BTO Research Report No. 200

Enhancements for monitoring of opportunistic bird populations

Andrew M Wilson, John H Marchant,
Richard D Gregory, Gavin M Siriwardena
& Stephen R Baillie

A report by the British Trust for Ornithology
under contract to the Department of the Environment, Transport and the Regions

April 1998

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

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ISBN 0-903793-95-4

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 general licence, 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 Government'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 these 13 species. Of these nine species, five increased strongly between 1988 and 1997, one showed little change while three showed population decreases. Conservation Vigilance is recommended for Starling *Sturnus vulgaris* and House Sparrow *Passer domesticus* on the basis of their continued decline between 1988 and 1997.

3. 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.

4. Both Starling and House Sparrow raise Medium Alerts due to statistically significant reductions in population level of more than 25% over 25 years. Jay *Garrulus glandarius* and Magpie *Pica pica* would raise alerts in the future if their recent population decreases were to be maintained over 25 years.

5. 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, D L Thomson pers. comm.). 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 3.1).

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.

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.

The fourth and final section presents work on the development of "Alert Levels" for opportunistic species. A novel set of analyses has been developed in order to define quantitative criteria and thresholds that identify species in serious population decline. 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.

There are four previous reports in this series (Marchant & Gregory 1995; Marchant *et al.* 1996, 1997a, 1997b).

3. MONITORING OPPORTUNISTIC SPECIES

3.1 Methods

3.1.1 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 10 years 1988-97 are shown in Table 3.1.1.1 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 1997. The 1997 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 1997.

Table 3.1.1.1 **Numbers of CBC plots censused in the United Kingdom during 1988-97, 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)
1988	100	74.4	86	20.0	25	33.9	211	47.5
1989	102	73.2	96	20.5	21	32.2	219	46.3
1990	99	73.3	97	21.3	25	37.3	221	46.5
1991	101	71.7	103	21.3	23	35.4	227	45.3
1992	97	73.6	103	21.4	23	35.4	223	45.7
1993	104	73.8	112	20.4	24	34.0	240	45.2
1994	103	74.0	117	21.4	27	37.1	247	45.0
1995	102	71.0	115	21.1	28	36.6	245	43.7
1996	101	71.4	110	20.4	26	34.6	237	43.7
1997	101	68.8	112	19.8	23	35.7	236	42.3

No 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%.

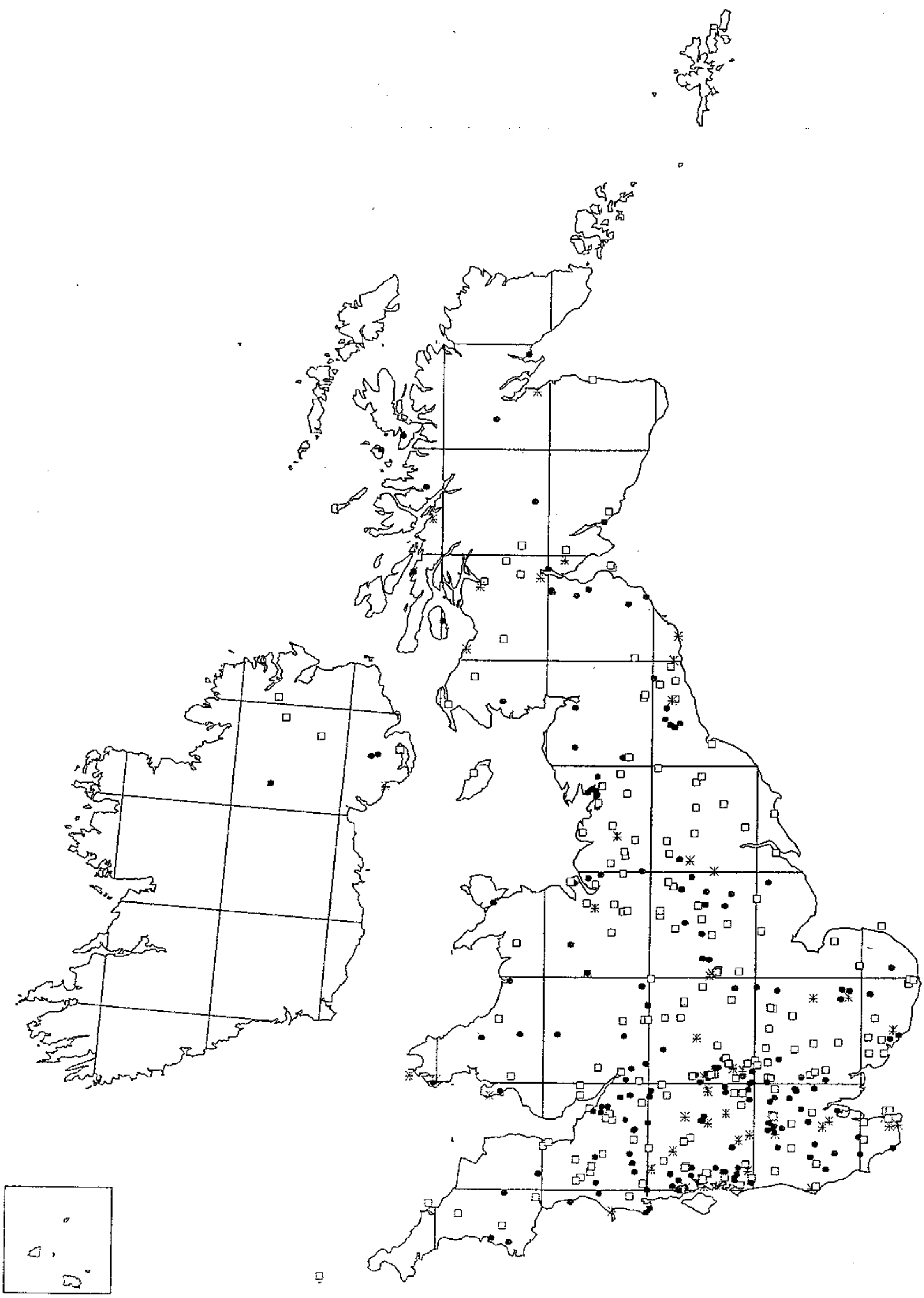
3.1.2 Estimation of population change

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 3.1.2.1. All regions of the United Kingdom were represented except the Northern and Western Isles. The distribution of plots contributing data during 1988-97, the period of this report, is essentially the same although differing in minor detail.

The conservation status of opportunistic species is described as "secure" if its population is stable or increasing. If a species shows a sustained decrease, "conservation vigilance" is urged, indicating that populations require close monitoring and action may be needed to stem the decline.

Figure 3.1.2.1 **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.**



3.1.3 Present limitations of the trend data

The population trends presented here are drawn from the only extensive census data set using the standard analysis methods that were available throughout the period of the contract. However, a series of new analytical methods have been developed in recent years and consideration given to survey design (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 3.1.2.1), 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, JNCC and RSPB 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 fourth 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. The time series from the BBS are too short to provide meaningful medium or long-term trends at present.

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 4. Section 4 also points the way to further improvements in this area.

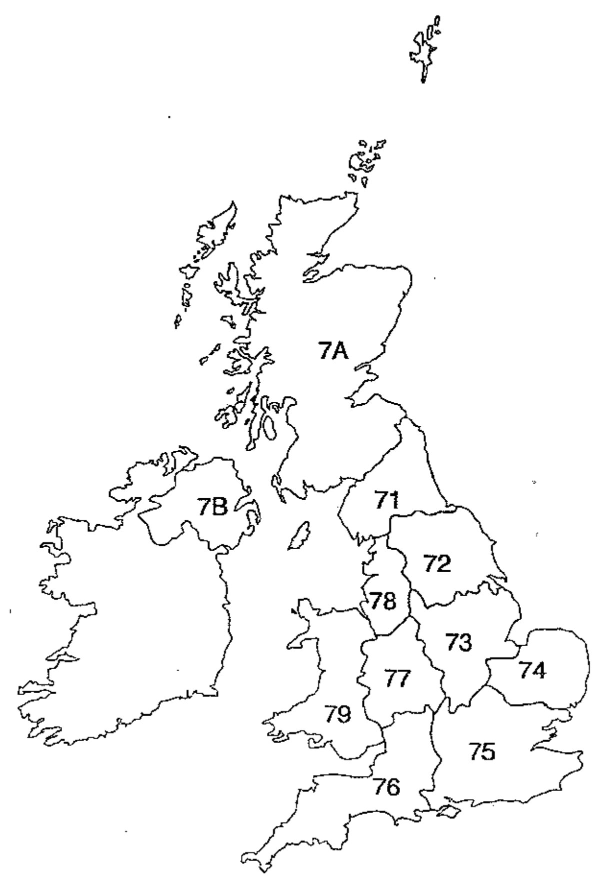
3.2 Results and discussion

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, unpublished). Regions used were the 11 NUTS (Nomenclature of Territorial Units for Statistics) regions of the United Kingdom (Figure 3.2.1). 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 3.2.1 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.



3.2.1 Woodpigeon *Columba palumbus*

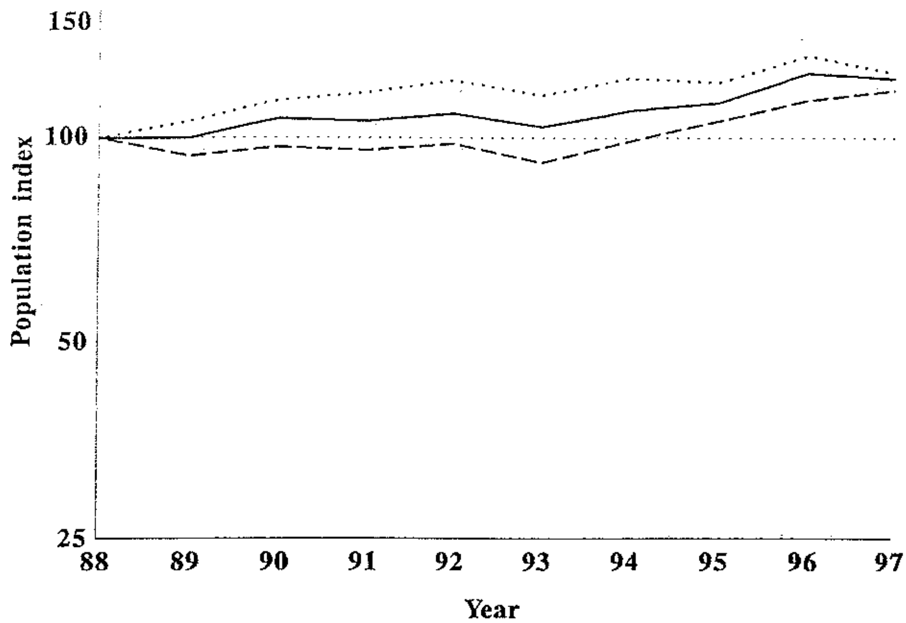


Figure 3.2.1.1 **CBC population changes between 1988 and 1997 for Woodpigeon on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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, unpublished) 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 3.2.1.1 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 (1988 = 100)
All habitats combined	**88**							**100**
	89	884	884	103	**0**	-8	+9	**100**
	90	940	1002	112	+7	0	+14	**107**
	91	1005	995	112	**-1**	-7	+6	**106**
	92	1097	1136	121	+4	-3	+10	**109**
	93	1183	1123	133	**-5**	-11	+1	**104**
	94	1200	1276	147	+6	-1	+14	**110**
	95	1283	1317	152	+3	-3	+9	**113**
	96	1318	1457	154	+11	+3	+18	**125**
	97	1348	1327	145	**-2**	-7	+4	**123**
Farmland plots	**88**							**100**
	89	402	427	51	+6	-9	+22	**106**
	90	475	512	58	+8	-2	+19	**114**
	91	485	495	54	+2	-7	+12	**117**
	92	534	557	58	+4	-6	+15	**122**
	93	592	565	62	**-5**	-13	+5	**116**
	94	573	608	68	+6	-4	+19	**123**
	95	644	631	70	**-2**	-10	+6	**121**
	96	584	640	70	+10	-2	+22	**133**
	97	554	523	62	**-6**	-14	+4	**125**
Woodland plots	**88**							**100**
	89	395	373	41	**-6**	-16	+6	**94**
	90	381	392	43	+3	-8	+16	**97**
	91	419	416	47	**-1**	-9	+9	**96**
	92	427	432	47	+1	-8	+11	**98**
	93	489	459	56	**-6**	-14	+2	**92**
	94	494	533	62	+8	-4	+21	**99**
	95	505	543	66	+8	-1	+17	**106**
	96	605	649	69	+7	-2	+17	**114**
	97	643	667	70	+4	-3	+12	**118**

3.2.2 Collared Dove *Streptopelia decaocto*

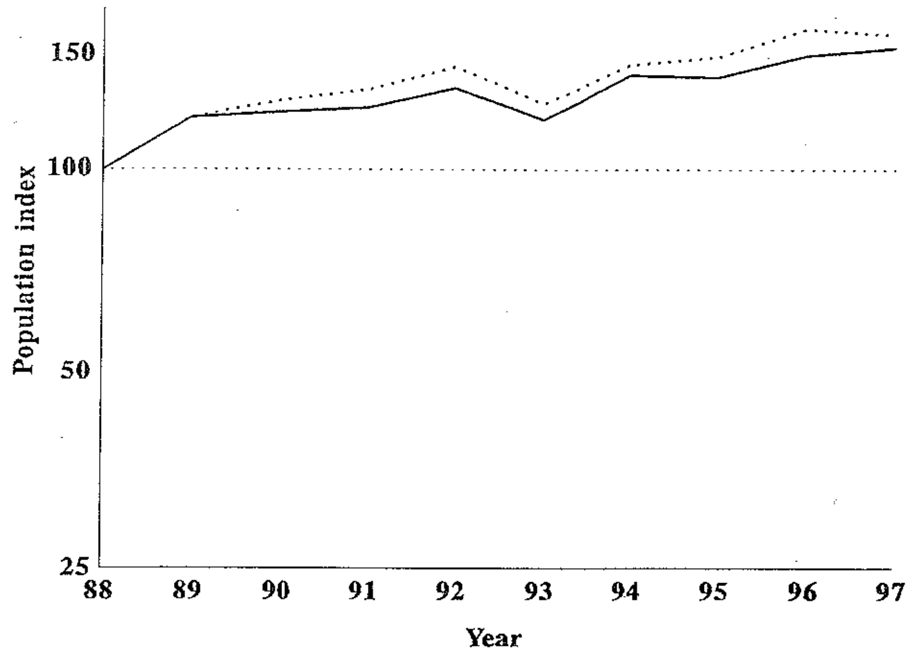


Figure 3.2.2.1 **CBC population changes between 1988 and 1997 for Collared Dove on farmland (dotted line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 3.2.2.1, Table 3.2.2.1).

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

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 3.2.2.1 **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 (1988 = 100)
All habitats combined	**88**							**100**
	89	171	206	82	**+20***	+7	+40	**120**
	90	190	192	83	**+1**	-13	+16	**122**
	91	185	188	79	**+2**	-13	+19	**124**
	92	204	219	88	**+7**	-8	+27	**133**
	93	189	169	80	**-11**	-24	+5	**119**
	94	175	205	83	**+17***	+4	+33	**139**
	95	205	203	85	**-1**	-14	+13	**138**
	96	188	203	83	**+8**	-8	+24	**149**
	97	172	177	78	**+3**	-8	+18	**153**
Farmland plots	**88**							**100**
	89	122	147	49	**+20***	+4	+47	**120**
	90	131	138	49	**+5**	-12	+21	**127**
	91	130	135	47	**+4**	-14	+28	**132**
	92	141	153	50	**+9**	-11	+35	**143**
	93	134	118	48	**-12**	-27	+9	**126**
	94	120	137	52	**+14***	0	+33	**144**
	95	135	139	54	**+3**	-13	+20	**148**
	96	125	138	54	**+10**	-11	+33	**163**
	97	109	107	47	**-2**	-15	+20	**160**

3.2.3 Jay *Garrulus glandarius*

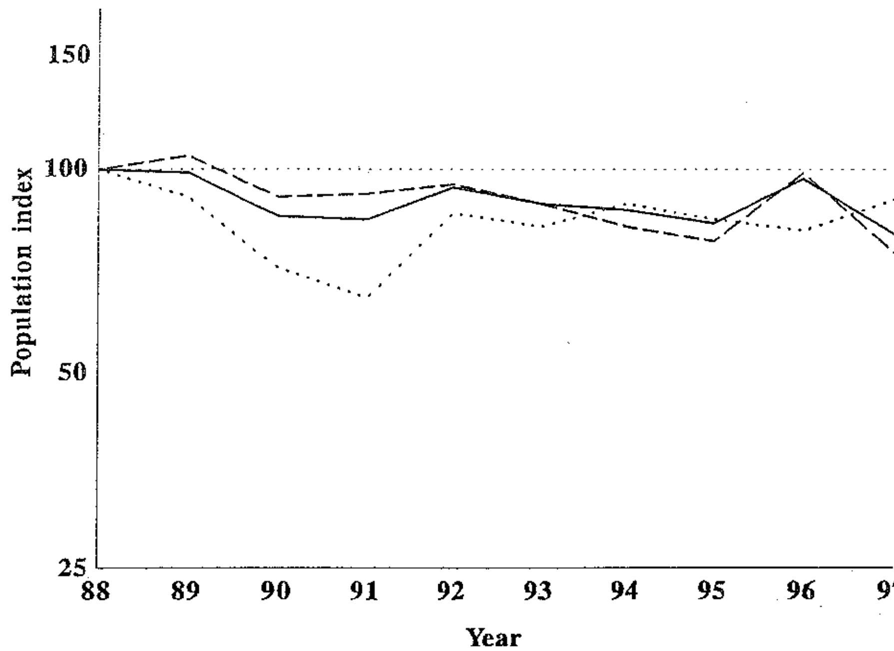


Figure 3.2.3.1 **CBC population changes between 1988 and 1997 for Jay on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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. An upturn in numbers in 1996 may have been due to the excellent acorn crop in 1995 - the downward trend was resumed in 1997. 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, unpublished).

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 1988-97; stable in the longer term**

Conservation status or concern: Status secure

Table 3.2.3.1 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 (1988 = 100)
All habitats combined	**88**							**100**
	89	174	172	107	**-1**	-10	+9	**99**
	90	186	160	108	**-14***	-22	-6	**85**
	91	162	160	108	**-1**	-10	+8	**84**
	92	179	199	121	**+11***	0	+23	**94**
	93	195	185	118	**-5**	-15	+6	**89**
	94	195	192	123	**-2**	-11	+9	**87**
	95	196	185	128	**-6**	-15	+5	**83**
	96	170	200	118	**+18***	+6	+31	**97**
	97	183	151	115	**-17***	-27	-7	**80**
Farmland plots	**88**							**100**
	89	54	49	37	**-9**	-26	+11	**91**
	90	50	39	32	**-22***	-34	-9	**71**
	91	39	35	30	**-10**	-28	+9	**64**
	92	37	50	36	**+35***	+10	+73	**86**
	93	45	43	36	**-4**	-29	+26	**82**
	94	44	48	36	**+9**	-14	+44	**89**
	95	45	42	39	**-7**	-31	+24	**84**
	96	40	39	34	**-3**	-27	+26	**81**
	97	30	33	31	**+10**	-24	+69	**90**
Woodland plots	**88**							**100**
	89	105	110	60	**+5**	-7	+18	**105**
	90	123	107	67	**-13***	-24	-2	**91**
	91	110	111	68	**+1**	-10	+12	**92**
	92	121	124	72	**+2**	-9	+16	**95**
	93	129	121	72	**-6**	-17	+6	**89**
	94	127	117	75	**-8**	-18	+4	**82**
	95	125	120	75	**-4**	-15	+8	**78**
	96	107	135	71	**+26***	+12	+43	**99**
	97	130	99	74	**-24***	-34	-13	**75**

3.2.4 Magpie *Pica pica*

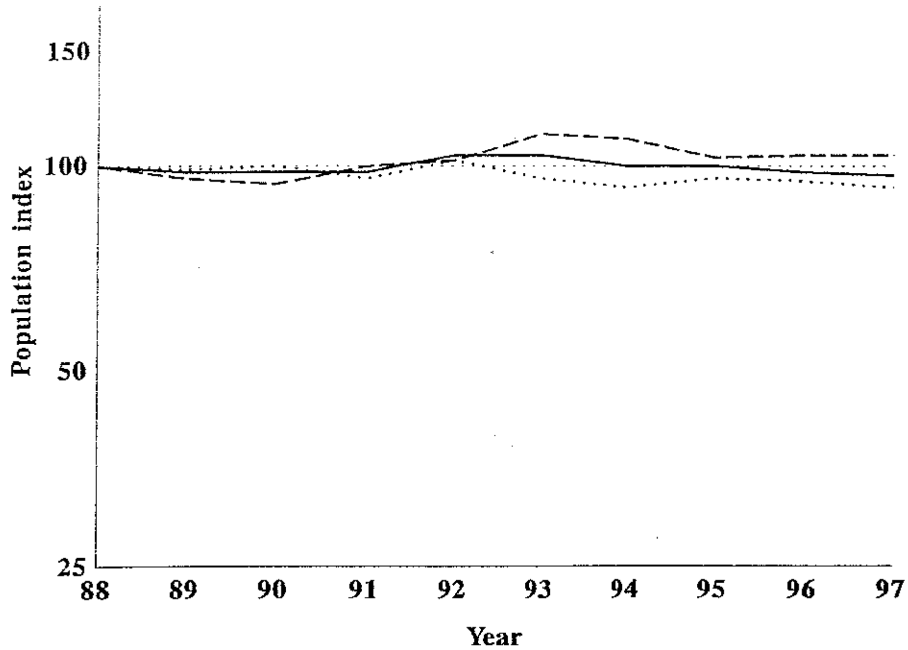


Figure 3.2.4.1 **CBC population changes between 1988 and 1997 for Magpie on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 signs of a small decrease during the 1990s (Figure 3.2.4.1).

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, unpublished). 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 unpublished).

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 3.2.4.1 **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 (1988 = 100)
All habitats combined	**88**							**100**
	89	502	493	152	**-2**	-8	+5	**98**
	90	474	474	152	**0**	-7	+7	**98**
	91	465	464	149	**0**	-7	+8	**98**
	92	487	519	150	**+7**	-1	+14	**104**
	93	511	509	152	**0**	-7	+7	**104**
	94	539	517	158	**-4**	-10	+2	**100**
	95	532	531	168	**0**	-7	+7	**100**
	96	508	498	166	**-2**	-8	+5	**98**
	97	443	440	149	**-1**	-6	+6	**97**
Farmland plots	**88**							**100**
	89	334	329	80	**-2**	-9	+7	**99**
	90	294	298	75	**+1**	-8	+11	**100**
	91	286	276	72	**-4**	-13	+7	**96**
	92	275	292	66	**+6**	-4	+17	**102**
	93	293	276	68	**-6**	-15	+4	**96**
	94	292	282	71	**-3**	-12	+6	**93**
	95	288	298	75	**+3**	-6	+14	**96**
	96	288	284	76	**-1**	-10	+8	**95**
	97	242	238	65	**-2**	-11	+8	**93**
Woodland plots	**88**							**100**
	89	129	124	56	**-4**	-14	+7	**96**
	90	144	141	63	**-2**	-10	+7	**94**
	91	137	146	62	**+7**	-5	+19	**100**
	92	156	159	65	**+2**	-9	+14	**102**
	93	158	173	67	**+9**	-2	+23	**112**
	94	179	176	70	**-2**	-11	+9	**110**
	95	176	165	75	**-6**	-17	+5	**103**
	96	160	161	72	**+1**	-10	+13	**104**
	97	155	155	70	**0**	-10	+11	**104**

3.2.5 Jackdaw *Corvus monedula*

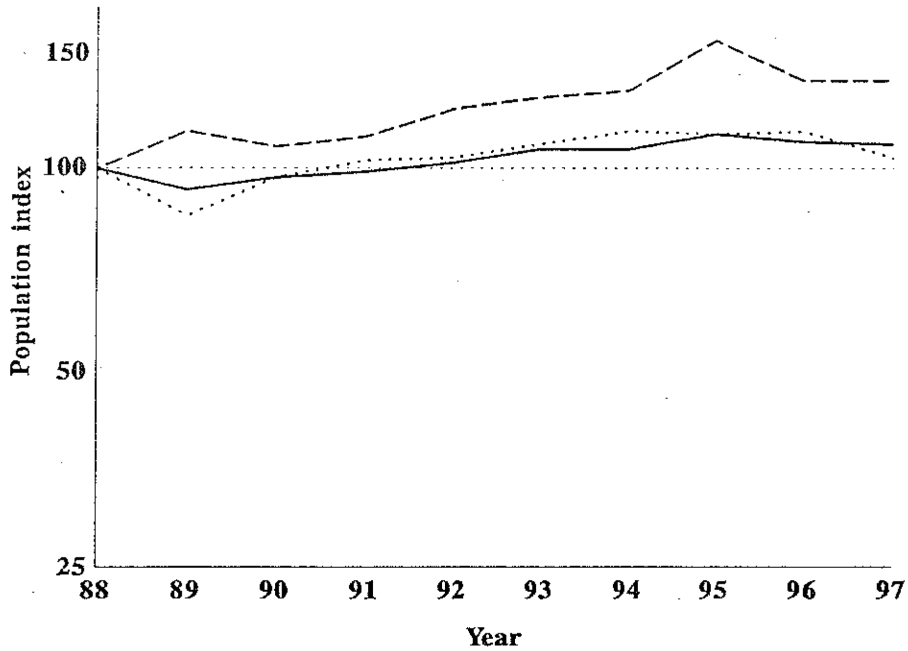


Figure 3.2.5.1 **CBC population changes between 1988 and 1997 for Jackdaw on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 3.2.5.1). 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, unpublished). 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 3.2.5.1 **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 (1988 = 100)
All habitats combined	**88**							**100**
	89	292	272	89	**-7**	-15	+2	**93**
	90	272	284	90	**+4**	-7	+18	**97**
	91	266	270	85	**+2**	-11	+16	**99**
	92	290	301	87	**+4**	-10	+19	**102**
	93	307	320	87	**+4**	-6	+16	**107**
	94	348	350	86	**+1**	-9	+13	**107**
	95	327	345	85	**+6**	-5	+17	**113**
	96	358	349	74	**-3**	-14	+12	**110**
	97	314	310	73	**-1**	-11	+10	**109**
Farmland plots	**88**							**100**
	89	185	158	51	**-15***	-25	-4	**85**
	90	156	177	52	**+13**	-1	+32	**97**
	91	148	158	45	**+7**	-6	+20	**103**
	92	171	172	45	**+1**	-17	+22	**104**
	93	198	208	45	**+5**	-8	+19	**109**
	94	205	214	46	**+4**	-8	+21	**114**
	95	194	192	47	**-1**	-14	+15	**113**
	96	184	185	37	**+1**	-15	+23	**114**
	96	159	145	30	**-9**	-24	+9	**104**
Woodland plots	**88**							**100**
	89	74	84	31	**+14**	-3	+32	**114**
	90	86	82	31	**-5**	-24	+11	**108**
	91	89	92	32	**+3**	-20	+39	**112**
	92	83	91	32	**+10**	-17	+38	**123**
	93	90	94	33	**+4**	-15	+31	**128**
	94	96	98	30	**+2**	-15	+26	**131**
	95	92	110	28	**+20**	-1	+44	**156**
	96	146	127	31	**-13**	-27	+10	**136**
	97	117	117	36	**-12**	+18	+36	**136**

3.2.6 Rook *Corvus frugilegus*

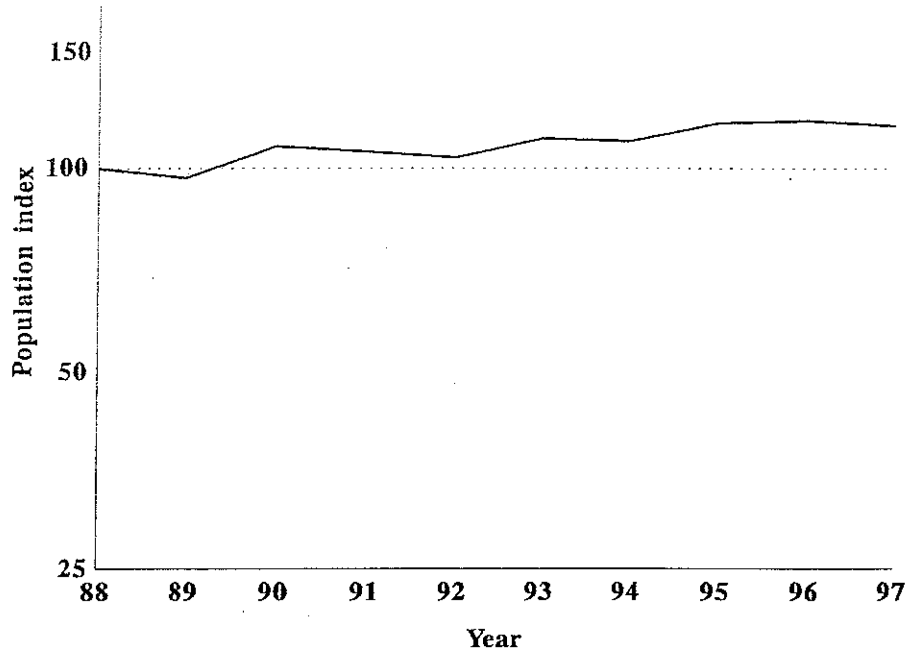


Figure 3.2.6.1 **CBC population changes between 1988 and 1997 for Rook in all habitats combined. Index values are relative to 100 in 1988.**

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 1988 and 1997 with rather little between-year fluctuation (Figure 3.2.6.1). As these results are based on few plots (Table 3.2.6.1), 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, unpublished).

A sample census in 1996 carried out by the BTO under contract to DETR estimated that the UK population had increased by about 40% since previous surveys in 1975-77 (Marchant & Gregory in press).

Population trend: **Stable or increasing shallowly**

Conservation status or concern: **Status secure**

Table 3.2.6.1 **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 (1988 = 100)
All habitats combined	**88**							**100**
	89	983	957	24	**-3**	-19	+20	**97**
	90	836	926	23	**+11**	-27	+39	**108**
	91	869	856	23	**-2**	-12	+22	**106**
	92	778	762	22	**-2**	-10	+5	**104**
	93	851	904	27	**+6**	-6	+31	**111**
	94	1038	1031	30	**-1**	-9	+16	**110**
	95	791	841	28	**+6**	-5	+18	**117**
	96	963	973	30	**+1**	-12	+17	**118**
	97	941	922	29	**-2**	-20	+16	**116**

3.2.7 Carrion Crow *Corvus corone*

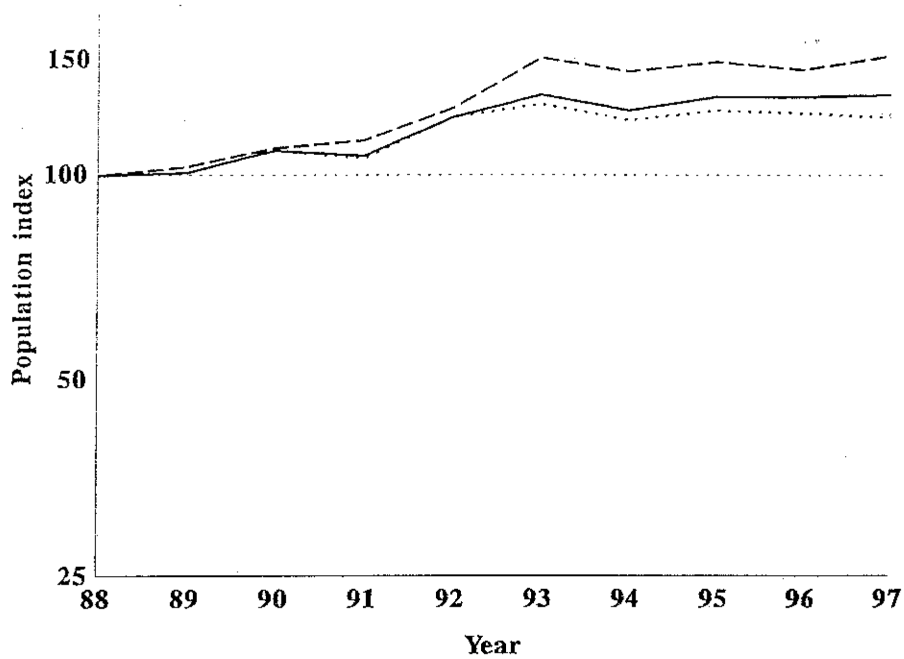


Figure 3.2.7.1 **CBC population changes between 1988 and 1997 for Carrion Crow on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 3.2.7.1).

During 1983-93, increases were remarkably consistent among 11 regions of the United Kingdom (Marchant, unpublished). 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 now stabilising**

Conservation status or concern: **Status secure**

Table 3.2.7.1 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 (1988 = 100)
All habitats combined	88							**100**
	89	429	434	157	+1	-6	+9	**101**
	90	410	438	153	+7	-1	+15	**109**
	91	430	423	151	-2	-9	+6	**107**
	92	431	491	159	+14*	+5	+23	**122**
	93	508	552	155	+9*	+1	+17	**132**
	94	537	506	162	-6*	-11	0	**125**
	95	524	550	168	+5	0	+11	**131**
	96	528	529	167	0	-6	+7	**131**
	97	481	483	160	0	-5	+6	**132**
Farmland plots	88							**100**
	89	292	294	80	+1	-9	+11	**101**
	90	268	290	74	+8	-2	+18	**109**
	91	284	277	69	-2	-12	+8	**106**
	92	271	311	70	+15*	+2	+28	**122**
	93	334	350	67	+5	-6	+16	**128**
	94	336	317	72	-6	-12	+2	**121**
	95	331	342	74	+3	-3	+10	**125**
	96	323	322	73	0	-8	+8	**124**
	97	284	279	-2	-2	-9	+6	**122**
Woodland plots	88							**100**
	89	107	110	61	+3	-10	+19	**103**
	90	115	121	64	+5	-11	+22	**110**
	91	116	119	66	+3	-13	+18	**113**
	92	124	139	70	+12	-3	+28	**126**
	93	142	169	70	+19*	+4	+38	**150**
	94	161	153	70	-5	-14	+5	**143**
	95	150	155	73	+3	-8	+15	**148**
	96	158	154	75	-3	-11	10	**144**
	97	152	159	76	+5	-4	+15	**151**

3.2.8 Starling *Sturnus vulgaris*

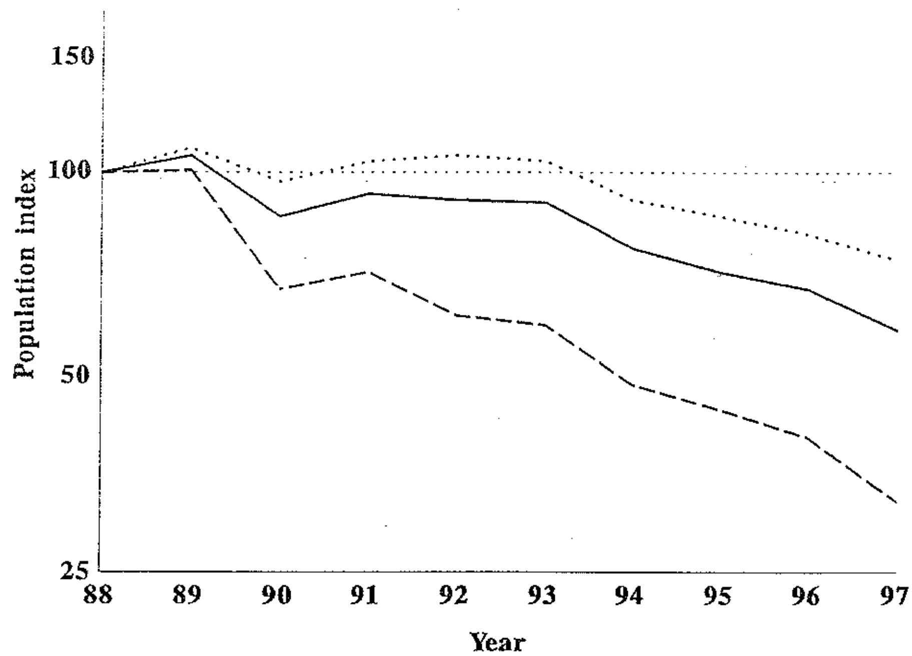


Figure 3.2.8.1 **CBC population changes between 1988 and 1997 for Starling on farmland (dotted line), in woodland (dashed line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 1988 to 1997 and were especially steep in woodland, where by 1997 the population had dwindled to less than a fifth 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 (41%, Table 3.2.10.1). 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, unpublished).

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 3.2.8.1 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 (1988 = 100)
All habitats combined	**88**							**100**
	89	602	639	112	**+6**	-6	+19	**106**
	90	645	525	109	**-19***	-27	-9	**86**
	91	531	571	104	**+8**	-5	+24	**93**
	92	660	648	115	**-2**	-14	+10	**91**
	93	556	546	105	**-2**	-12	+10	**90**
	94	567	486	105	**-14***	-21	-7	**77**
	95	479	446	107	**-7**	-16	+4	**71**
	96	422	393	106	**-7**	-16	+3	**67**
	97	348	305	87	**-12***	-22	-3	**58**
Farmland plots	**88**							**100**
	89	395	429	73	**+9**	-8	+24	**109**
	90	387	344	65	**-11**	-22	+2	**97**
	91	329	355	58	**+8**	-9	+33	**104**
	92	410	417	63	**+2**	-16	+16	**106**
	93	373	365	58	**-2**	-14	+13	**104**
	94	365	322	58	**-12***	-20	-2	**91**
	95	343	324	63	**-6**	-16	+8	**86**
	96	298	281	63	**-6**	-17	+5	**81**
	97	236	214	51	**-9**	-20	+2	**74**
Woodland plots	**88**							**100**
	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	70	30	**-9**	-29	+18	**40**
	97	69	55	23	**-20**	-47	+13	**32**

3.2.9 House Sparrow *Passer domesticus*

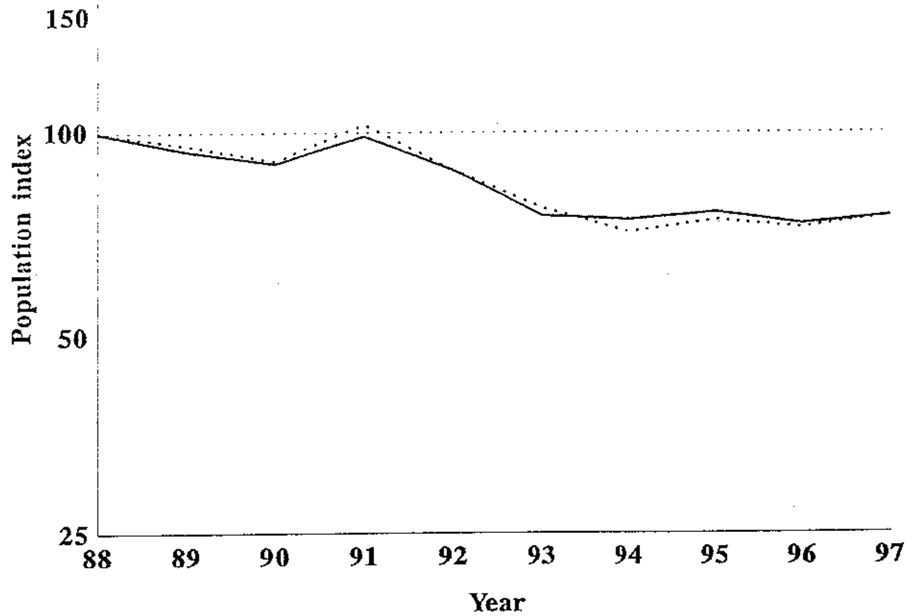


Figure 3.2.9.1 **CBC population changes between 1988 and 1997 for House Sparrow on farmland (dotted line) and in all habitats combined (solid line). Index values are relative to 100 in 1988.**

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 3.2.9.1). 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, unpublished).

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 3.2.9.1 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 (1988 = 100)
All habitats combined	**88**							**100**
	89	317	299	61	**-6**	-20	+10	**94**
	90	304	290	60	**-5**	-18	+11	**90**
	91	247	271	55	**+10**	-7	+28	**99**
	92	353	315	62	**-11**	-24	+3	**88**
	93	322	273	58	**-15***	-27	-4	**75**
	94	328	323	64	**-2**	-16	+26	**74**
	95	377	388	69	**+3**	-9	+16	**76**
	96	353	339	67	**-4**	-18	+13	**73**
	97	236	243	61	**+3**	-9	+16	**75**
Farmland plots	**88**							**100**
	89	281	271	47	**-4**	-19	+14	**96**
	90	272	257	45	**-6**	-20	+12	**91**
	91	213	240	40	**+13**	-6	+34	**103**
	92	300	258	44	**-14**	-28	+1	**88**
	93	272	238	41	**-13**	-26	0	**77**
	94	285	262	46	**-8**	-22	+20	**71**
	95	317	332	51	**+5**	-8	+19	**74**
	96	296	285	47	**-4**	-19	+16	**72**
	97	186	194	43	**+4**	-10	+18	**75**

3.2.10 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. The differences between these predicted indices at the start and end of the period are given in Table 3.2.10.1. These figures are a more reliable estimate of overall change than those derived from the uncorrected index values.

Table 3.2.10.1 **Overall trends during 1988-97, as measured by the Common Birds Census. The figures tabulated are the percentage differences between index values for 1988 and 1997, predicted from quadratic regressions.**

Species	All habitats	Farmland	Woodland
Woodpigeon	+23	+24	+20
Collared Dove	+40	+49	.
Jay	-11	0	-20
Magpie	-1	-6	+10
Jackdaw	+18	+20	+42
Rook	+19	.	.
Carrion Crow	+37	+27	+58
Starling	-41	-27	-66
House Sparrow	-29	-32	.

There are substantial increases in population levels for Carrion Crow, Woodpigeon and Collared Dove within this 10-year period of the CBC data set. While the rate of increase in Collared Dove was steady throughout the 10-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. Magpie, a species whose population size was until recently expanding rapidly, showed little overall change during the period. Indeed, the trend for farmland indicates a slight decline.

Starling was the species most strongly in decline, especially in woodland where 66% of the 1988 population had been lost by 1997. These declines accelerated slightly over the 10-year period. Jay and House Sparrow were also in overall decline.

4. SETTING ALERT LEVELS FOR OPPORTUNISTIC SPECIES

4.1 Summary of Alert levels

DETR 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 3 time-spans: 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.

Starling and House Sparrow were the only opportunistic species to raise a conservation alert but decreases in Jay and Magpie numbers over the last 5 to 10 years would be large enough to trigger alerts if they were to be maintained over 25 years.

4.2 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 last 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 4 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.

This method was tested on a range of species for 1, 5, 10 and 25 year periods up to 1994 (Marchant *et al.* 1997b). 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.

4.3 Estimating population change

4.3.1 Methods

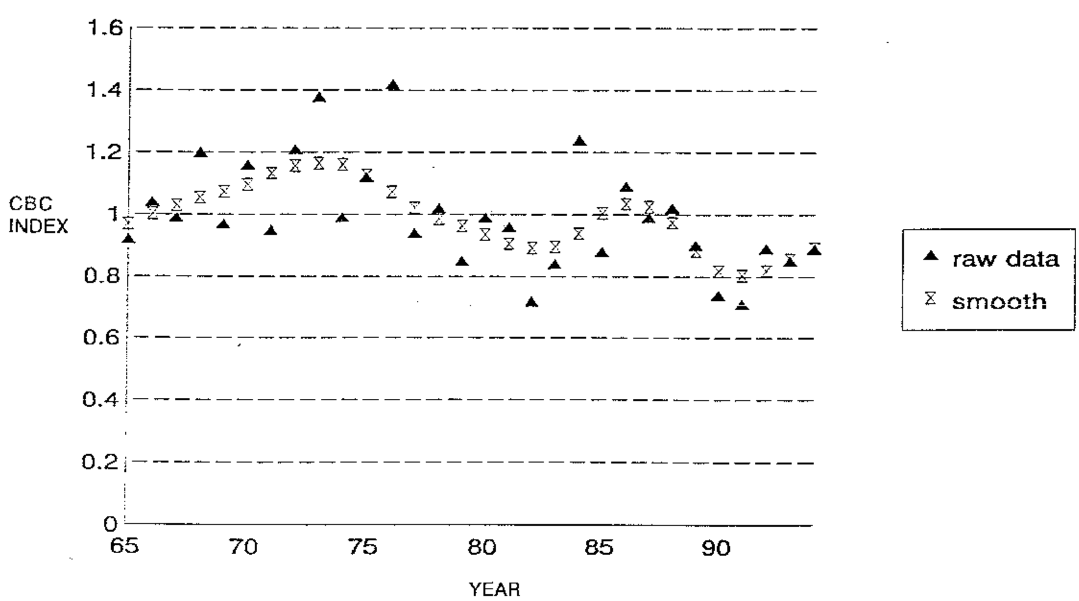
Previous estimates of population change have used indices calculated from the chain method (Marchant *et al.* 1990) in which successive between-year percentage changes are linked around an arbitrary base year. A characteristic of CBC data is that there is a continual turnover of census plots from year 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 (Trends and Indices for Monitoring Data) (Pannekoek & van Strien 1996), 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 4.3.1.1. 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.

Figure 4.3.1.1 A comparison of raw and smoothed Mountford indices for Jay on farmland.



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.* Table 3.2.10.1). Smoothing was also employed on the 999 bootstrap samples to produce smoothed upper and lower confidence intervals.

Problems with the Mountford method can be encountered when count data are sparse, *i.e.* where there are very few non-zero counts for particular years, as can occur with significant proportions of the bootstrap samples generated for scarcer species. In such cases, the confidence intervals produced tend to be too wide to be of use. Where such problems were encountered in this study we re-analysed the data for the species in question using a Generalized Additive Model (GAM) approach (Hastie & Tibshirani 1990). This method is a generalization of the TRIM approach in which a pre-determined level of smoothing is built in (Fewster *et al.* in prep). The smoothed Mountford method attempts to estimate abundance in each year and then fits a smoothed curve to the data; the GAM approach, however, estimates the smoothed function directly and therefore copes better with years with missing counts (Fewster *et al.* in prep). Confidence intervals for GAM indices were obtained by bootstrapping, as with the Mountford method. A major drawback of the GAM approach is that it is very demanding of computer resources: as a result, we have used it only for the species with the sparsest CBC data.

4.3.2 Results

Smoothed Mountford or GAM indices and 95% confidence limits are shown for 9 opportunistic species on farmland in Figures 4.3.2.1 to 4.3.2.9. Indices were calculated for the last 25 years for each species except for House Sparrow, where indices could only be determined from 1975 onwards, due to small samples in the early years. Woodpigeon, Collared Dove, Magpie, Jackdaw, Rook and Carrion Crow show evidence of increasing populations, Jay shows a slight decrease while Starling and House Sparrow show an appreciable decrease between 1972 and 1997. 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.

The Mountford method of producing population indices and confidence intervals did not work adequately or at all in three opportunistic species: Woodpigeon, Rook and House Sparrow. The confidence limits on the population indices for Woodpigeon and House Sparrow were very wide, with the lower limit tending to zero, while the program was unable to produce any estimates for Rook.

The failure of the Mountford method for Rook and House Sparrow is 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 to produce adequate results for Woodpigeon 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 especially difficult to census. Generalised Additive Model indices and confidence limits were produced for these three species.

Figure 4.3.2.1 **Generalised Additive Model indices and 95% confidence limits for Woodpigeon (all habitats).**

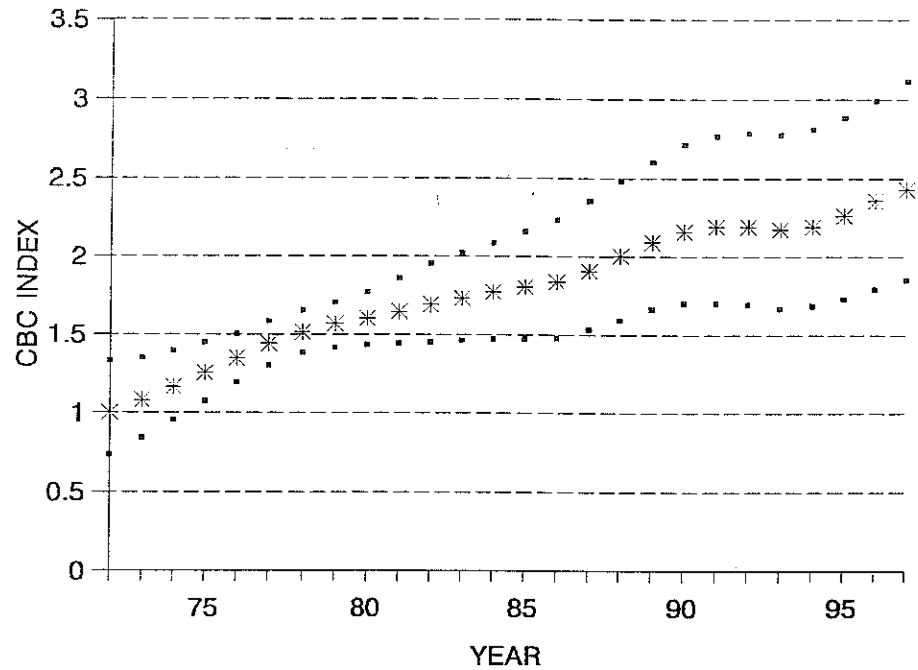


Figure 4.3.2.2 **Smoothed Mountford indices and 95% confidence limits for Collared Dove (all habitats).**

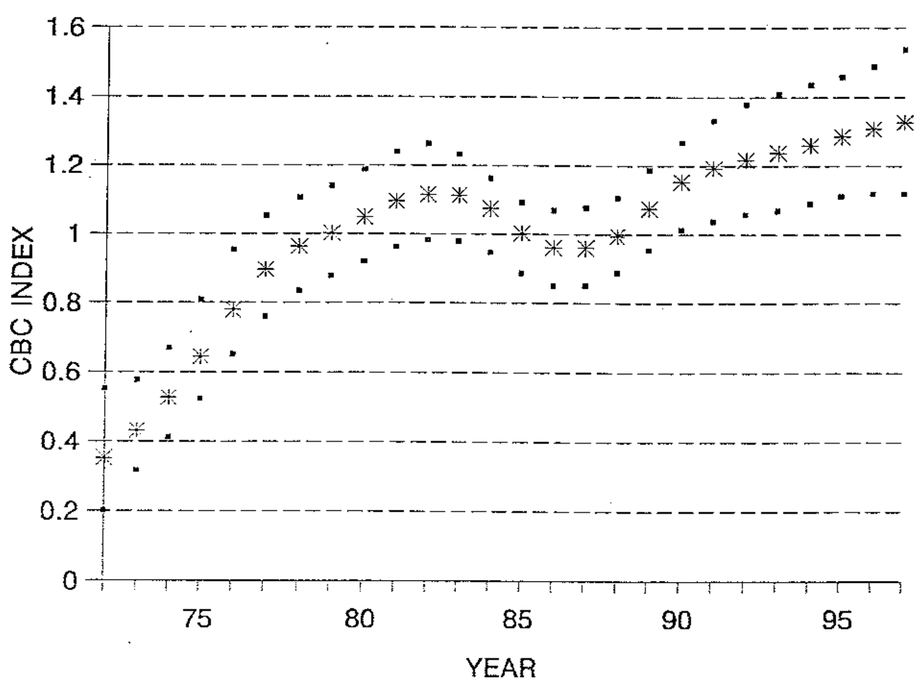


Figure 4.3.2.3 **Smoothed Mountford indices and 95% confidence limits for Jay (all habitats).**

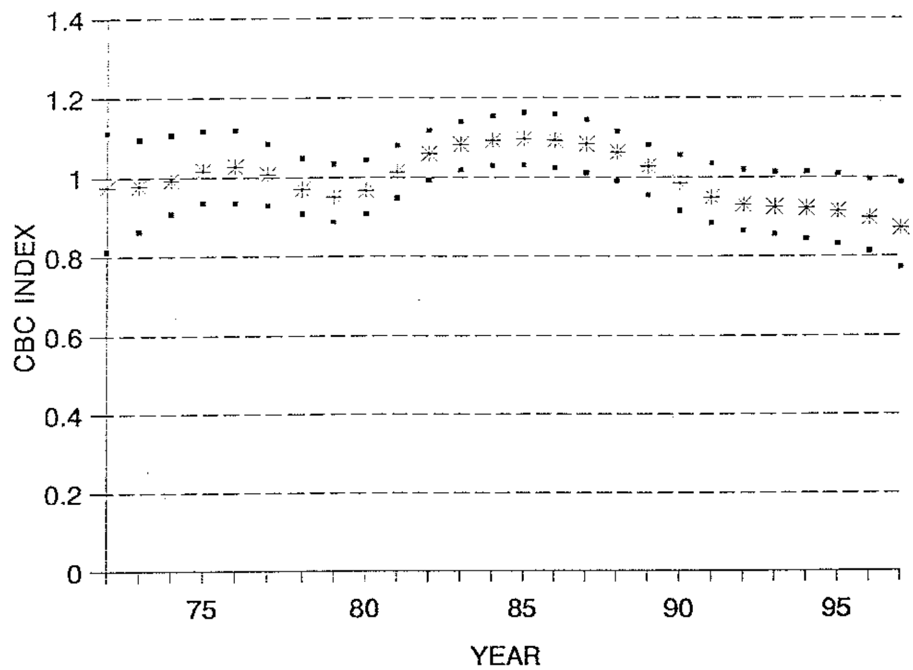


Figure 4.3.2.4 **Smoothed Mountford indices and 95% confidence limits for Magpie (all habitats).**

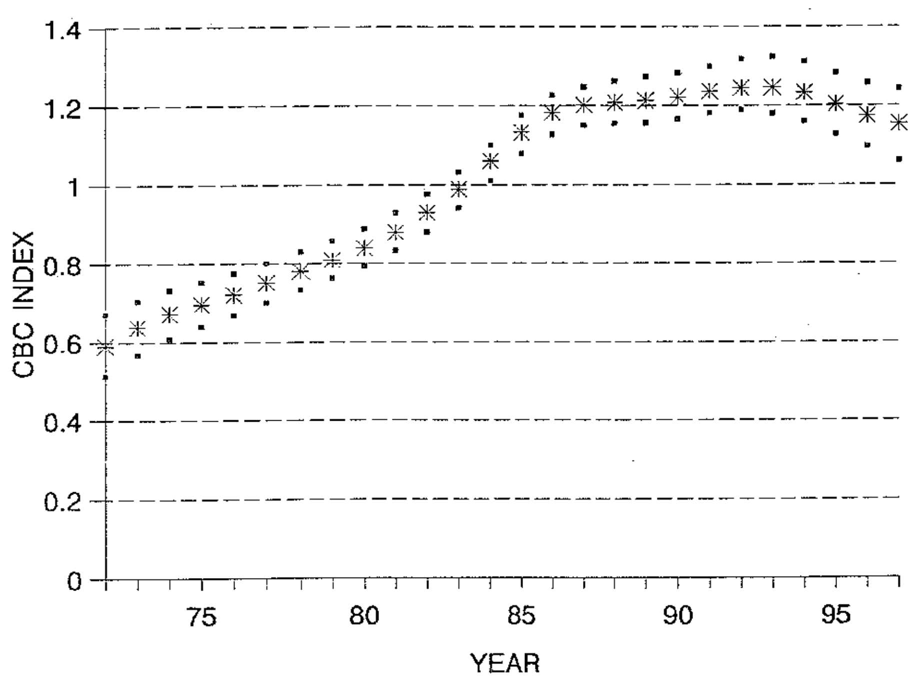


Figure 4.3.2.5 **Smoothed Mountford indices and 95% confidence limits for Jackdaw (all habitats).**

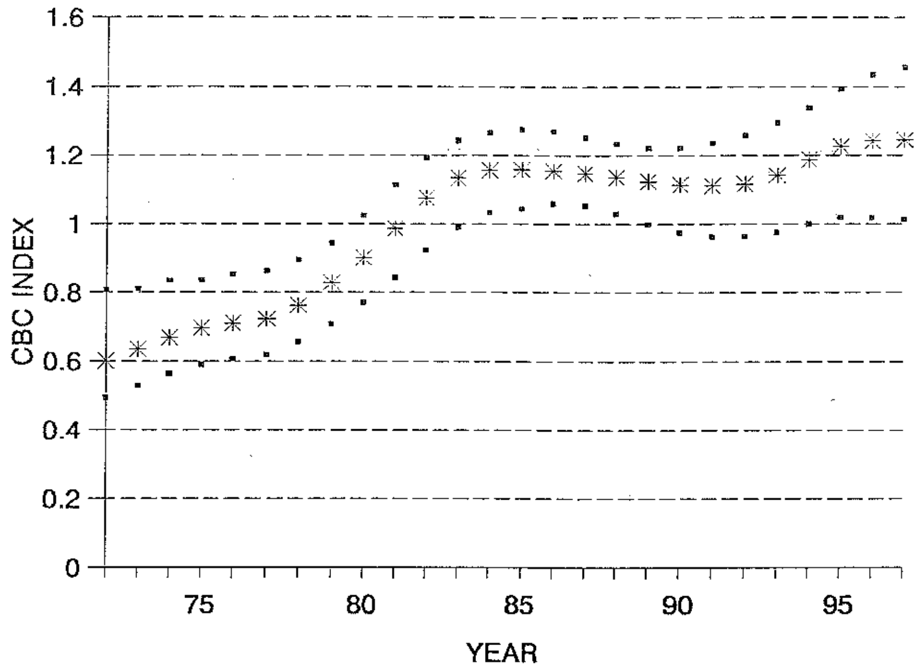


Figure 4.3.2.6 **Generalised Additive Model indices for Rook (all habitats).**

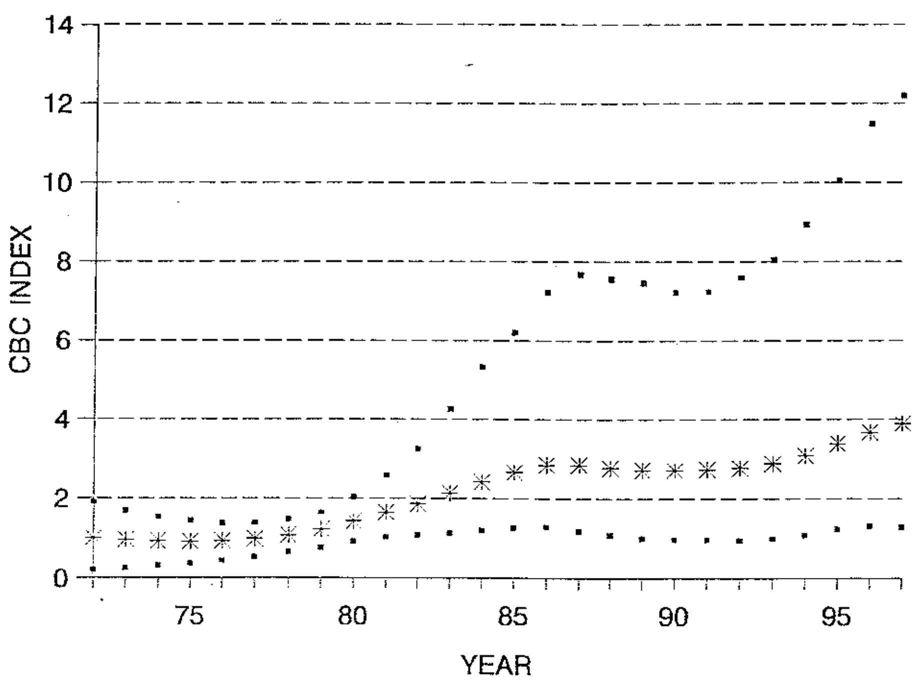


Figure 4.3.2.7 Smoothed Mountford indices and 95% confidence limits for Carrion Crow (all habitats).

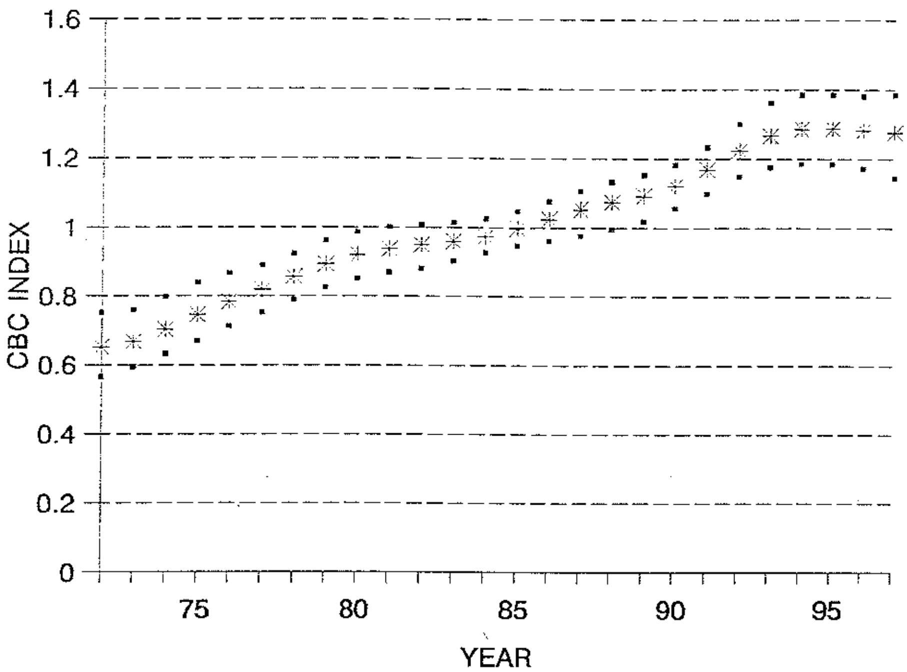


Figure 4.3.2.8 Smoothed Mountford indices and 95% confidence limits for Starling (all habitats).

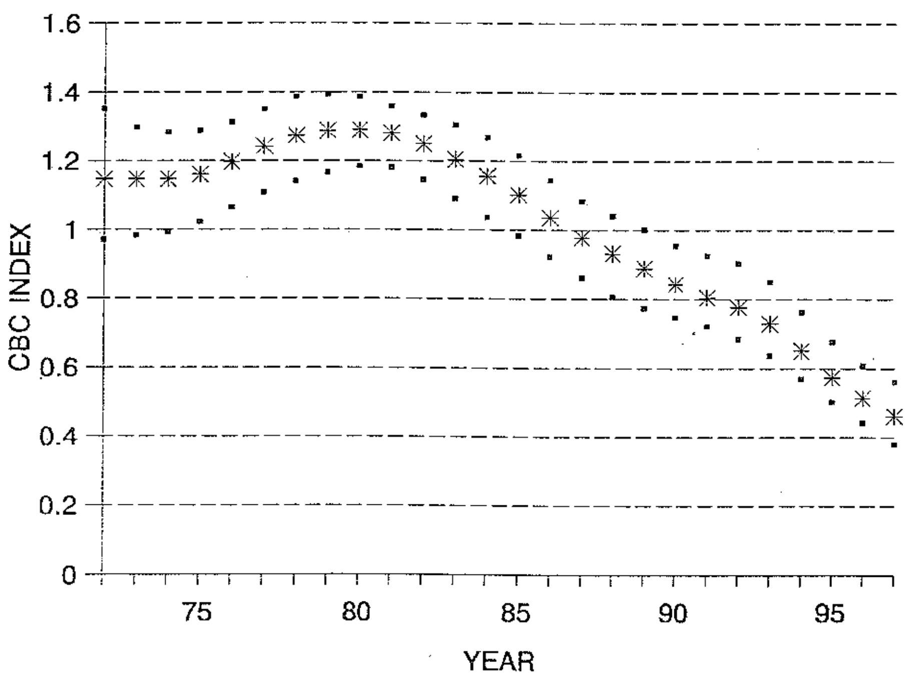
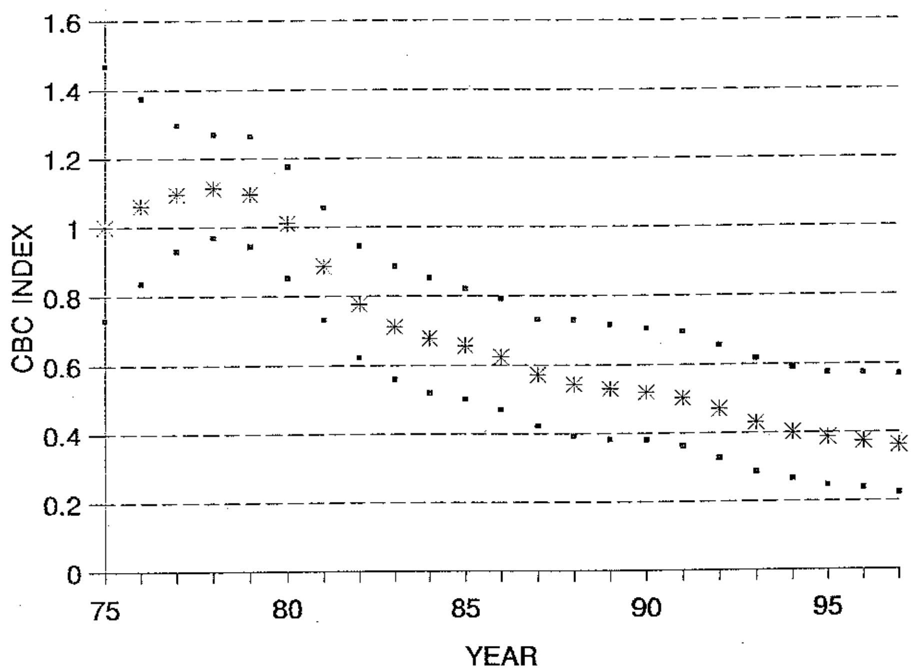


Figure 4.3.2.9 **Generalised Additive Model indices for House Sparrow (all habitats).**



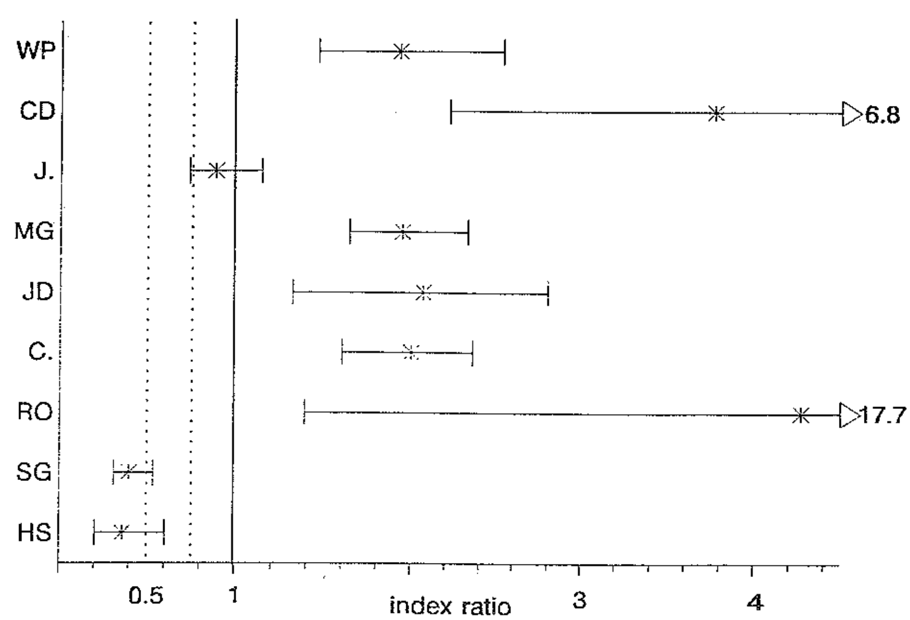
4.4 Detecting population change

The bootstrapping technique for Mountford and GAM 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, 1997, divided by the index from 1972. 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. Confidence limits calculated for the GAM index are used for Woodpigeon, Rook and House Sparrow.

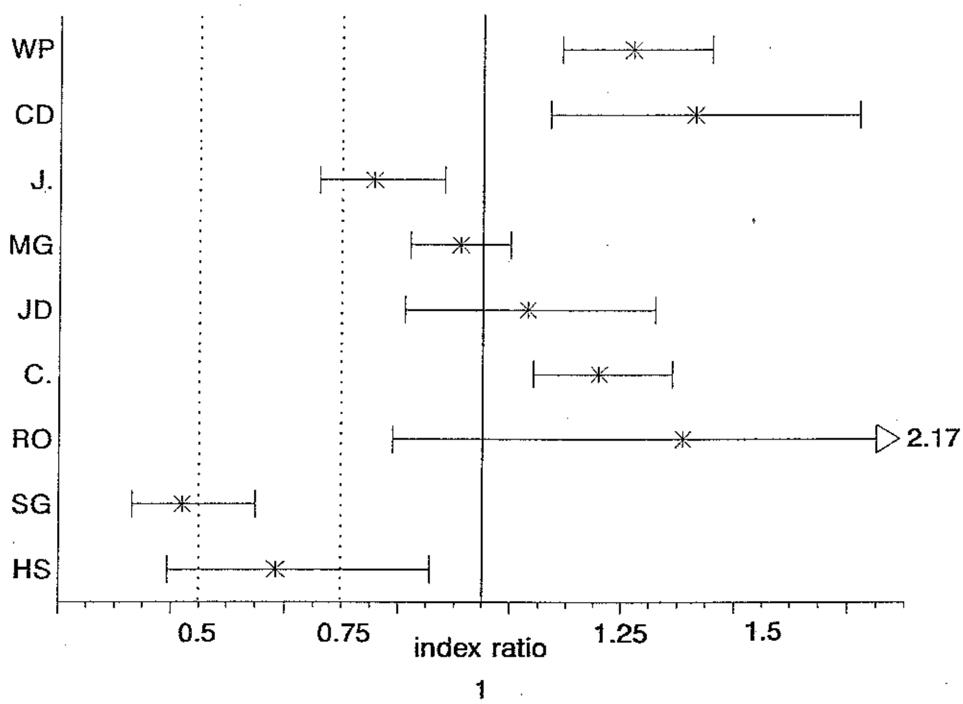
This approach is illustrated in Figure 4.4.1 which shows 95% confidence intervals for the population change ratio over 25 years for the nine opportunistic species. Lower confidence limits of the index ratio for Collared Dove, Magpie, Jackdaw and Carrion Crow all exceed 1, signifying a significant increase between 1972 and 1997. Both Starling and House Sparrow showed a significant population decrease over the same period.

Figure 4.4.1 **1997 index/1972 index and 95% confidence limits calculated from 999 bootstraps for opportunistic species. Smoothed indices were used. Vertical dotted lines represent 50% and 25% population decline. WP=Woodpigeon, CD=Collared Dove, J.=Jay, MG=Magpie, JD=Jackdaw, RO=Rook, C.=Carrion Crow, SG=Starling, HS=House Sparrow.**



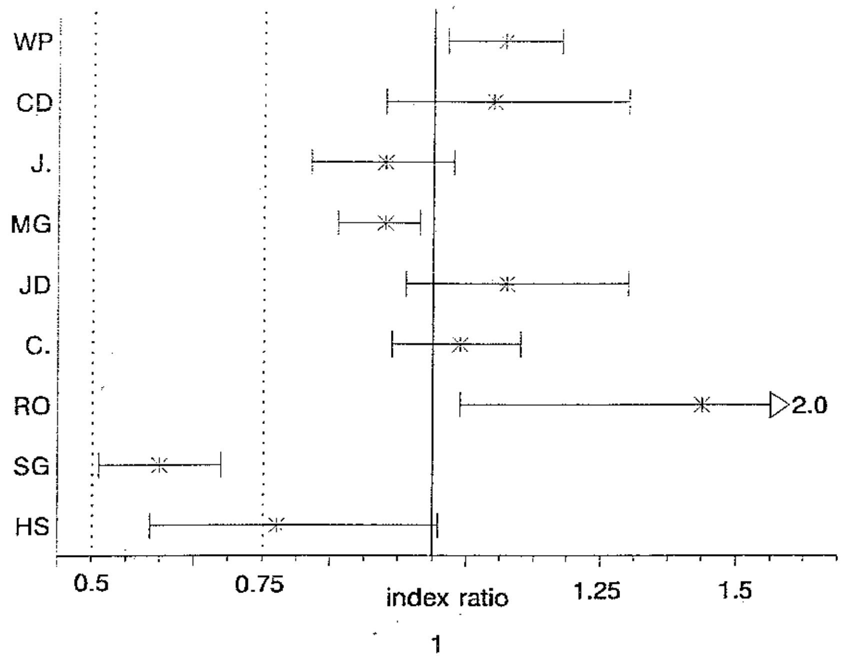
The above procedure was repeated for differences of 10 and 5 years from the most recent index (Figures 4.4.2 & 4.4.3) in order to detect medium- and short-term changes. Changes over 10 years showed similar patterns to the long-term changes, although fewer species showed a significant population change. Woodpigeon, Collared Dove and Carrion Crow showed significant increases while Jay, Starling and House Sparrow showed significant population decreases. The Starling declined by more than 50% in the last 10 years.

Figure 4.4.2 **1997 index/1987 index and 95% confidence limits calculated from 999 bootstraps for opportunistic species. Smoothed indices were used. Vertical lines represent 50% and 25% population decline. WP=Woodpigeon, CD=Collared Dove, J.=Jay, MG=Magpie, JD=Jackdaw, RO=Rook, C.=Carrion Crow, SG=Starling, HS=House Sparrow.**



Changes over the five years between 1992 and 1997 (Figure 4.4.3) were, as is to be expected, smaller than those over 10 or 25 years. There were no significant increases but Starling still showed a significant decrease. Although the decrease in Magpie numbers over this period was modest, confidence intervals around the estimated decrease were small, giving the decrease statistical significance.

Figure 4.4.3 **1997 index/1992 index and 95% confidence limits calculated from 999 bootstraps for opportunistic species. Smoothed indices were used. Vertical lines represent 50% and 25% population decline. WP=Woodpigeon, CD=Collared Dove, J.=Jay, MG=Magpie, JD=Jackdaw, RO=Rook, C.=Carrion Crow, SG=Starling, HS=House Sparrow.**



4.5 Alert Levels

4.5.1 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 4.5.1.1). 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 4.4.1 to 4.4.3).

Table 4.5.1.1 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 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 4.5.1.2. 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 the biology of individual species as some may be more prone to short-term fluctuations.

For a species to qualify for a Level 1 alert level, both the population change and the upper confidence limit of the change must be more than 50%, similarly, a Level 2 alert must be greater than 25% with an upper confidence limit of more than 25%.

Table 4.5.1.2 **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
Rapid	Level 1	absolute % change	-50	-50	-50
Moderate	Level 2	absolute % change	-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.

4.5.2 Results

A summary of 1997 alert levels for the 9 opportunistic species is shown in Table 4.5.2.1. A medium conservation alert is issued for Starling on the basis of decreases of significantly greater than 25% for all 3 time periods while House Sparrow also qualifies for a medium alert based on decreases over the last 10 and 25 year periods. If the short-term population changes noted over the period 1987 to 1997 were maintained for the next 25 years, Jay would be given medium conservation alert, while Starling would be given high conservation alert. If we use population changes over the period 1992 to 1997 to predict changes over the next 25 years, in addition to the three alerts mentioned above, Magpie would merit a medium conservation alert.

Table 4.5.2.1 **1997 alert levels for 9 opportunistic species. For definitions of alert levels see Table 4.5.1.2. Figures in brackets indicate alert levels based on predicted changes over the next 25 years, estimated from rates of population change over the last 5 and 10 years.**

Species	1997 alert level				
	25 year alert	10 year alert		5 year alert	
Woodpigeon *Columba palumbus*	**0**	**0**	(0)	**0**	(0)
Collared Dove *Streptopelia decaocto*	**0**	**0**	(0)	**0**	(0)
Jay *Garrulus glandarius*	**0**	**0**	(4)	**0**	(4)
Magpie *Pica pica*	**0**	**0**	(0)	**0**	(4)
Jackdaw *Corvus monedula*	**0**	**0**	(0)	**0**	(0)
Rook *Corvus frugilegus*	**0**	**0**	(0)	**0**	(0)
Carrion Crow *Corvus corone*	**0**	**0**	(0)	**0**	(0)
Starling *Sturnus vulgaris*	2	2	(3)	2	(3)
House Sparrow *Passer domesticus*	2	2	(4)	**0**	(4)

4.6 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 with some of the scarcer species, or species that 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. 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 *Troglodytes troglodytes* 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 4.5.2.1) 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.

ACKNOWLEDGEMENTS

The contributions of fieldwork and paperwork by volunteer BTO members have been the essential ingredient of this study, and the primary acknowledgement must go to them. Figure 3.1.2.1 was prepared using the program DMAP, with thanks to Alan Morton.

Robin Groombridge, Christine Harry, John Clorley, Gy Ovenden and Sarah Jones of the Department of the Environment, Transport and the Regions' European Wildlife Division gave valuable assistance at various stages of the project. We also thank Will Peach, Humphrey Crick, Greg Mudge, Steve Parr and Peter Clement for useful discussion and Dan Chamberlain for assisting with the developing the Alert Limit methodology. The Common Birds Census was funded by DoE and DETR during this project, and in earlier years was also funded by the Joint Nature Conservation Committee (on behalf of English Nature, Scottish Natural Heritage, the Countryside Council for Wales and the Department of the Environment for Northern Ireland).

We are also grateful to Census Unit staff who have helped process the maps during the recent ten year period, particularly Dawn Balmer, Lynette Musty, Phil Whittington and the late Steve Carter, and to Sam Rider for secretarial assistance.

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