	+4	+38	**162**
	94	161	153	70	**-5**	-14	+5	**154**
	95	150	155	73	**+3**	-8	+15	**159**
	96	156	152	73	**-3**	-11	+10	**155**

3.3.8 Starling *Sturnus vulgaris*

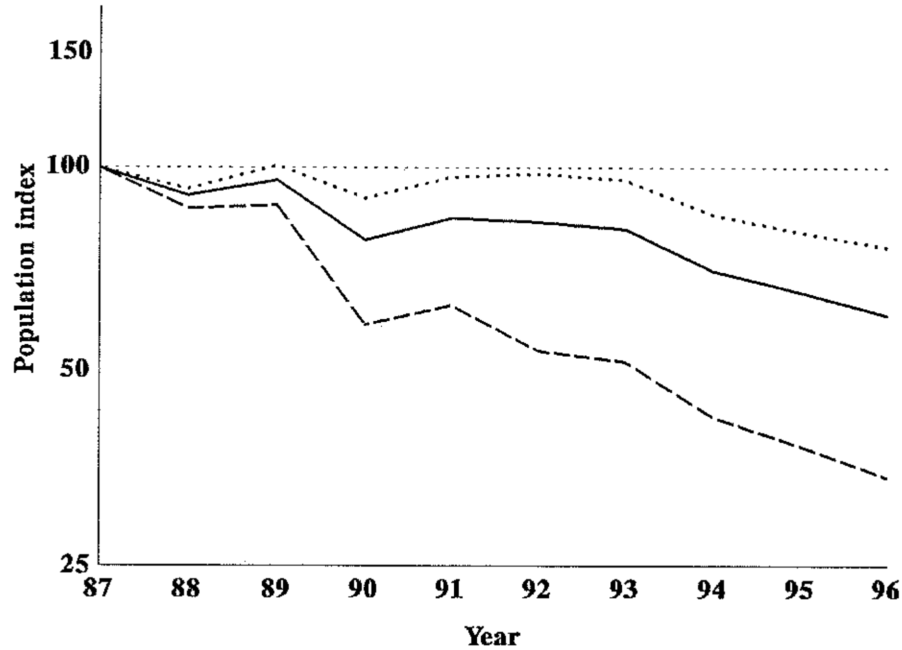


Figure 3.3.8.1 CBC population changes between 1987 and 1996 for Starling on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

There have been strong declines in the rural populations of Starlings since about 1980, a decline evident on both farmland and woodland CBC plots (Marchant *et al.* 1990). Declines continued during the period 1987 to 1996 and were especially steep in woodland, where by 1996 the population had dwindled to less than a quarter of its 1980 level. The decreases identified by the CBC are accompanied by declines elsewhere in northern Europe, which have resulted in lower numbers wintering in southern and western Europe (Feare 1996).

The Starling is now given **Amber** listing within the new list of *Bird Species of Conservation Concern in the United Kingdom, Channel Islands and Isle of Man* on account of a decline of between 25% and 49% over the last 25 years (Gibbons *et al.* 1996). The overall decrease within the shorter ten-year period covered by this report is also well within this range (37%, Table 3.3.8.1). Within woodland, however, the level of decline recorded (66%) would qualify the species for **Red** listing under the criteria set out in the new list.

During 1983-93, populations declined in the United Kingdom as a whole and also separately in four regions constituting the English south and east: a significant increase was recorded in Yorkshire/Humberside, although this was based on a small sample, and elsewhere in the north and west of the UK there was little evidence of change (Marchant in press).

The CBC measures Starling breeding population trends and densities on farmland and in woodland. Densities and trends are unknown for the urban and suburban sections of the population, where breeding densities are believed to be substantially higher.

Population trend: **In decline since early 1980s; severe decline in woodland**

Conservation status or concern: *Conservation vigilance required*

Table 3.3.8.1 Population changes for Starling in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al*. (1986). Statistically significant changes are marked with an asterisk.

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	87							100
	88	653	592	113	-9*	-17	-2	91
	89	602	639	112	+6	-6	+19	96
	90	645	525	109	-19*	-27	-9	78
	91	531	571	104	+8	-5	+24	84
	92	660	648	115	-2	-14	+10	83
	93	556	546	105	-2	-12	+10	81
	94	567	486	105	-14*	-21	-7	70
	95	479	446	107	-7	-16	+4	65
	96	401	374	100	-7	-16	+3	60
Farmland plots	87							100
	88	419	389	67	-7	-16	+3	93
	89	395	429	73	+9	-8	+24	101
	90	387	344	65	-11	-22	+2	90
	91	329	355	58	+8	-9	+33	97
	92	410	417	63	+2	-16	+16	98
	93	373	365	58	-2	-14	+13	96
	94	365	322	58	-12*	-20	-2	85
	95	343	324	63	-6	-16	+8	80
	96	294	280	60	-5	-16	+6	76
Woodland plots	87							100
	88	191	166	31	-13*	-31	-1	87
	89	176	178	27	+1	-16	+34	88
	90	223	147	30	-34*	-51	-20	58
	91	156	166	32	+6	-12	+42	62
	92	184	158	34	-14	-30	+6	53
	93	136	131	32	-4	-22	+15	51
	94	125	103	30	-18*	-35	-1	42
	95	79	72	28	-9	-36	+33	38
	96	77	69	29	-10	-31	+16	34

3.3.9 House Sparrow *Passer domesticus*

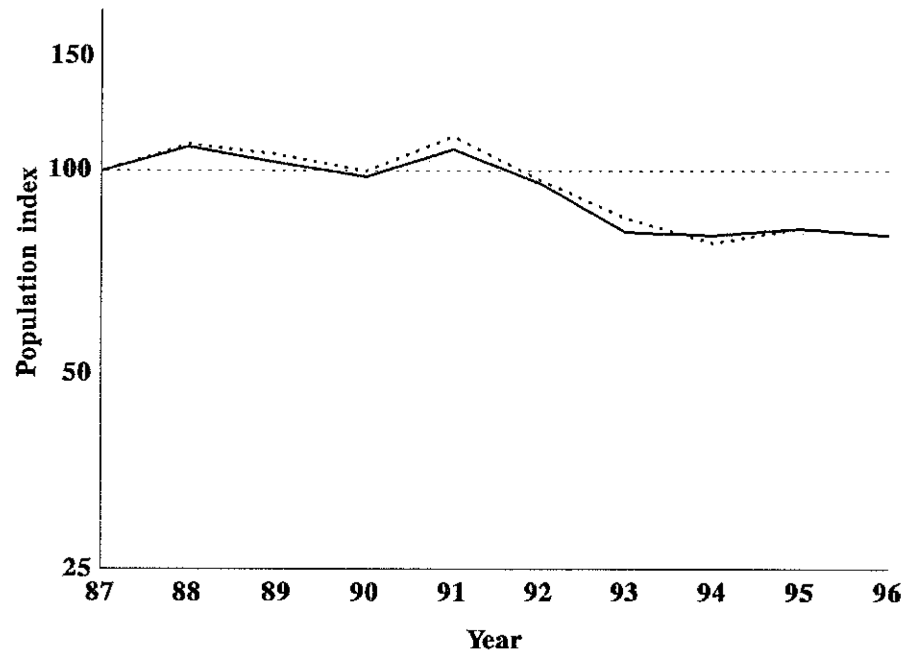


Figure 3.3.9.1 CBC population changes between 1987 and 1996 for House Sparrow on farmland (dotted line) and in all habitats combined (solid line). Index values are relative to 100 in 1987.

The CBC has documented a long-term decline in farmland House Sparrow populations since the late 1970s. These results are drawn from counts of birds associated with farmyards and areas of human habitation on farmland and may not reflect trends in the substantial populations found within our towns and cities. The past ten years have shown a continuation of the downward trend on CBC plots, although the indices have shown overall stability for the last three or four years (Figure 3.3.9.1). Data from woodland are extremely sparse and are therefore not presented.

Regionally, the only statistically significant trends during 1983-93 were decreases in the East Midlands and South West (Marchant in press).

The overall results of the CBC showed a 32% decline in numbers between 1976 and 1992 (Balmer & Marchant 1993). The *1988-91 Atlas* revealed that there had been some range contraction since 1968-72 (Gibbons *et al.* 1993), and there were other more subjective indications of population decrease during this period (Balmer & Marchant 1993). The decline in the House Sparrow population appears to be part of a general decline among a suite of seed-eating birds of farmland, particularly since the late 1970s (Fuller *et al.* 1995). The closely related Tree Sparrow *Passer montanus* is among this group of birds and declined by 88% on farmland between 1974 and 1994.

Population trend: **Continuing decline since late 1970s, possibly now stabilised**
Conservation status or concern: ***Conservation vigilance required***

Table 3.3.9.1 **Population changes for House Sparrow in the UK, as measured by the Common Birds Census. The index is chained from percentage changes in the year totals of territories, drawn from paired plots surveyed similarly in the two years: the number of contributing plots is shown. Confidence limits were calculated according to the method of Baillie *et al.* (1986). Statistically significant changes are marked with an asterisk.**

Habitat	Year (year 2)	Year 1 total	Year 2 total	Number of plots	% change	Lower 95% c.l.	Upper 95% c.l.	Index (1987 = 100)
All habitats combined	**87**							**100**
	88	234	255	52	**+9**	-9	+30	**109**
	89	317	299	61	**-6**	-20	+10	**103**
	90	304	290	60	**-5**	-18	+11	**98**
	91	247	271	55	**+10**	-7	+28	**108**
	92	353	315	62	**-11**	-24	+3	**96**
	93	322	273	58	**-15***	-27	-4	**81**
	94	328	323	64	**-2**	-16	+26	**80**
	95	377	388	69	**+3**	-9	+16	**82**
	96	334	324	63	**-3**	-16	+13	**80**
Farmland plots	**87**							**100**
	88	196	215	36	**+10**	-11	+34	**110**
	89	281	271	47	**-4**	-19	+14	**106**
	90	272	257	45	**-6**	-20	+12	**100**
	91	213	240	40	**+13**	-6	+34	**113**
	92	300	258	44	**-14**	-28	+1	**97**
	93	272	238	41	**-13**	-26	0	**85**
	94	285	262	46	**-8**	-22	+20	**78**
	95	317	332	51	**+5**	-8	+19	**82**
	96	281	275	46	**-2**	-17	+18	**80**

3.3.10 Overall trends of opportunistic species in the United Kingdom

To provide an overview of trends in the species under discussion, we fitted quadratic regressions to the trends of log index against year, and calculated the values predicted by these equations for the first and last of the ten years of the study. These calculations were made for each of the three ten-year periods covered by the interim reports (Marchant & Gregory 1995; Marchant, Wilson & Gregory 1996, 1997). The differences between these predicted indices at the start and end of each run of index values are shown in Table 3.3.10.1. These figures are a more reliable estimate of overall change than those derived from the uncorrected index values.

Table 3.3.10.1 Overall trends during 1985-96, as measured by the Common Birds Census. The figures tabulated are the percentage differences between index values for 1985 and 1994, 1986 and 1995, and 1987 and 1996, predicted from quadratic regressions.

Species	All habitats			Farmland			Woodland		
	85-94	86-95	87-96	85-94	86-95	87-96	85-94	86-95	87-96
Woodpigeon	+43	+38	+27	+53	+43	+29	+30	+31	+24
Collared Dove	+40	+40	+38	+46	+50	+48	.	.	.
Jay	-15	-16	-7	-20	-17	-10	-17	-20	-12
Magpie	+10	+7	+4	+10	+3	-3	+12	+15	+15
Jackdaw	+6	+9	+15	+7	+9	+18	+36	+55	+53
Rook	+17	+14	+17	.	.	.	.	.	.
Carrion Crow	+50	+48	+44	+52	+43	+36	+63	+75	+65
Starling	-33	-33	-37	-15	-17	-20	-61	-63	-66
House Sparrow	-20	-30	-27	-20	-32	-28	.	.	.

There are substantial increases in population levels for Carrion Crow, Woodpigeon and Collared Dove within this 12-year period of the CBC data set. While the rate of increase in Collared Dove was steady throughout the 12-year period, the increase in Woodpigeon and Carrion Crow slowed down, especially on farmland. Rook and Jackdaw also increased, the latter particularly in woodland habitats. Only a negligible increase was found for Magpie, a species whose population size was until recently expanding rapidly. Indeed, the trend for farmland during the last of the ten-year periods indicates a slight decline.

Starling was the species most strongly in decline, especially in woodland where 66% of the 1987 population had been lost by 1996. These declines accelerated slightly over the 12-year period. Jay and House Sparrow were also in overall decline, although high numbers of Jays in 1996 reduced the estimate of overall change for the last of the three ten-year periods.

4. BTO SAMPLE CENSUS OF ROOKERIES 1996

4.1 Introduction

Despite the relative paucity of their CBC data, Rook population changes have been very well studied. The BTO, along with several of the county bird clubs, has been deeply involved in monitoring rookeries for many decades - but on a periodic rather than an annual basis. The BTO carried out virtually complete national surveys during 1943-46 (Fisher 1947) and in 1975 (with fill-in counts in 1976-77) (Sage & Vernon 1978), and a partly randomised sample survey (that excluded Northern Ireland and most of Scotland) in 1980 (Sage & Whittington 1985).

There was a fall of 43% in Rook numbers between 1944-46 and 1975 (Sage & Vernon 1978), attributed largely to the conversion of pasture to intensive cereal farming (O'Connor & Shrubb 1986). The most recent national census of rookeries was a BTO sample survey in 1980, in which over 234,000 nests were counted. This survey found 7% more nests than in the previous census in 1975, but these were concentrated into 8% fewer rookeries (Sage & Whittington 1985).

In spring 1996, the BTO carried out a new sample survey of rookeries, sponsored by the Department of the Environment. The main aims of the survey were to improve the current estimate of the size of the Rook's UK breeding population and to estimate population change since the previous full census in 1975.

4.2 Field methods

The 1996 survey was based on an unstratified random sample of tetrads (2x2-kilometre squares) of the National Grid. The randomised design of the sample means that we can be confident that the results it provides are representative of the population as a whole. The choice of the tetrad as a sampling unit was a departure from the precedent of the 1975 and 1980 surveys, which had both used 10-kilometre squares. The larger units, however, are now regarded as difficult for volunteer observers to search thoroughly, while it was felt that results from tetrads would be more likely to be complete and more easily repeatable.

Calculations based on the 1975 and 1980 results suggested that 2000 tetrads would provide a suitable sample size in terms of numbers of rookeries and nests. The complications of stratification of the sample were not considered necessary and were avoided. To ensure an even sampling distribution, however, sampling density was fixed in each of 120 BTO regions at a uniform level of 3.14%. This resulted in the selection of 1999 tetrads from an overall UK total of 63633.

Counting methods for 1996 repeated those of previous BTO Rook surveys, with the aim of obtaining a maximum count of each rookery just before bud-burst in mid or late April. As before, a rookery was defined as any active Rook nest, or group of nests, 100 metres or more from the next nearest nest. A firm definition like this is necessary to allow the positions and sizes of rookeries to be compared between years. Report forms asked observers to record, for each rookery within or partly within the tetrad: a reference name; a six-figure grid reference; the date of the best count; the total number of nests in the rookery; the number of nests in the rookery that lay outside the boundary of the tetrad; and the number of nests in each of nine tree-species categories.

The aim of recording the number of nests outside the tetrad boundary was to allow these to be excluded from an estimate of the nest density within each tetrad. Nest density would then be used to extrapolate national population size. The total number of nests in each rookery centred within the tetrad, whether the nests were inside or outside the tetrad boundary, was also needed, to enable the data to be compared between 1996 and earlier surveys.

Distinguishing occupied and unoccupied nests requires detailed observation and is not practical for extensive studies. As in previous surveys, observers were requested to count all nests other than clearly disused structures and nests belonging to other birds or to squirrels. In practice, unoccupied nests are raided for sticks by nesting pairs and are quickly dismantled.

4.3 Survey coverage

Of the 1999 selected tetrads, a full report was received from survey volunteers for 1915 and partial reports were received for a further 5 (Table 4.3.1). Around 40,000 nests were counted during the survey. Only 4% of tetrads were not covered. The usual reason for non-coverage reported by regional organisers was that volunteers detailed to cover particular squares had not reported their failure to do so until after the nesting season. In a small number of cases, such blanks were filled by visits between November 1996 and March 1997, during which the numbers of active nests in spring 1996 were estimated from the number of surviving nest platforms.

There was no reason to believe that tetrads not covered were in any way atypical of the total sample. If they had been, a bias would have been introduced to the overall, by definition unbiased, random sample. In any case, if such a bias did exist, the 96% coverage achieved by the census will have ensured that its effects on the survey results would have been tiny.

Figure 4.3.1 shows the total distribution of sample tetrads, showing separately those that held rookeries and those that were not covered. The distribution of occupied tetrads is as expected from the *1988-91 Atlas* (Gibbons *et al.* 1993). It should be noted that the density of occupied tetrads reflects the density of rookeries rather than that of Rooks. Unvisited tetrads were distributed thinly but widely.

Observers were asked to fill in a map on each tetrad report form to show the grid references of the area they had visited, the locations of rookeries found and any parts of the tetrad which had not been visited. Thus, full coverage was confirmed for most tetrads. Coverage of individual tetrads was assumed to be complete except where there was some indication to the contrary.

Table 4.3.1 Coverage achieved for BTO Sample Census of Rookeries, 1996. Regions are the 11 NUTS regions of the UK (Figure 3.3.1).

Region or country		Number of tetrads selected for coverage	Tetrads covered fully or known to be empty	Partial cover only	Not covered	% of selected tetrads covered fully
71	N England	120	120	-	-	100%
72	Yorkshire/Humbs	120	119	-	1	99%
73	East Midlands	127	123	1	3	97%
74	East Anglia	104	98	-	6	94%
75	SE England	221	215	-	6	97%
76	SW England	190	182	2	6	96%
77	West Midlands	102	98	-	4	96%
78	NW England	59	53	-	6	90%
79	Wales	171	157	-	14	92%
7A	Scotland	667	639	1	27	96%
7B	Northern Ireland	111	104	1	6	94%
	Isle of Man	5	5	-	-	100%
	Channel Islands	2	2	-	-	100%
England & Isle of Man		1048	1013	3	32	96.7%
Gt Britain & Isle of Man		1886	1809	4	73	95.9%
UK & Isle of Man		1997	1913	5	79	95.8%

Two tetrads had been selected in the Channel Islands. It transpired, however, that no rookeries had been recorded in those islands for many years. Analysis of the data is therefore confined to the United Kingdom & Isle of Man (excluding the Channel Islands), with the nil returns for the two Channel Island tetrads not used.

Figure 4.3.1 The distribution of sample tetrads for the BTO Sample Census of Rookeries 1996. All 1999 tetrads selected randomly for the survey are mapped. Filled circles indicate tetrads where rookeries were found, open circles tetrads found to be empty, and asterisks the tetrads covered only partially or not at all.

4.4 The size of the Rook's nesting population in 1996

Since the survey's randomly selected tetrads could be taken as a representative sample of the whole UK, and of its constituent regions, population sizes could be estimated very simply. The mean numbers of Rook nests per tetrad were calculated from the relevant sample squares, excluding all nests beyond the tetrad boundaries, and these figures multiplied by the total numbers of tetrads in the respective areas (Table 4.4.1). The Isle of Man was too small an area for independent analysis and has been linked with the nearest English region (71 North England).

Confidence intervals around the population estimates were calculated by a bootstrapping method. This involved resampling randomly with replacement from the whole data-set, up to the actual number of tetrads surveyed, to produce 999 separate estimates of population size. The 5% and 95% quantiles of each of these estimates were taken as the lower and upper confidence limits of the population estimates.

Table 4.4.1 Estimation of total UK nesting population size of the Rook in 1996, based on the BTO's sample survey. Confidence intervals were estimated by bootstrapping (resampling with replacement 999 times). Population estimates are rounded to 4 significant figures and confidence limits to 3 significant figures. Units throughout are breeding pairs. Regions are the 11 NUTS regions of the UK (Figure 3.3.1).

Region or country		Total tetrads	Mean nests per tetrad	1996 Rook population estimate	5% quantile	95% quantile
71	N England & I of Man	3979	22.2	88,460	54,200	128,000
72	Yorkshire/Humberside	3805	23.7	90,140	61,800	121,000
73	East Midlands	4050	15.5	62,760	42,700	85,500
74	East Anglia	3290	13.8	45,420	24,100	69,900
75	SE England	7065	19.9	139,500	105,000	177,000
76	SW England	6076	33.0	200,200	167,000	234,000
77	West Midlands	3199	22.3	71,420	54,700	90,100
78	NW England	1903	8.8	17,060	9,000	26,900
79	Wales	5389	10.0	53,820	36,700	73,000
7A	Scotland	21258	17.7	376,600	253,000	527,000
7B	Northern Ireland	3554	35.5	126,100	95,300	159,000
England & Isle of Man		33367	21.5	715,000	641,000	796,000
Britain & Isle of Man		60014	19.2	1,145,000	1,000,000	1,310,000
United Kingdom & Isle of Man		63568	20.0	1,271,000	1,120,000	1,440,000

4.5 Population change between 1975 and 1996

The 1975 survey covered 94% of all 3011 10-km squares in the UK and was close therefore to being a complete census. This survey provides the best comparative data for estimating recent population change. The sample survey carried out in 1980 is less useful. It did not set out to cover Northern Ireland or Scotland north of Glasgow and Edinburgh. The planned random design was supplemented by complete counts in a number of widely scattered counties and regions (including a part of Aberdeenshire), while a substantial number of the squares forming the random sample were not covered. In all, the 1980 survey covered 482 10-km squares.

The population estimates for 1996, presented in Table 4.4.1, are higher than for 1975 for all regions that can be compared directly (Table 4.5.1). The comparison of published population estimates indicates a substantial rise (39% in the UK as a whole) in the population since 1975, but that the higher numbers found by the surveys during 1944-46 have not been regained.

Table 4.5.1 National population estimates for the Rook in the United Kingdom. Data for previous surveys are drawn from Fisher (1947), Castle (1977), Sage & Vernon (1978) and Sage & Whittington (1985).

	1944-46	1975	1980	1996
England & Isle of Man	923,750	511,223	-	715,000 (641,000-796,000)
Wales	98,250	38,916	-	53,820 (36,700-73,000)
Scotland	391,000	252,339	-	376,600 (253,000-527,000)
Northern Ireland	-	108,837	-	126,100 (95,300-159,000)
Britain & Isle of Man	1,413,000	802,478	857,000	1,145,000 (1,000,000-1,310,000)
United Kingdom & Isle of Man	-	911,315	-	1,271,000 (1,120,000-1,440,000)

An alternative approach to estimating the extent of change since 1975, aside from comparing the overall population estimates, is to compare tetrads that were covered in both surveys. The design of the 1996 survey specifically allowed for this tetrad-by-tetrad approach, which allows the precision of the population change estimates to be assessed.

This assessment of 1975-96 change was made using the following procedure. For each tetrad, and for 1975 and 1996 separately, totals were assembled of all rookeries with a central grid reference within the tetrad. Data for 1976 or 1977 were used for squares covered in one of those years but not in 1975. Tetrads not covered fully in 1996 were omitted. Coverage in 1975 was harder to check. However, it was important to ensure that, wherever possible, tetrads incompletely covered in 1975 were omitted from the 1975-96 comparison. Accordingly, the Regional Organisers were each sent a summary of the paired data for their region and asked to comment on coverage. A file was built of 10-km squares and the extent of coverage in each of the earlier survey years, incorporating feedback from 1996 regional organisers and information gleaned from the original survey cards. Comparisons were then allowed to enter the calculations only if coverage in both 1975 and 1996 appeared to be complete.

Data were available on this basis from 641 tetrads, of which 607 (95%) had been covered in 1975, 27 (4%) in 1976 and 7 (1%) in 1977. The overall results of the paired comparison are shown in Table 4.5.2.

Table 4.5.2 Estimate of change 1975-96 in the UK Rook population, from paired comparison of tetrads covered in both 1975 and 1996, with its confidence interval as estimated by bootstrapping.

	Number of tetrads	Nests counted 1975	Nests counted 1996	Overall change	5% & 95% quantiles
United Kingdom & Isle of Man	641	24486	34541	**+41%**	+12% +67%

The width of the confidence interval reflects the problems in monitoring population change in a species where counts in a given area may vary so widely between years.

Both approaches suggest an overall increase in the population of around 40%. However, Some caution is required in interpreting this result, because it is known that, aside from the 6% of squares not covered in 1975, not every square that was covered was searched thoroughly. Sage & Vernon (1978) emphasised that, because of the difficulties of locating and counting every rookery, the 1975 figures must be regarded as minimum estimates of the breeding population. It is difficult to assess the completeness of cover within individual 10-km squares, because observers had not been asked to record the extent of their fieldwork. It is conceivable therefore that the 1975 survey may have underestimated the population to some degree and that the increase since 1975 has not been as great as the 40% implied by the new survey.

The more rigorous design of the 1996 survey has provided a firmer basis for future assessments of population change.

4.6 Regional variations in population change

Rook is a favourite species for bird club surveys. In some counties or regions there is a long history of rookery surveys that charts local population change in considerable detail. Recent surveys provide evidence for increase since 1975 in Shetland, the Clyde area, Dumfries, Kirkcudbright, north Ceredigion, West Glamorgan and Dorset, in line with the overall results for 1996. However, decreases in southeast Sutherland, Greater Manchester, Hertfordshire, Sussex and Kent, and relative stability in Avon, show clearly that trends have not been regionally uniform.

The BTO's national survey was not designed to measure change at a local level. Regional analysis of the 641 tetrads that provided counts in both 1975 and 1996 does, however, tend to confirm that the increase has not been regionally uniform (Table 4.6.1). The statistical significance of the regional differences has not yet been assessed, but as for the UK estimate of change (Table 4.5.2) the confidence intervals around each regional percentage change will be wide.

Table 4.6.1 Regional assessments of change 1975-96 in the nesting population of Rooks, based on paired comparison of tetrads surveyed in both years. Regions are the 11 NUTS regions of the UK (Figure 3.3.1).

Region or country		Number of tetrads	Nests counted 1975	Nests counted 1996	Overall change
71	N England & I of Man	41	2509	2738	+9%
72	Yorkshire/Humberside	49	1608	2763	+72%
73	East Midlands	50	1240	1855	+50%
74	East Anglia	36	878	957	+9%
75	SE England	105	3568	4246	+19%
76	SW England	121	3738	5570	+49%
77	West Midlands	48	900	2040	+127%
78	NW England	17	480	470	-2%
79	Wales	41	994	1350	+36%
7A	Scotland	79	5971	9238	+55%
7B	Northern Ireland	54	2600	3314	+27%

The figures suggest that increases have been strongest in the West Midlands and Yorkshire/Humberside, and weakest in NW England, N England and East Anglia. To some extent, however, the totals may reflect regional differences in the completeness of cover during the 1975 survey.

5. SETTING ALERT LEVELS FOR OPPORTUNISTIC SPECIES

5.1 Summary

The government has recently secured a derogation under the EC Birds directive to allow general licensing for pest control in certain species. Part of the derogation is to ensure the continued monitoring of these species. DoE has contracted the BTO to develop a method to monitor population changes in 9 species of bird: Woodpigeon, Collared Dove, Carrion Crow, Rook, Jackdaw, Jay, Magpie, Starling and House Sparrow. This has been achieved by the development of an Alert Level system which can be used to identify population declines of conservation concern using Common Birds Census data. This system is not specific to opportunistic species nor to the CBC and should prove to be a valuable tool in wildlife conservation.

Population trends, usually monitored using chain indices (see section 3), were calculated using the more accurate Mountford moving windows method and underlying population trends were identified using a smoothing technique for a number of species. Bootstrapping was employed to fit confidence limits to the indices which were used as a basis for testing hypotheses about population change. Four alert levels were defined quantitatively on the basis of past declines and predicted rates of decline of 50% and 25% over 25 years. These figures were based on previously published criteria for listing birds of conservation importance used by the statutory and voluntary conservation bodies. Population changes were studied over 4 time-spans: 1, 5, 10 and 25 years back from the present. If confidence limits were below the threshold designated in the alert level's criteria then an alert was raised for that level, with the highest alert raised in any of the four time-spans being given the most consideration.

No opportunistic species raised alerts, but examples of a number of other species which gave evidence of serious decline are presented. Further methods, using different techniques of index estimation and trend smoothing, and the possibility of incorporating life-history traits into alert level criteria, are discussed.

5.2 Introduction

Population monitoring is an essential part of wildlife conservation. An effective monitoring programme should keep populations under surveillance and should be able to relate population changes to established threshold levels of conservation concern (Greenwood *et al.* 1995). Such an approach has been carried out in identifying "Red Data Birds", species of high conservation priority, within the UK (Batten *et al.* 1990). There are a number of criteria for inclusion on such lists, including species with populations of international importance, species which show very localised breeding ranges, species with fewer than 300 breeding pairs, and species which are in a state of rapid population decline. The latter category has been set at a 50% decline over 25 years for species of high conservation priority. A recent modification to the criteria (Avery *et al.* 1995) has also recommended the identification of species of medium conservation priority, defined as those species which have declined by 25-49% over 25 years. These criteria for rapid and moderate declines have recently been adopted by the statutory and voluntary conservation agencies (Anon 1995, Gibbons *et al.* 1996, JNCC 1996). Declines in widespread species have usually been identified using data from the CBC (Gibbons *et al.* 1996). Species are also considered to have undergone rapid or moderate declines if their ranges have been shown to have contracted by 50% or 25% respectively in terms of occupied 10-km squares. However, range changes are not considered further here as they can only be assessed through atlas studies that are carried out at approximately 20-year intervals.

Identification of species undergoing rapid or moderate declines has until the present been purely concerned with differences between indices over a 25-year period, estimated using a polynomial regression through the index values (Gibbons *et al.* 1996). A problem with identifying declining species in this way is that little account is taken of the degree of natural variation in indices between species or of the precision of the indices (by fitting confidence intervals for example) and it is not possible to apply statistical tests to hypotheses concerning population change. Furthermore, trends that have developed only recently are not fully taken into account.

In section 5 a method is presented which detects levels of significant population declines ('alert levels') using CBC data. Calculation of CBC indices is carried out by a more efficient method than previously, which allows the fitting of confidence intervals and therefore testing of hypotheses about population change. Using this method, alert levels are defined both by considering past population changes and predicted future rates of population decline. The raising of an alert identifies circumstances where the decline in population is such that conservation action or further research is needed.

Development of the method is initially in relation to opportunistic species as defined in the Wildlife and Countryside Act (1981). The methods presented here are applicable to all species that have long-term population data available and should therefore prove to be a very useful technique to wildlife conservation.

5.3 Estimating population change

5.3.1 Methods

Previous estimates of population change have used indices calculated from the chain method (Marchant *et al.* 1990) in which successive between-year percentage changes are linked around an arbitrary base year. A characteristic of CBC data is that there is a continual turnover of census plots from year to year. The calculation of population indices using the chain method is unable to take the unbalanced nature of the data into account and therefore may lead to inaccurate estimates of population change. A further drawback to this method is that only data from sites visited in consecutive years are used, and thus some data are omitted from the index calculations. In practice the chain method has provided reliable results that are similar to those obtained by more rigorous methods, at least for the more abundant species. However, it is clearly prudent to move wherever practicable to the more rigorous analytical methods that are now available.

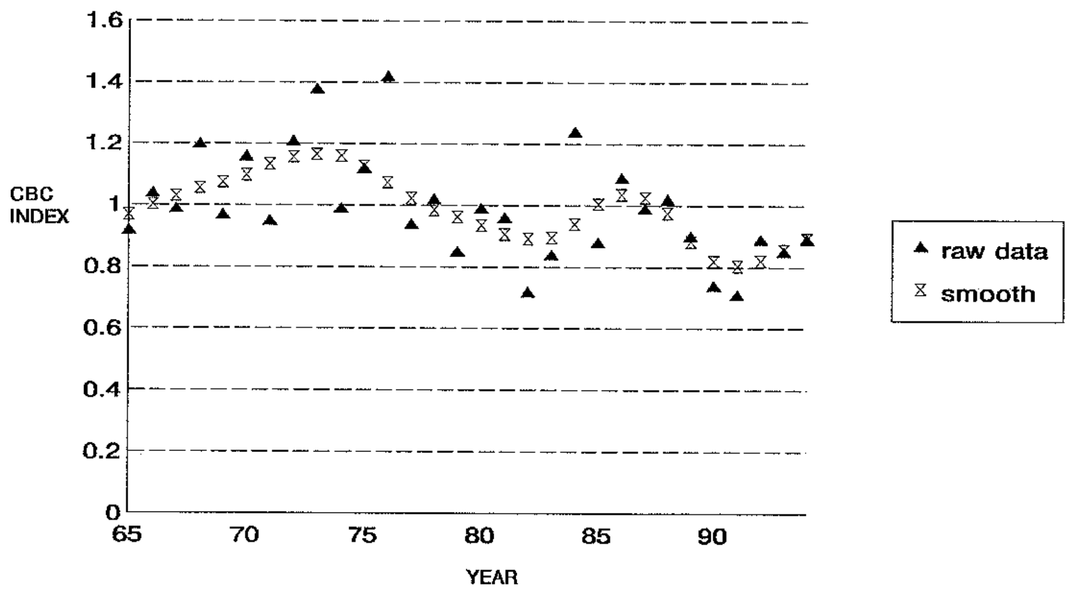
Mountford (1982, 1985) proposed an alternative method for calculating indices of population change which incorporated year and plot effects. This method is more efficient in the use of the data and is generally more accurate than the chain method, but the original method was limited in that only relatively short runs of years (6-12 depending on species) could be considered; longer runs of years led to violation of a crucial assumption of the method, that between-year changes across plots were homogeneous. However, the method has recently been refined by using a moving window to link shorter runs of years together and then rescaling the data to calculate indices over long periods (Peach & Baillie 1994). This method also has some drawbacks (ter Braak *et al.* 1994) but it is the most fully developed method currently available. However, the method for setting alert levels set out here does not depend on the use of any specific indexing method, so the Mountford method could eventually be replaced by an alternative such as TRIM (below), subject only to the practicalities of developing the necessary software.

Plotting annual indices against year gives an indication of population trends. However, some measure of the precision of the estimate is also needed in order to be able to make firmer conclusions about the extent to which a population has declined. Confidence limits may be calculated for the indices by bootstrapping (Manly 1991), a technique which involves randomly resampling the data with replacement over sites a large number of times (in this case 999) and recalculating a new index for each iteration. 95% confidence limits (which are the values at 2.5% and 97.5% of the distribution of the bootstraps, *i.e.* values 25 and 975) are then calculated from this resampled data set. Using a bootstrapping technique in this way has the advantage of making no assumptions about the underlying distribution of the data.

When considering population declines, it is important to identify underlying trends over time rather than to be concerned with short-term fluctuations due to random events, such as the weather. In order to identify underlying population trends, the technique of smoothing was employed on the data, using a 4253H-twice running median (Velleman & Hoaglin 1981). This method was found to be the best of a number of techniques for analysing ecological time-series data (Buckland *et al.* 1992). An example of how smoothing can help to identify trends is shown in Figure 5.3.1.1. The scatter of the raw Mountford indices is such that it is difficult to identify underlying trends. However, when the indices are smoothed it can be seen that there is a fluctuating pattern to the data. This method is non-parametric, using running medians to calculate each smoothed value, and because it is not dependent on the distribution of the data it is preferable to parametric methods such as quadratic regression which have previously been used to estimate population trends (*e.g.* Baillie *et al.* 1990). Smoothing was also employed on the 999 bootstrap samples to produce smoothed upper and lower confidence intervals.

The majority of CBC plots are classified as either farmland or woodland habitat. There is a third 'special' habitat category which incorporates areas such as wetlands, suburban parkland and moorland. Until the early 1980s the number of special plots was almost equal to the number of woodland or farmland plots, but since then the numbers have decreased greatly, due mainly to a change in BTO policy (Marchant *et al.* 1990). In this report, most of the analyses deal with farmland habitat only, although final alert levels are presented for both woodland and farmland habitats. Special habitats are not considered because they represent a very wide spectrum of land use and because only a small number have been surveyed in recent years.

Figure 5.3.1.1. A comparison of raw and smoothed Mountford indices for Jay on farmland.



5.3.2 Results

Smoothed Mountford indices and 95% confidence limits are shown for 5 selected opportunistic species on farmland in Figures 5.3.2.1 - 5.3.2.5. Indices were calculated for the last 32 years for each species except for Jay, where indices could only be determined from 1965 onwards, due to small samples in the early years. Carrion Crow, Jackdaw and Magpie show evidence of increasing populations, Starling shows a slight decrease and Jay shows no particular trend. The width of the confidence interval gives a measure of the precision of each index. Thus Carrion Crow and Magpie can be taken to be very precise, but Jackdaw shows much variation, particularly in the early years.

Mountford indices for three additional species, Wren *Troglodytes troglodytes*, Song Thrush *Turdus philomelos* and Tree Sparrow are also shown (Figures 5.3.2.6 - 5.3.2.8). The Wren is a species whose population is very much affected by severe winters, and is included here in order to see how an alert level system responds to a species which can show such large annual fluctuations. The other two are examples of species in serious decline.

This method of producing population indices and confidence intervals did not work adequately or at all in four opportunistic species: Collared Dove, Woodpigeon, Rook and House Sparrow. For the Collared Dove indices could not be produced when considering a run of 32 years. This species has undergone a dramatic increase in range throughout Europe this century (Cramp 1985) and was quite rare in Britain when the CBC started. Considering the population trend from a later year, 1969, did produce viable indices and confidence intervals (Figure 5.3.2.9) showing that the species has continued to increase.

Figure 5.3.2.1 Smoothed Mountford indices and 95% confidence limits for Carrion Crow on farmland.

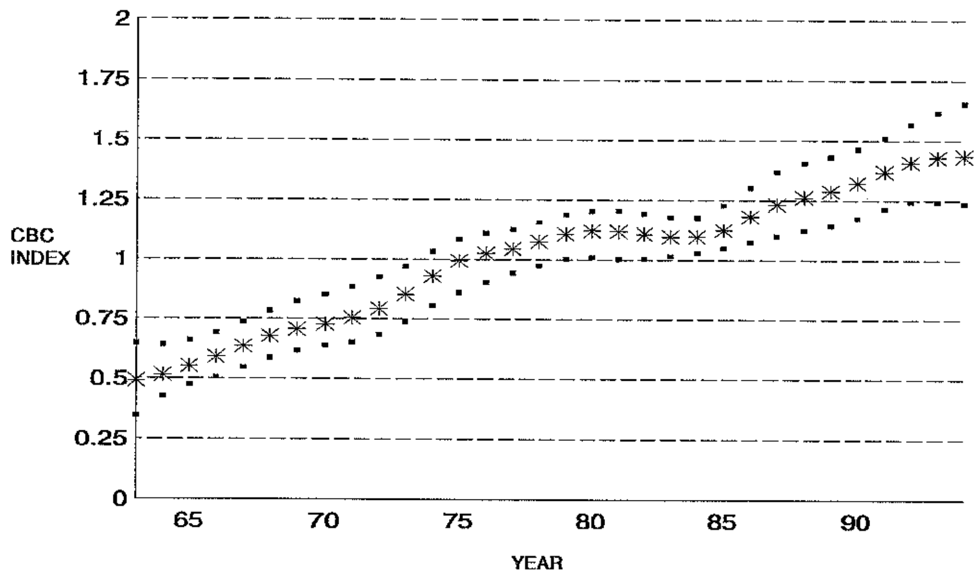


Figure 5.3.2.2 Smoothed Mountford indices and 95% confidence limits for Jackdaw on farmland.

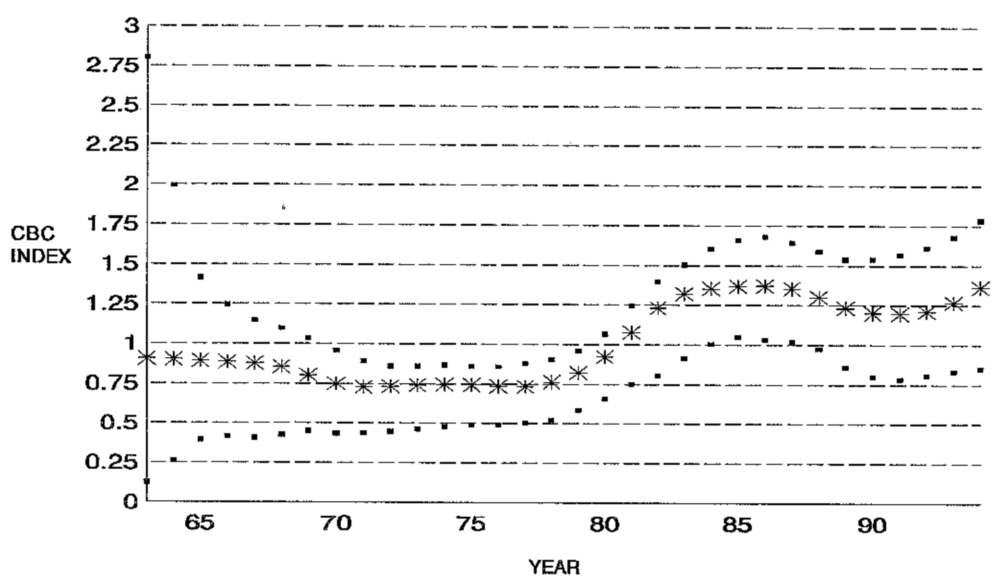


Figure 5.3.2.3 Smoothed Mountford indices and 95% confidence limits for Magpie on farmland.

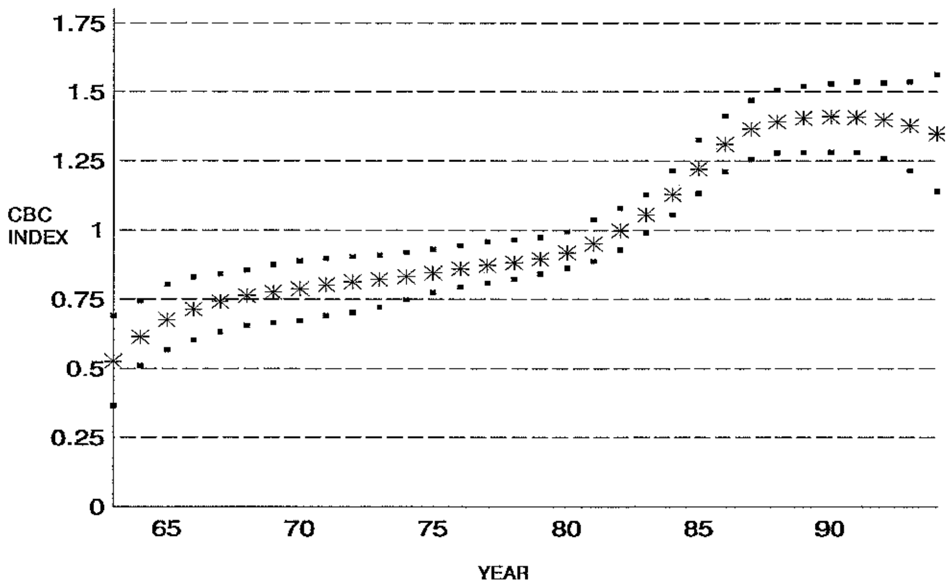


Figure 5.3.2.4 Smoothed Mountford indices and 95% confidence limits for Jay on farmland. Mountford indices could only be calculated from 1965 onwards.

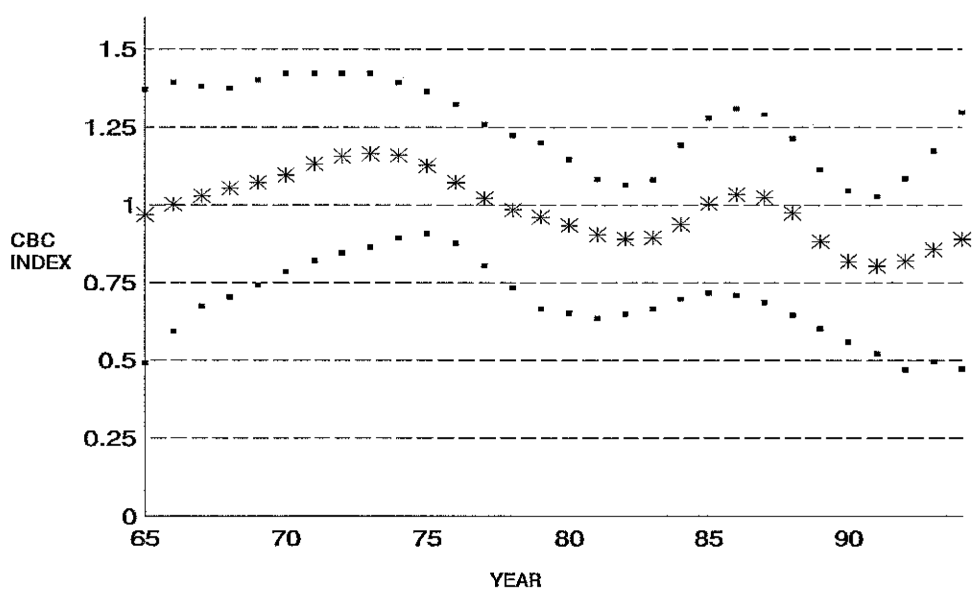


Figure 5.3.2.5 Smoothed Mountford indices and 95% confidence limits for Starling on farmland.

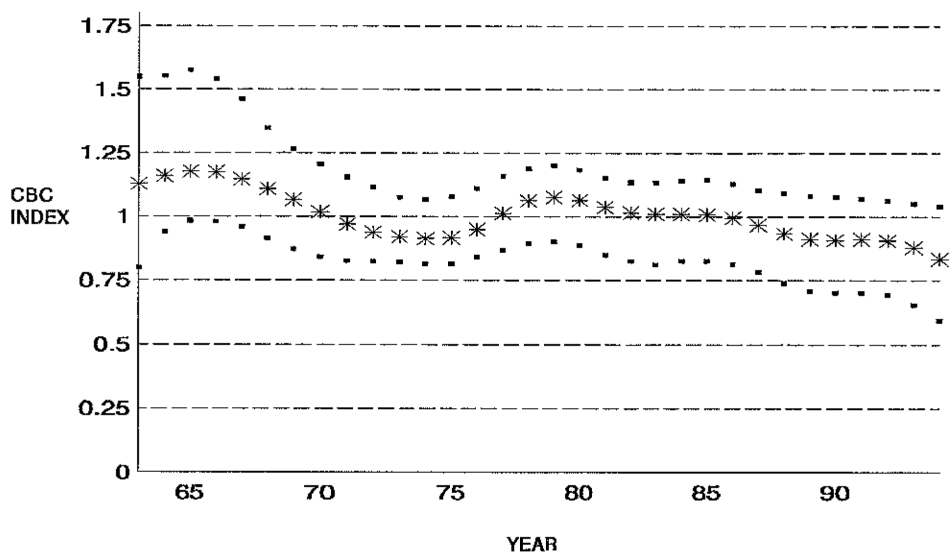


Figure 5.3.2.6 Smoothed Mountford indices and 95% confidence limits for Wren on farmland.

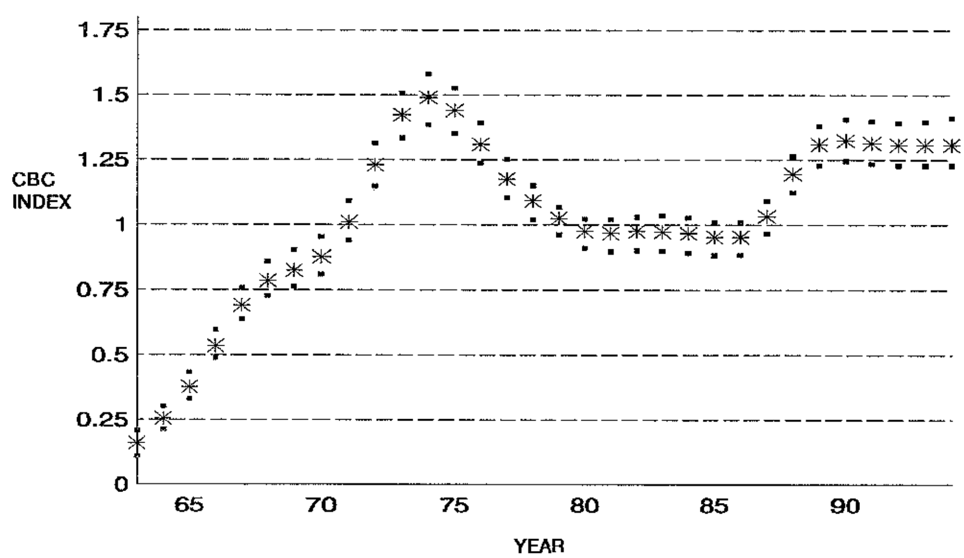


Figure 5.3.2.7 Smoothed Mountford indices and 95% confidence limits for Song Thrush on farmland.

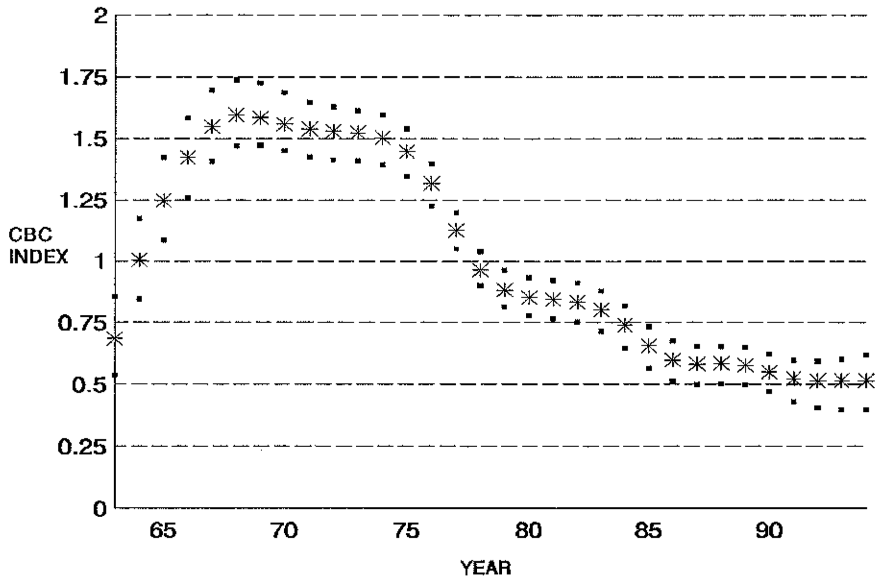


Figure 5.3.2.8 Smoothed Mountford indices and 95% confidence limits for Tree Sparrow on farmland.

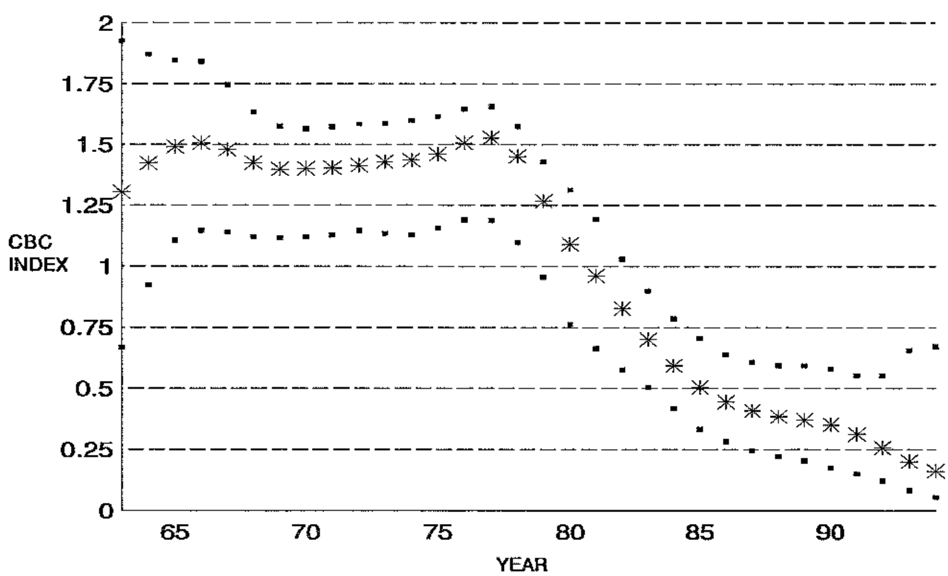


Figure 5.3.2.9 Smoothed Mountford indices and 95% confidence limits for Collared Dove on farmland. Mountford indices could only be determined from 1969 onwards.

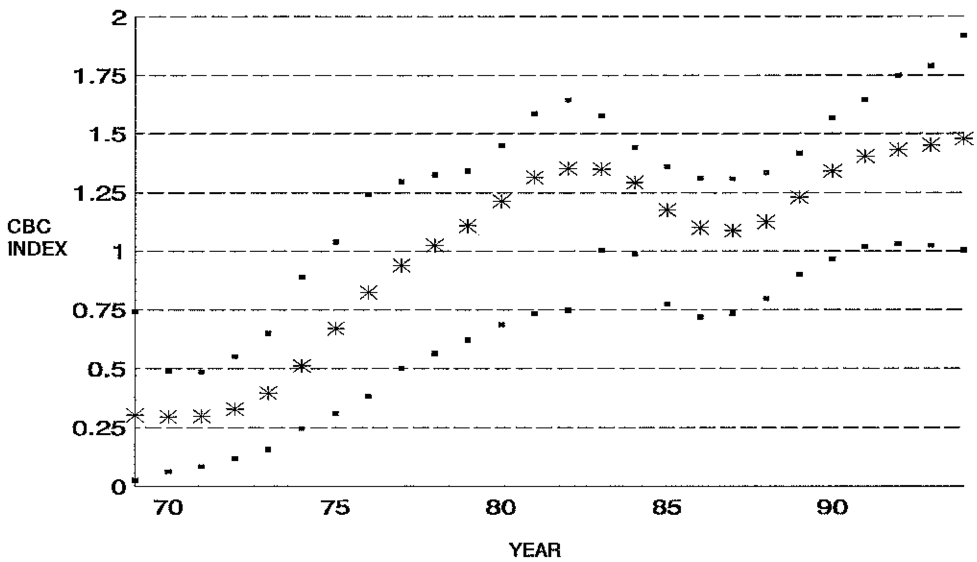
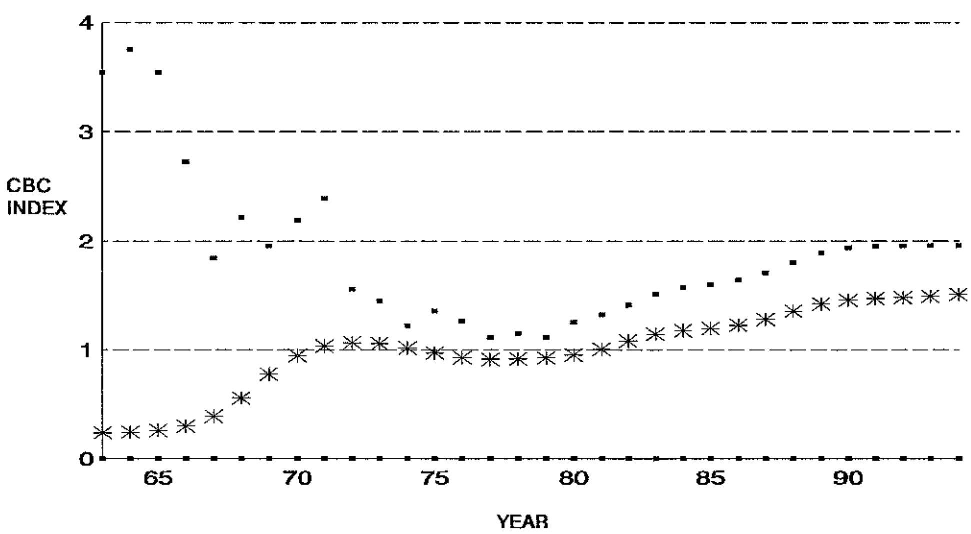
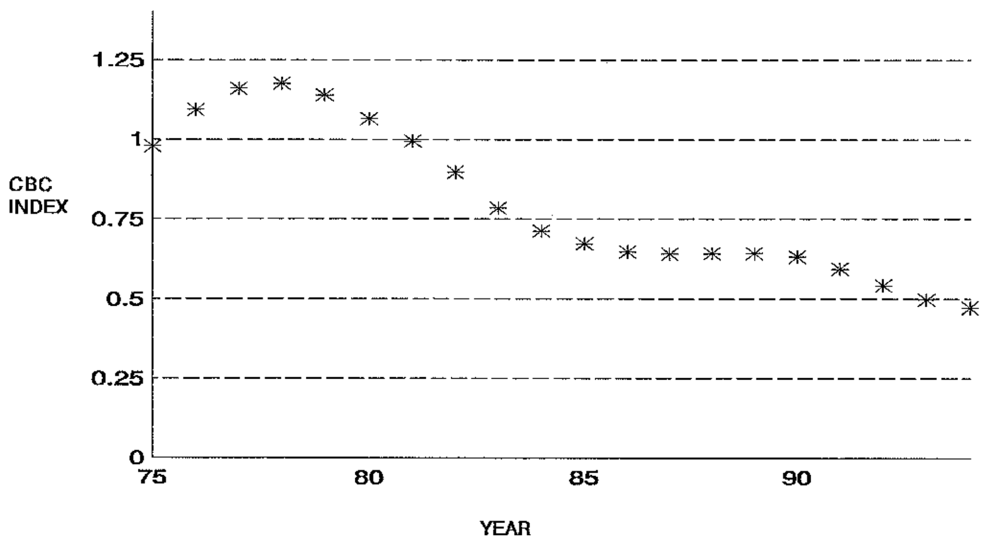


Figure 5.3.2.10 Smoothed Mountford indices and 95% confidence limits for Woodpigeon in woodland and farmland habitats combined.



Mountford indices were produced for the Woodpigeon when woodland and farmland habitats were combined. However, these may be highly imprecise estimates as the lower confidence limit was zero in most years (Figure 5.3.2.10). Similarly, indices were produced for House Sparrow, but only with a reduced number of years, and the bootstrapping procedure did not work so no confidence intervals could be calculated (Figure 5.3.2.11). The Mountford method was not able to produce indices at all for the Rook. The reasons for the failure of the method in the latter two species are probably due to the highly aggregated distributions shown by these communally nesting birds, with many plots having zero counts and a small number of plots having very high counts. The failure of the Woodpigeon to produce adequate results is due to the fact that many observers did not record this species, particularly in the early years of the CBC, as it was considered to be particularly difficult to census. An alternative technique was carried out to estimate population indices and confidence intervals in these three species (see below).

Figure 5.3.2.11 Smoothed Mountford indices for House Sparrow on farmland. Mountford indices could only be determined from 1975 onwards. It was not possible to fit confidence limits to these data.

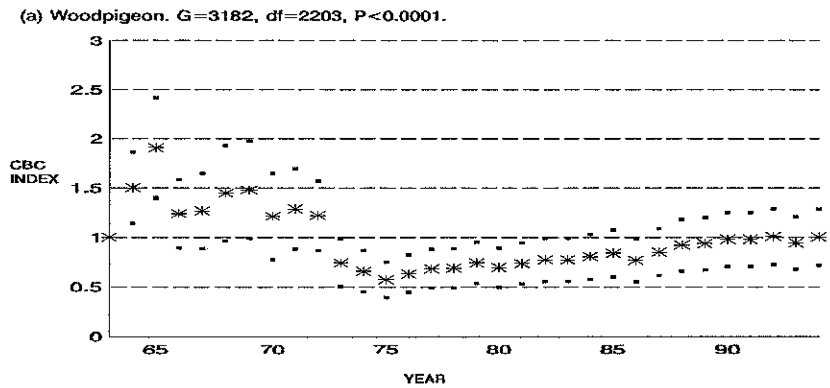


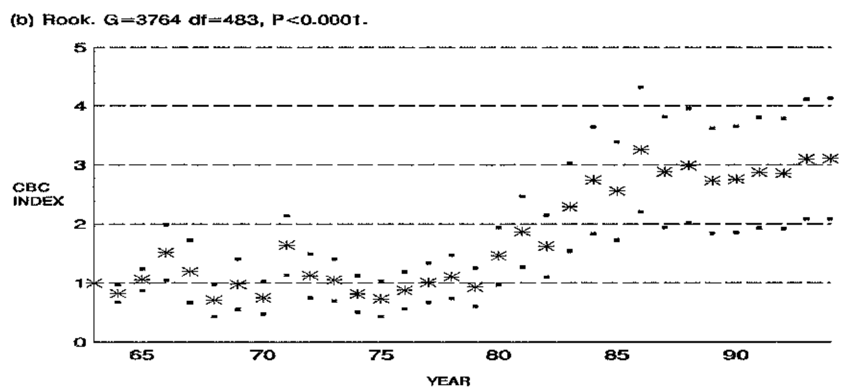
5.3.3 Trend Analysis and Indices for Monitoring (TRIM)

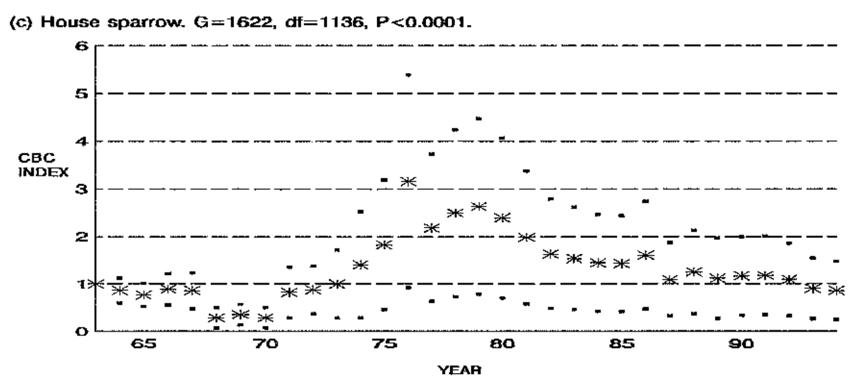
An alternative method of calculating population indices is to use a log-linear Poisson regression (ter Braak 1994). This is a technique which involves modelling logarithms of expected counts. It has a number of advantages over the Mountford moving windows technique. Most importantly various statistical tests can be carried out for factors such as habitat or observer effects, thus the model is able to take into account differing between-year trends across sites. This method is fairly new and the development of TRIM programs that deal with large data sets is only recent. Bootstrapping and smoothing methods have therefore yet to be developed for this technique. However, each annual index has a standard error and thus 95% confidence limits may be calculated.

Population indices and 95% confidence limits calculated from TRIM are presented in Figure 5.3.3.1 for Woodpigeon, Rook and House Sparrow. The indices include both farmland and woodland plots. Also included in the figures are log-likelihood ratios (G) from goodness-of-fit tests which test the assumption that trends are homogeneous across plots. Both Woodpigeon and Rook show evidence of recent increases in population. The House Sparrow shows a peak in the late 1970s and a decline thereafter. However, for each species the goodness-of-fit result was significant (*i.e.* significant heterogeneity between plots) which means that the 95% confidence limits may be too narrow.

Figure 5.3.3.1 TRIM indices and 95% confidence limits for Woodpigeon, Rook and House Sparrow in all habitats. Likelihood ratios from goodness-of-fit tests are shown.





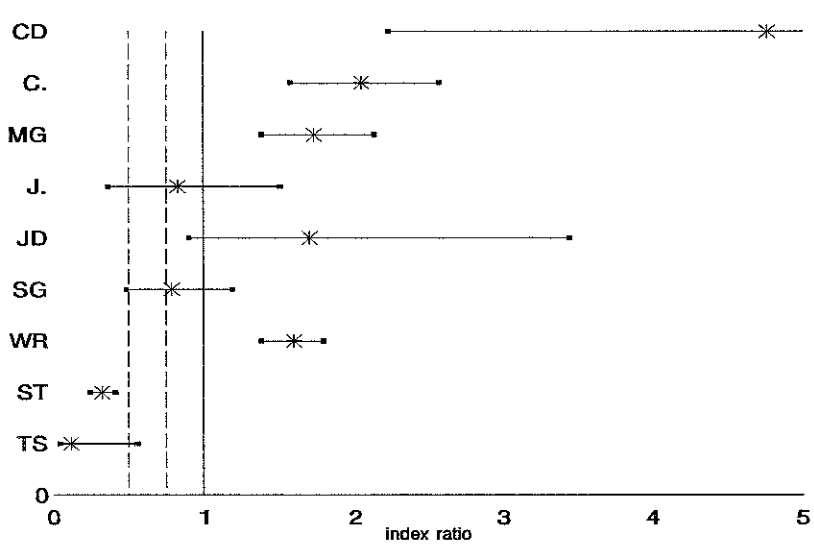


5.4 Detecting population change

The bootstrapping technique for Mountford indices may be used to test specific hypotheses concerning population change between two given years by calculating the difference between the smoothed indices for each bootstrap sample and then determining 95% confidence limits. In this case it is better to express the difference between the years as a ratio of the current index to the earlier index - thus an index ratio of 1 indicates no change and less than 1 indicates a decrease. For example, if we are interested in a population change over the last 25 years, the difference between the population indices would be calculated as the most recent index, 1994, divided by the index from 1969. Confidence limits would then be calculated by considering the distribution of all ratios calculated from each of the 999 bootstrap samples. If the confidence interval is less than a certain level, then it can be concluded that the population decrease is significant for that level.

This is illustrated in Figure 5.4.1 which shows 95% confidence intervals for the population change ratio over 25 years for six opportunistic species on farmland. Also included are Wren, Song Thrush and Tree Sparrow. Rates of 25% and 50% population decrease are indicated. Collared Dove, Carrion Crow, Magpie and Wren confidence intervals exceed 1, so we can conclude that there have been significant increases in these species over the last 25 years, although we can be less confident of exactly how much the population has increased in the Collared Dove as the interval is very wide. Conversely, Song Thrush and Tree Sparrow both show significant decreases (confidence interval less than 1), with the former species having an upper confidence limit less than 0.5, indicating that it has decreased significantly by more than 50% in 25 years. In the other species there was no evidence of significant population change.

Figure 5.4.1 **1994 index/1969 index and 95% confidence limits from 999 bootstraps for a range of farmland species. Smoothed indices were used. Vertical lines represent 50% and 25% population decline. CD=Collared Dove, C.=Carrion Crow, MG=Magpie, J.=Jay, JD=Jackdaw, SG=Starling, WR=Wren, ST=Song Thrush, TS=Tree Sparrow.**



The above procedure was repeated for differences of 10, 5 and 1 years from the most recent index (Figures 5.4.2 - 5.4.4) in order to detect medium- and short-term changes. When considering a single year's change we are interested in sudden population crashes rather than in the underlying trend, so for this analysis only, unsmoothed indices are used. Changes over 10 years showed similar patterns to the long-term changes, although fewer species showed a significant population change. Only Song Thrush showed a significant decrease. For the shorter time-spans, only Carrion Crow, which increased over 5 years, showed a significant change.

A bootstrapping program has yet to be written for the TRIM method of determining population indices. However, confidence intervals can be calculated from the standard errors of each index. If confidence intervals between any given pair of years do not overlap then there has been significant population change. With reference to Figure 5.4.1, neither Woodpigeon nor House Sparrow has shown a significant change over any time period, although in the latter species this is due mainly to the very wide confidence intervals. The Rook has shown a significant increase over a 25-year period, consistent with the results of the recent survey. However, these tests are not very reliable as there was significant heterogeneity between plots (Figure 5.4.1). It is hoped that bootstrapping and smoothing techniques can be applied to TRIM indices in the near future to provide better hypothesis testing (section 5.6.2).

Figure 5.4.2 **1994 index/1984 index and 95% confidence limits calculated from 999 bootstraps for a range of species on farmland. CD=Collared Dove, C.=Carrion Crow, MG=Magpie, J.=Jay, JD=Jackdaw, SG=Starling, WR=Wren, ST=Song Thrush, TS=Tree Sparrow.**

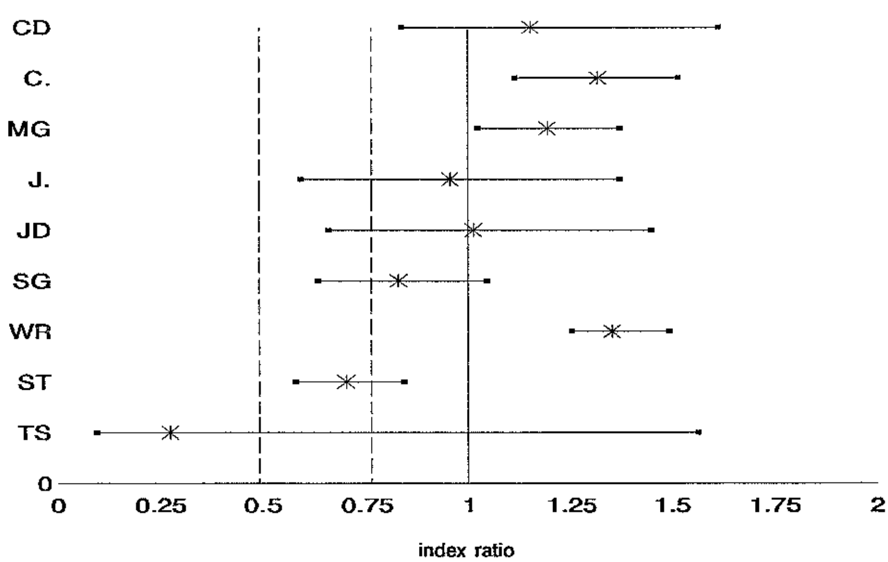


Figure 5.4.3 **1994 index/1989 index and 95% confidence limits calculated from 999 bootstraps for a range of species on farmland. Species codes as per figure 5.4.2. The upper confidence limits for Tree Sparrow was very large and is not shown.**

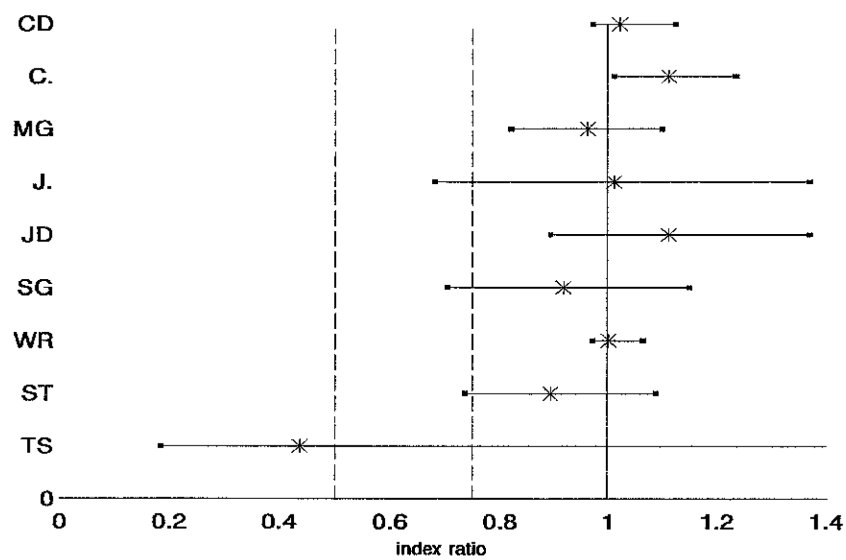
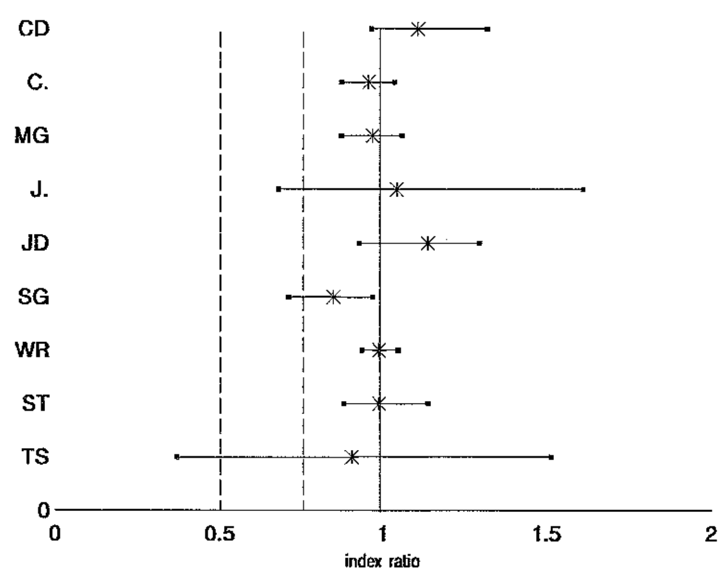


Figure 5.4.4 **1994 index/1993 index and 95% confidence limits calculated from 999 bootstraps for a range of species on farmland. Species codes as per figure 5.4.2. Indices were not smoothed.**



5.5 Alert Levels

5.5.1 Methods

Hypothesis tests such as those outlined above may be used as a basis for setting alert levels. A first criterion to consider is the decrease that has already occurred. As 50% and 25% declines are used to list species of conservation importance by statutory and voluntary bodies concerned with conservation (Anon 1995, Gibbons *et al.* 1996, JNCC 1996), these seem sensible criteria to use, but the analytical approach adopted to define alert levels is compatible with any defined level of population decline. A further criterion that can be used in setting up alert levels for 5- and 10-year changes involves predicting future population levels based on the current rate of decrease. For the differences between any given pair of years we can calculate the rate of decline that would result in a 50% decrease in 25 years time (Table 5.5.1.1). Confidence limits for each species can then be used to determine whether that rate is likely to be met, in a similar way to testing for a significant population change (as in Figures 5.4.2 - 5.4.4).

Table 5.5.1.1 Percentage population change rates required to result in 50% and 25% decreases in 25 years' time.

changes over 25 years	rate of change over n years	
	n = 5	n = 10
-50%	-12.9	-24.2
-25%	-5.6	-10.9

The above criteria can be used to define specific alert levels. These will be based on decreases of 50% and 25-49% over 1, 5, 10 and 25 years' duration and will use both knowledge of current population declines and predicted future declines. Four alert levels are quantitatively defined, as shown in Table 5.5.1.2. Levels 1 and 2 involve previous changes in population size classified as rapid or moderate respectively, while levels 3 and 4 involve predicted rates of change over 25 years again split into rapid and moderate declines. The latter two levels were only applied to 5- and 10-year changes. The number of years over which changes are considered were chosen to reflect long-, medium- and short-term trends, with an alert being raised if an alert level is reached at any time period. The method is such that any time period can be analysed although, with very short changes, alert levels must be put into the context of individual species as some may be more prone to short-term fluctuations.

Table 5.5.1.2 Quantitative criteria for proposed Alert Levels for population declines. Alert levels are reached if absolute changes or predicted changes are reached for any given time period. For any alert level to be raised, upper confidence limits must be lower than 1.

Decline category	Alert level		Years from present			
			25	10	5	1
Rapid	Level 1	absolute % change	-50	-50	-50	-50
Moderate	Level 2	absolute % change	-25	-25	-25	-25
Rapid	Level 3	predicted rate of change over 25 years	-	-50	-50	-
Moderate	Level 4	predicted rate of change over 25 years	-	-25	-25	-

Each of the four levels are qualitatively defined as follows:

Level 1 High conservation alert due to rapid decline. Given the observed decline the population must recover to avoid being listed as rapidly declining at the next formal revision of the list (or change measures must become less precise).

Level 2 Medium conservation alert due to moderate decline. Given the observed decline the population must recover to avoid being listed as moderately declining at the next formal revision of the list (or change measures must become less precise).

Level 3 Heading for high conservation alert due to rapid decline. If the recent rate of population decline continues over 25 years (and its precision remains the same) the species will be listed as rapidly declining at the next formal revision of the list.

Level 4 Heading for medium conservation alert due to moderate decline. If the recent rate of population decline continues over 25 years (and its precision remains the same) the species will be listed as moderately declining at the next formal revision of the list.

5.5.2 Results

A summary of 1994 alert levels for a range of species in farmland is shown in Table 5.5.2.1. Alert levels for woodland habitat were also calculated but in many cases Mountford indices could not be produced, usually because there were not enough data from woodland for primarily farmland species. The method was not applied to Woodpigeon, Rook and House Sparrow but, according to the determination of population trends by TRIM, there was no significant decrease in these species and thus they are put at level 0.

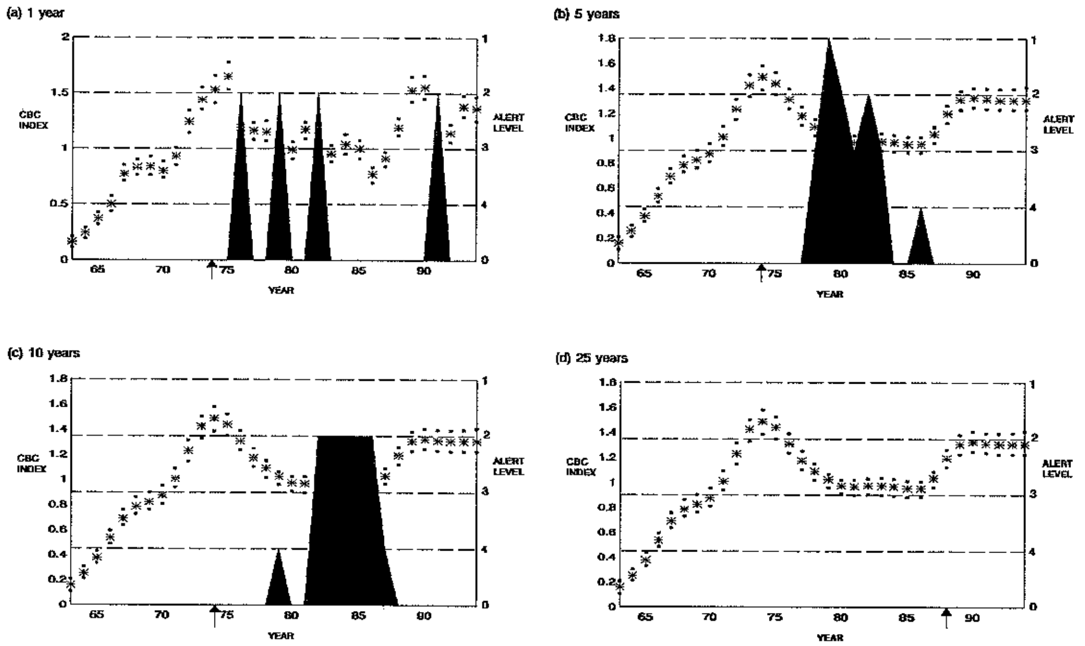
Table 5.5.2.1 1994 alert levels for 9 opportunistic species and a range of other species in farmland and woodland habitats. A dash (-) indicates insufficient data to determine an alert level. For definitions of alert levels see Table 5.5.1.2.

Species	1994 alert level	
	farmland	woodland
Woodpigeon *Columba palumbus*	0	-
Collared Dove *Streptopelia decaocto*	0	0
Carrion Crow *Corvus corone*	0	0
Rook *Corvus frugilegus*	0	-
Jackdaw *Corvus monedula*	0	0
Magpie *Pica pica*	0	0
Jay *Garrulus glandarius*	0	0
Starling *Sturnus vulgaris*	0	-
House Sparrow *Passer domesticus*	0	-
Grey Partridge *Perdix perdix*	1	-
Skylark *Alauda arvensis*	2	-
Wren *Troglodytes troglodytes*	0	0
Blackbird *Turdus merula*	2	0
Song Thrush *Turdus philomelos*	1	1
Spotted Flycatcher *Muscicapa striata*	1	-
Tree Sparrow *Passer montanus*	1	-
Bullfinch *Pyrrhula pyrrhula*	1	4
Linnet *Carduelis cannabina*	2	-
Reed Bunting *Emberiza schoeniclus*	0	-
Yellowhammer *Emberiza citrinella*	3	-

In order to test the performance of the alert levels criteria, the methods were applied at each year from 1974 onwards for changes over 1, 5, and 10 years, and from 1988 for 25-year changes for selected species. In this way it can be seen how past population changes would have been detected using the alert level criteria. Figures 5.5.2.1 - 5.5.2.3 show population indices with 95% confidence limits and alert levels for each of the four spans of years for Wren, Song Thrush and Tree Sparrow (none of the opportunistic species showed large changes over time so it would not be worthwhile carrying out this procedure for those species). It should be stressed that a new run of Mountford indices was calculated for each year analysed using alert levels, as the Mountford method, in common with other methods based on statistical modelling, changes the values of previous indices when new data are incorporated. Thus the magnitude of the differences from which the alert levels were actually calculated are slightly different to those shown, which are the latest ones (from 1994). However, this makes little difference as the relative rank of each year's index is always the same.

The Wren suffered greatly in the severe winter of 1962/63 and numbers were steadily recovering from that throughout the 1960s (figure 5.5.2.1). Further decreases followed in the mid 1970s which were sufficient to raise alerts for the 5- and 10-year time periods. Some alerts were also raised for the single year time period which is to be expected in a

Figure 5.5.2.1 Mountford indices with associated alert levels calculated for differences of 1, 5, 10 and 25 years for Wren on farmland. Arrows indicate starting years for alert level calculations. Smoothed indices were used with the exception of the analysis of 1 year's difference.



species such as this which is very sensitive to cold winters. However, the declines do not appear to have been long-term and the population has recovered somewhat since the 1970s and consequently at present no alerts are raised. The alert system in some respects may therefore be too sensitive for the Wren as alerts were raised when there was probably little actual threat of a serious long-term population decline. This example stresses that alert levels raised should be taken in the context of an individual species' natural population variation (see below), particularly when considering short-term changes. Wren populations are a great deal more variable than those of the opportunistic species covered by this project.

Both Song Thrush (figure 5.5.2.2) and Tree Sparrow (figure 5.5.2.3) show similar population trends, being characterised by a steep decline from the mid 1970s. During this period alert levels are reached for both of the intermediate periods which continue almost up to the present for the 10-year period indicating continuing population decline. The actual levels reached for the 5- and 10-year periods showed some fluctuation in both species, but for the 25-year period, level 1 alerts were raised for at least the last 5 years. A higher alert overrides any other for any given year, so overall these species show increasing alert levels over time and must be considered to be seriously declining.

Figure 5.5.2.2 **Mountford indices with associated alert levels calculated for differences of 1, 5, 10 and 25 years for Song Thrush on farmland. Arrows indicate starting years for alert level calculations. Smoothed indices were used with the exception of the analysis of 1 year's difference.**

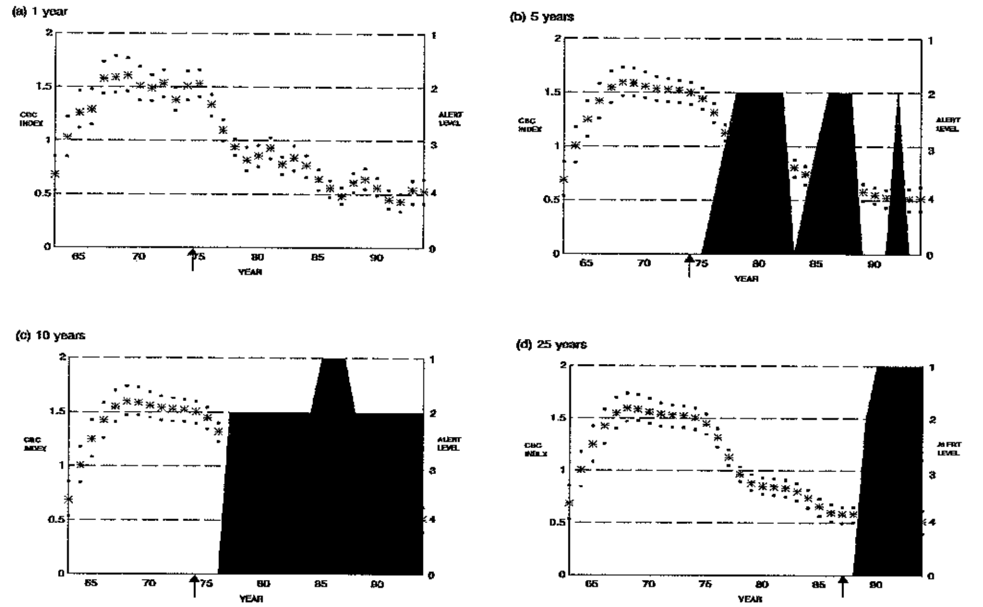
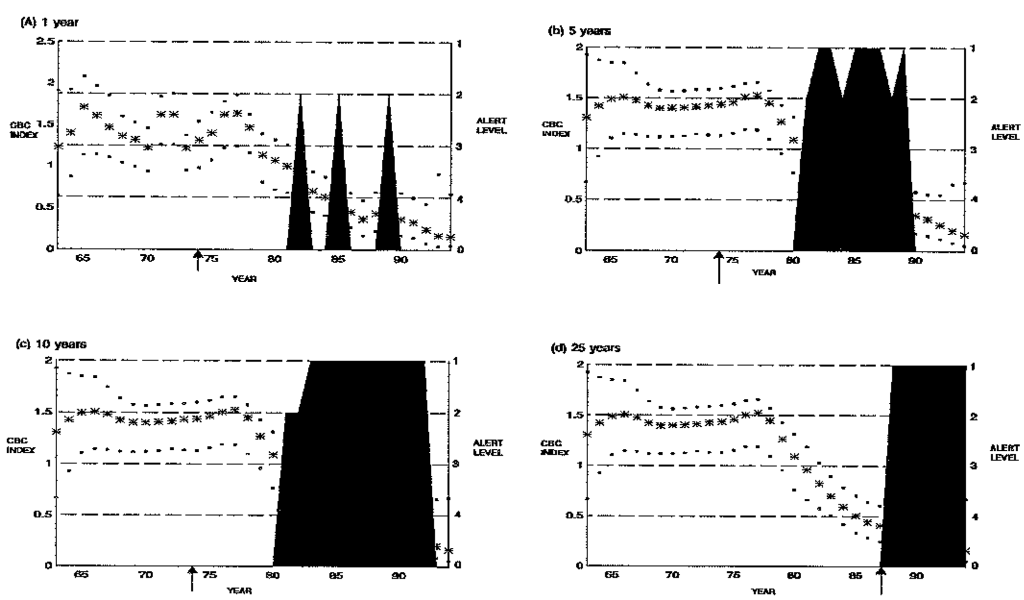


Figure 5.5.2.3 **Mountford indices with associated alert levels for differences of 1, 5, 10 and 25 years for Tree Sparrow on farmland. Arrows indicate starting years for alert level calculations. Smoothed indices were used with the exception of the analysis of 1 year's difference.**



5.6 Discussion

5.6.1 Current proposals

Of the nine opportunistic species analysed, only two, Starling and House Sparrow, showed evidence of any decline in population over time. However, neither of these raised alerts, so overall no opportunistic species appear to be under the threat of a serious population decline. The Starling has shown a steady decline, having an index ratio of less than 1 at each of the four time periods. However, the rate of decline is slow and the indices are not particularly precise and so no changes in population were significant. The House Sparrow has apparently undergone a decline in population since the mid 1970s. However, TRIM indices indicate that this may have been a peak and that earlier populations were at a similar level to the present. The low precision of the indices and the fact that the data are not statistically testable means that little can be concluded about population trends in this species. Alert levels were reached for other species. For Tree Sparrow and Song Thrush the 5- and 10-year alerts would have drawn attention to recent declines at an earlier stage than if only 25-year alerts were considered.

The alert level method has a number of advantages over a straightforward determination of population decline. Considering a range of years over which a decline may have occurred enables short-term changes to be taken into consideration. Also defining alert levels in terms of possible future declines means that species which have the potential to be listed as rapidly or moderately declining can be identified and appropriate action may be implemented. Particular care needs to be taken in the interpretation of alerts raised on the basis of a single-year change (*e.g.* Wren). In general terms we would not recommend the use of single-year changes beside other time periods, except where there was a particular reason to suspect that these were relevant for the species in question (see below). It should be stressed that the lower levels of alerts are intended to provide advance warning that problems may be developing. Further investigation of such alerts would generally be advisable but they do not necessarily imply that immediate conservation action is needed.

One of the problems with the method is that little can be concluded about species whose indices are estimated with low precision. In some cases, index ratios showed a large decline, but confidence intervals were very wide and thus changes could not be regarded as significant. It is important to know the precision of estimates of population change, even where it is disappointing that they are not more precise. Where precision is consistently poor, further attention should be given to the quality and quantity of census data available. In some cases it may also be possible to obtain more precise estimates of change by using alternative statistical techniques.

Where precision is poor, the index is still the best estimate of population change and so in such cases it may not be advisable to assume that the species is not in trouble. A precautionary principle would seem appropriate in such cases and this might mean further research would be initiated and further data sought. It would be better to say that there is some evidence of population decline but the data are not good enough to make firmer conclusions. Alternative methods (see below) and further research should be pursued in such cases.

5.6.2 Future developments

Mountford indices are much better than the chain index for calculating population change, but they have some drawbacks. The bootstrapping technique used to define alert levels did not work in some of the scarcer species or species which had aggregated distributions. The continuing development of the TRIM method may provide a better estimate of population change in this species. A further advantage of this method is the potential to test for differences between habitats. A bootstrapping technique applied to TRIM indices would enable alert-level determination to be carried out on problem species. A possible extension of the TRIM approach is the use of a technique known as Generalized Additive Modelling which allows non-parametric smoothed population trend curves (as opposed to simple linear or polynomial trends) to be fitted within a single statistical model. The smoothed curves (given an appropriate number of degrees of freedom) are similar to those based on running medians that are presented in this report. Generalized Additive Models have the advantage of improved statistical efficiency which may be particularly helpful for species with sparse data. They also allow smoothed population trends to be placed in a more general statistical framework. Confidence intervals should be produced by bootstrapping, although this can be very computer intensive.

We have demonstrated how the proposed system of alerts would work for opportunistic species and for a number of other species. The system should ideally be tested on the full suite of species covered by the CBC but such an analysis was beyond the scope of the present project.

In the methods for detecting alert levels, all species are subject to the same criteria. Thus a greater than 25% decline and an upper confidence level lower than 1 would cause a level 2 alert to be raised in any species from a Wren to a Golden Eagle *Aquila chrysaetos*. However, the seriousness of any decline must be looked at in the context of the life history of each individual species. The Wren is a species which can show much variation in population from year to year, largely dependent on the weather, as was shown in the retrospective analysis (Figure 5.5.2.1) when this species raised a number of level 2 alerts. Adult survival is generally low, but reproductive rates can be high and recovery can be rapid. Conversely a species such as the Golden Eagle tends to show fairly stable populations, is long-lived and breeds at a relatively slow rate. It seems therefore intuitively obvious that a 25% decrease in the Golden Eagle population is much more serious than the same decline in Wrens. An example such as the above is admittedly extreme. The results presented in this report tend to be from species which are broadly comparable in terms of life-history traits and thus it seems useful to use the same criteria across species. However, if the methods are to be applied more widely to a range of species then some additional criteria, such as population recovery rates, may need to be incorporated.

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