



## Research Report

Contract No: F90-01-708  
Participation of the National Gamebag Census in the Mammal  
Surveillance Network

A report to JNCC for the year 2008/09

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## 1 Summary

1. The NGC was formally established in 1961 and collects bag statistics from about 650 estates or shoots each year. Each contributor completes an annual return form that provides the means to record 19 mammal species, namely Rabbit *Oryctolagus cuniculus*, Brown Hare *Lepus europaeus*, Mountain Hare *Lepus timidus*, Roe Deer *Capreolus capreolus*, Red Deer *Cervus elaphus*, Fallow Deer *Dama dama*, Muntjac *Muntiacus reevesi*, Sika Deer *Cervus nippon*, Chinese Water Deer *Hydropotes inermis*, Wild Boar *Sus scrofa*, Hedgehog *Erinaceus europaeus*, Grey Squirrel *Sciurus carolinensis*, Fox *Vulpes vulpes*, Feral Cat *Felis catus*, Weasel *Mustela nivalis*, Stoat *Mustela erminea*, Polecat *Mustela putorius*, Mink *Mustela vison*, Brown Rat *Rattus norvegicus*. All series are ongoing, with 2007 the last season included here (throughout, the year denotes the year in which a shooting season starts, e.g. 2007 refers to the 2007/08 season).
2. Species-specific annual bag indices are estimated using appropriate statistical methods (generalised linear models with Poisson error, logarithmic link function, log(shot area) and year and shoot as factors). Percentage changes over the periods 1961-2007, 1981-2007, 1986-2007, 1991-2007, 1995-2007, 1996-2007, 2001-2007 are evaluated after smoothing out annual fluctuations in bag indices (using generalised additive models). The 95% confidence intervals of the estimates are obtained by bootstrapping. To allow comparisons between years and sites, bags are expressed per unit area.
3. At the UK level, mammal species coverage is good except for Chinese Water Deer and Wild Boar. Coverage for England and Scotland is very similar, with the additional exception of Mountain Hare in England and Muntjac in Scotland. In Wales, species coverage is adequate apart from Mountain Hare, Roe Deer, Red Deer, Fallow Deer, Muntjac and Sika Deer.
4. At the UK level, the NGC data show significant medium-term (post-1960) increases in bag sizes for Rabbit, Roe Deer, Red Deer, Muntjac, Sika Deer, Grey Squirrel, Fox, Stoat, American Mink and Brown Rat, and significant medium-term decreases in bag sizes for Brown Hare, Hedgehog, Feral Cat and Weasel.
5. Temporal trends and spatial changes in distribution for Hedgehog, Red Fox, Feral Cat and Brown Rat, calculated from 1122 estates submitting bag records between 1960 and 1999 inclusive for one or more of the species, revealed a steady decline throughout the UK for Hedgehog, a decrease mostly in Wales and the southern half of England for Feral Cat, an increase in density across the UK for Fox and an expansion of range in northern Scotland and Wales for Brown Rat.

## 2 Introduction

Management measures for conservation or population control rely upon accurate records of a species' distribution and abundance. Monitoring refers to the collection of data on various aspects of a species' ecology or biology; the specific parameters subject to monitoring will depend on its objectives. Monitoring changes in the size of animal populations is an important yet difficult problem for wildlife biologists and managers. In order to manage a population successfully for its conservation it is necessary to have information about its status i.e. absolute abundance and distribution at any point in time and trends in abundance over time. Complete censuses of populations are not feasible for virtually any species of animal, since every individual would have to be detected and counted in order to get a precise figure. For most species, the expense of mark-recapture or mark re-sight estimation programs is prohibitive. The use of count data as indices of abundance and indicators of trends in abundance is therefore the only practical means of monitoring most animal populations, provided that the indices are related in a constant way to abundance over time.

Monitoring wildlife populations is also a legal requirement for a number of species. This is stated explicitly in Article 7 of the 1992 Convention on Biological Diversity, which requires contracting parties to '*monitor through sampling and other techniques the components of biological diversity, paying particular attention to those requiring urgent conservation measures and those offering the potential for sustainable use*'. As a signatory to the Convention, the UK published the UK Biodiversity Action Plan (BAP) in January 1995, incorporating separate Action Plans for priority species and habitats, recognizing the importance of the conservation of biological diversity and sustainable use of biological resources.

The National Gamebag Census (NGC) is of considerable interest to the statutory agencies charged by the government with monitoring the status of UK wildlife, particularly with respect to mammals that are difficult to monitor by other means. The Joint Nature Conservation Committee (JNCC) is responsible for assessing and reporting on the state of UK biodiversity on behalf of these agencies. In 2003, JNCC invited the Game & Wildlife Conservation Trust (GWCT) to join the Tracking Mammals Partnership, thereby giving official recognition of the importance of NGC records as a monitoring tool for wildlife management and conservation.

The resulting agreement seeks to improve data collection, collation and analysis of the NGC, which will make it an important part of the Tracking Mammals Partnership. The latter comprises 25 organisations and aims to detect changes in the abundance and distribution of terrestrial and freshwater mammals. Information collected by the Partnership will act as an early warning system for detecting changes in abundance for species of conservation interest and for pest or problem species.

The following items form part of the GWCT NGC work plan within the Tracking Mammals Partnership for 2008/2009:

1. Update annual bag index trends for all NGC mammals from 1961 to 2007 and from 1995 to 2007, for the UK, by country, by Environmental Zone and by Government Office Region, where there are sufficient data.
2. For all NGC mammals, tabulate percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.
3. Examine temporal changes, by decade from 1961 to 2000, in the UK geographical distribution of bags at vice-county level for Hedgehog, Red Fox, Feral Cat and Brown Rat.

### 3 The National Gamebag Census

The NGC was formally established by the GWCT in 1961, and is a voluntary scheme that currently collects bag statistics from over 650 shooting estates annually in England, Wales, Scotland and Northern Ireland. Through the inclusion of data from historical game books, series for several species extend back to the 19<sup>th</sup> century. The GWCT believes that the NGC approach, which targets the estate rather than individual shooters, is the best way of assessing bags on driven shoots. The NGC statistics also include bags from rough shooting carried out on the same estates, as well as numbers of predatory species culled as part of legal pest control.

At the end of the shooting season, each participant completes an annual bag survey form detailing the numbers of each species shot or culled, numbers of shoot days, estate area and, in the case of upland estates, moorland area. In many cases, additional data extracted from game books extend the time series back to at least the 19<sup>th</sup> century. Reminders are issued for non-returned forms and the return rate exceeds 90%.

When expressed as the numbers of animals shot per unit area, the data provide temporal and regional trends in bags on shooting estates (Tapper 1992; Aebischer & Baines 2008). Overall, the NGC collates data on the shooting bags of 24 huntable species and 19 predator species. Of these, 19 species are mammals, namely Rabbit *Oryctolagus cuniculus*, Brown Hare *Lepus europaeus*, Mountain Hare *Lepus timidus*, Roe Deer *Capreolus capreolus*, Red Deer *Cervus elaphus*, Fallow Deer *Dama dama*, Muntjac *Muntiacus reevesi*, Sika Deer *Cervus nippon*, Chinese Water Deer *Hydropotes inermis*, Wild Boar *Sus scrofa*, Hedgehog *Erinaceus europaeus*, Grey Squirrel *Sciurus carolinensis*, Fox *Vulpes vulpes*, Feral Cat *Felis catus*, Weasel *Mustela nivalis*, Stoat *Mustela erminea*, Polecat *Mustela putorius*, Mink *Mustela vison* and Brown Rat *Rattus norvegicus*. All series are ongoing, with 2007 the last season included here (throughout this report, the year denotes the year in which a shooting season starts, e.g. 2007 refers to the 2007/08 season).

#### 4 Temporal trends in bags for NGC mammals

One of the main purposes of the participation of the NGC in the Tracking Mammals Partnership is the provision of summary trends in annual bag statistics, where there are sufficient data, for all NGC mammals from 1961 to 2007 and from 1995 to 2007, for the UK, by country, by Environmental Zone and by Government Office Region (see Figure 1). The year 1961 corresponds to the formal start of the NGC. The year 1995 is when the British Trust for Ornithology (BTO) and many other members of the Tracking Mammals Partnership began their mammal monitoring schemes, so provides a standard period over which the results from several different schemes may be compared. In addition, a 25-year period is also a standard component in the UK Biodiversity Action Plan listing procedure (Anon. 1994, 1995), in the evaluation of avian conservation status (e.g. Gregory et al. 2002) and in other monitoring schemes such as the BTO's joint Common Birds Census / Breeding Bird Survey. The evaluation of percentage change over intervening periods helps to understand how each bag index series changes over time. Accordingly, we have produced and tabulated percentage changes (with 95% confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, for all NGC mammal species where there are sufficient data. The details of the statistical procedures are given below.

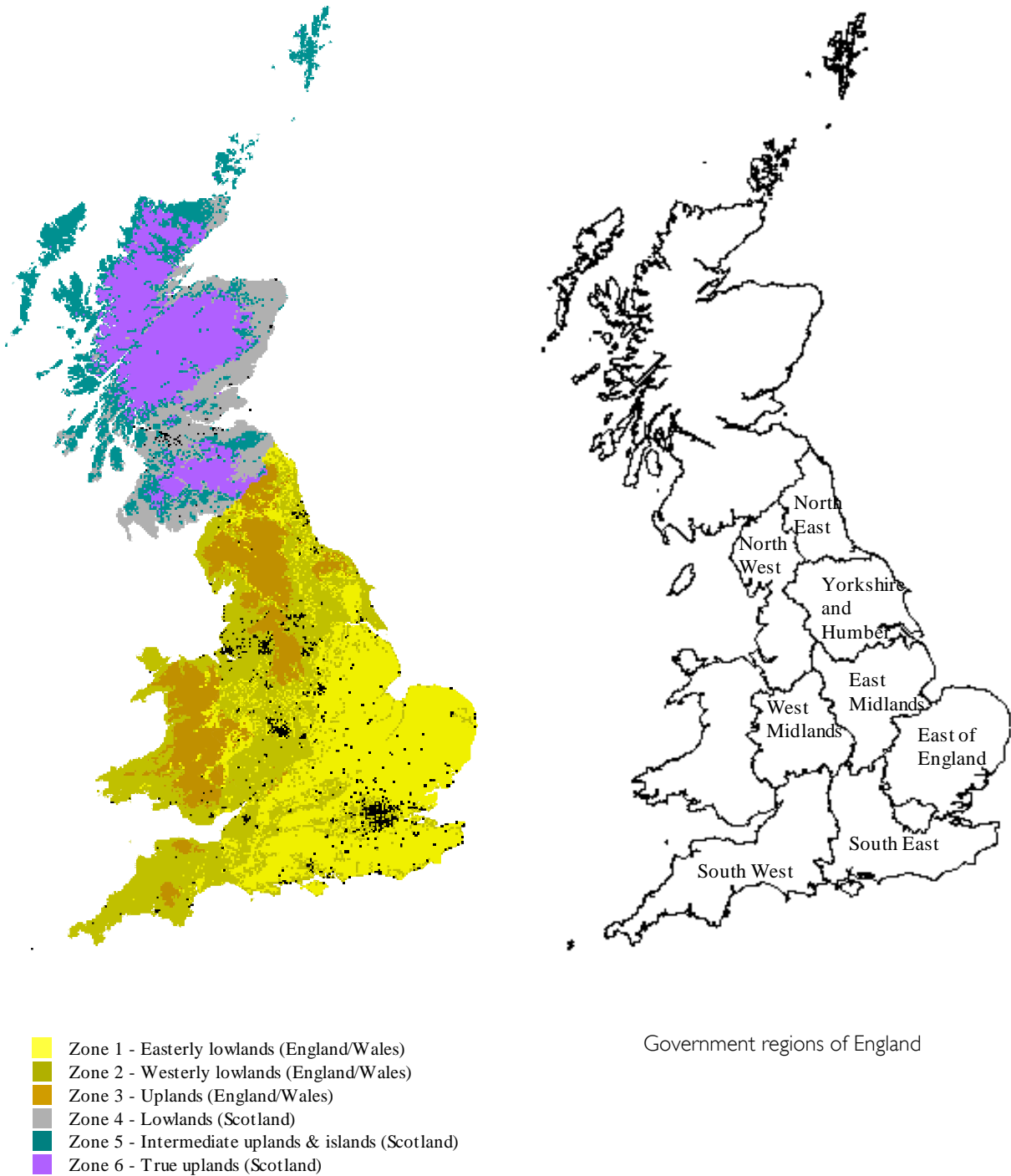
For each species, analysis was based on all annual shoot returns greater than zero. Shoots contributing only one year's data were omitted. Statistical analysis followed the approach adopted by Whitlock *et al.* (2003) and was carried out using Genstat (Lawes Agricultural Trust, Rothamsted). For each species, bag data were analysed using a generalised linear model (McCulloch & Nelder 1996) with a Poisson error distribution and logarithmic link function, with shoot and year as factors and the logarithm of shoot area as an offset variable. Data were analysed at the UK, country and environmental zone levels. For most species, the bag data spanned the period from 1961 to 2007, but for several species the start year had to be moved forward because of insufficient sites in early years (five contributing sites in any one year was a minimum requirement). The year coefficients were exponentiated to give an index of bag size on the arithmetic scale. All index values were relative to the start year, which had a value of 1. To obtain index values for the standard Tracking Mammals Partnership period of 1995-2007, the index values from the full analysis were recalibrated by dividing by the 1995 value. The 95% confidence intervals around the index values were obtained by bootstrapping at the shoot level: for each of 199 bootstrap runs, shoots equal in number to the original sample were selected at random with replacement and a new set of indices obtained as described above. For each year, the 95% confidence limits were taken as the lower and upper 95th percentiles of the distribution of all 200 index values.

To measure the percentage change between the first and last years of each time series, a generalized additive model (GAM, Hastie & Tibshirani 1990) was fitted to the bag indices with one degree of freedom per decade or part-decade then the percentage change calculated from the GAM fitted values for the first and last years. The 95% confidence limits were obtained by fitting GAMs to each bootstrap sample, calculating the percentage change, and selecting the lower and upper 95th percentiles of the 200 values that resulted. If the 95% confidence interval did not include zero, then the percentage change was declared significant at  $P < 0.05$  (indicated by \* to the right of the percentage change value in the tables that follow).

This procedure resulted in bag indices and confidence limits from the NGC data for the periods 1961 to 2007 and 1995 to 2007, together with estimates of change (and confidence limits of change) across 5-, 10-, 15-, 20-, 25- and 30-year periods ending in 2007. Bag indices were expressed relative to the start year, so the index value for the first year of each series is always one. Analyses were carried out for the UK as a whole, at country level (England, Scotland, Wales), by environmental zone and by government region (Figure 1). Analysis was carried out for all mammal species covered by the NGC except Chinese Water Deer and Wild Boar, for which there were insufficient data.

Post-1961 and post-1995 UK trends were graphed for all mammals in a similar format to that used within the BTO Research Report No. 428 dated February 2006.

Figure 1. Breakdown of the UK by environmental zone (left), and of England by government region (right).



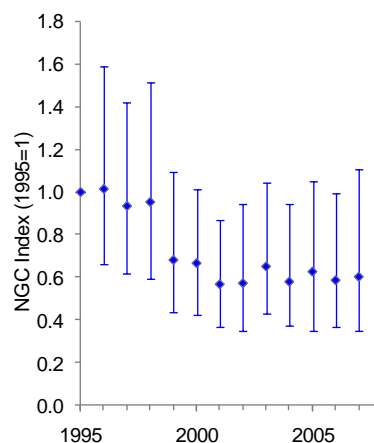
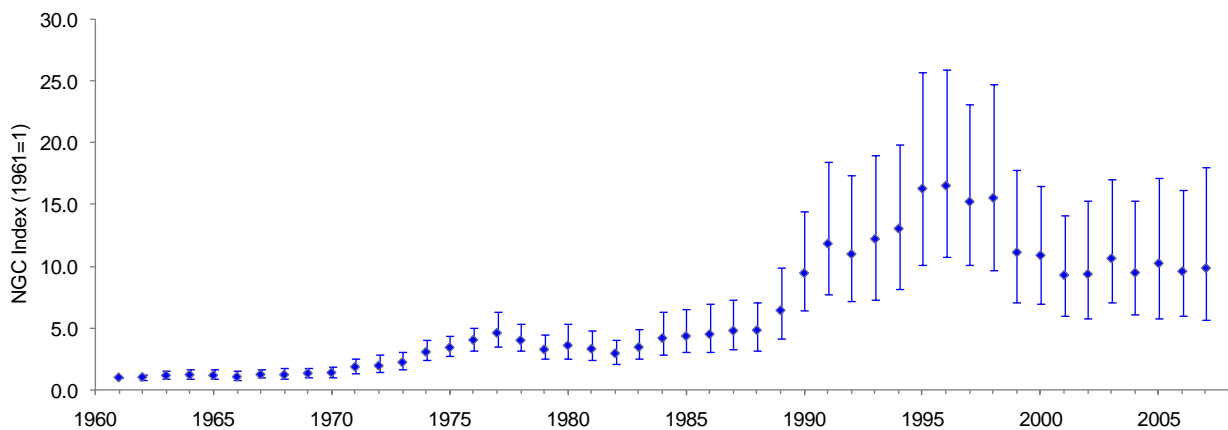
#### 4.1 Rabbit *Oryctolagus cuniculus*

**Summary:** A significant increase in the index of bag density across the UK between 1961 and 2007 (although still less than half pre-myxomatosis levels), rapidly so for a time between 1989 and 1995 and a decline thereafter, significantly so in Scotland, the West Midlands and the UK as a whole.

a) Sample size and % change of Rabbit bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1235	989*	526 to 1852	-29*	-50 to -4
COUNTRIES					
England	887	1166*	573 to 2226	24	-11 to 72
Wales	41	5092*	615 to 22559	-33	-66 to 47
Scotland	290	693*	378 to 1614	-79*	-87 to -68
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	520	1399*	695 to 3207	32	-18 to 96
2 - Westerly lowlands (England/Wales)	191	399*	161 to 1192	-36*	-57 to -5
3 - Uplands (England/Wales)	107	2546*	452 to 14559	26	-19 to 116
4 - Lowlands (Scotland)	98	868*	131 to 3472	-76*	-91 to -38
5 - Intermediate uplands/islands (Scotland)	48	182	-3470 to 6494	-98*	-105 to -51
6 - True uplands (Scotland)	144	781*	382 to 2727	-76*	-85 to -64
GOVERNMENT REGIONS					
South West	152	346	-16 to 3398	-55	-82 to 14
South East	172	789*	368 to 1710	-17	-37 to 26
East of England	195	1924*	404 to 17127	66	-17 to 209
East Midlands	98	1250*	249 to 6356	128	-11 to 293
West Midlands	83	680*	301 to 1951	-48*	-66 to -28
North West	47	565	-20931 to 21133	0	-61 to 82
Yorkshire and Humber	107	1863*	672 to 5205	25	-27 to 162
North East	33	1248	-89 to 28161	-31	-94 to 160

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.





#### 4.1 Rabbit *Oryctolagus cuniculus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1235	-19*	-34 to -3	-31*	-50 to -8
COUNTRIES					
England	887	12	-4 to 27	19	-11 to 60
Wales	41	-24	-51 to 13	-33	-63 to 31
Scotland	290	-68*	-78 to -57	-79*	-87 to -68

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1235	-17	-42 to 12	43*	2 to 101
COUNTRIES					
England	887	42	-2 to 102	119*	44 to 237
Wales	41	-28	-69 to 98	16	-61 to 296
Scotland	290	-75*	-85 to -62	-51*	-70 to -25

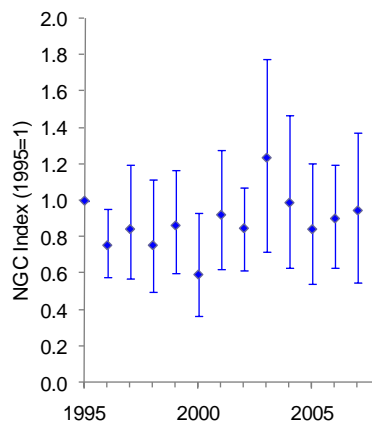
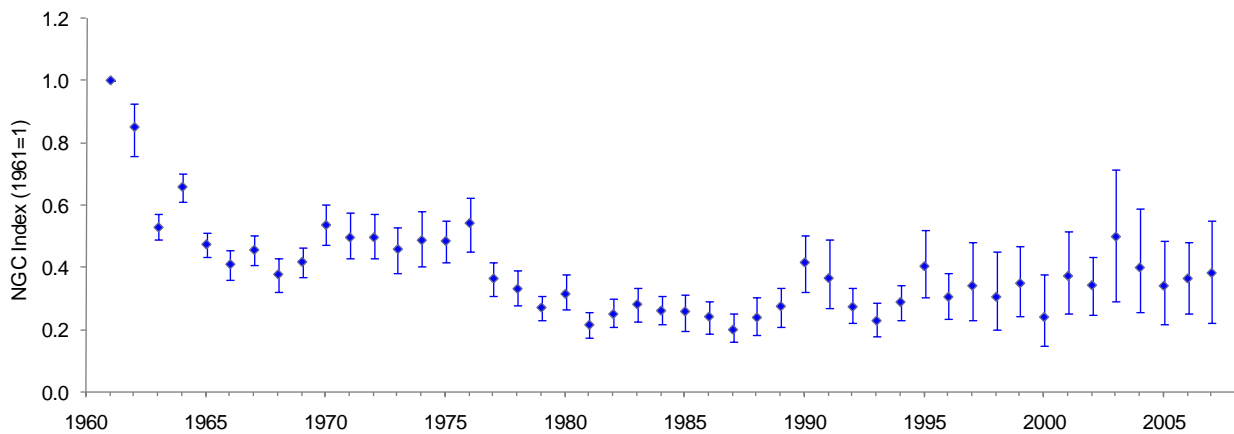
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1235	140*	64 to 249	194*	85 to 364
COUNTRIES					
England	887	228*	106 to 442	273*	117 to 586
Wales	41	188	-26 to 753	1314*	94 to 3734
Scotland	290	-1	-40 to 49	43	-14 to 150

## 4.2 Brown Hare *Lepus europaeus*

**Summary:** A significant decline in the index of bag density between 1961 and 2007. The trend has reversed since the 1980s in the UK (significant increase of 47% since 1987) and England, but persists downwards in Wales. There has been a significant regional increase in the West Midlands and in Yorkshire and Humber between 1995 and 2007, but also a decline in south-east England.

a) Sample size and % change of Brown Hare bags.	1961-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	1128	-51*	-70 to -33	23	-9 to 54
COUNTRIES					
England	858	-46*	-63 to -21	28	-2 to 59
Wales	34	-98*	-99 to -96	-78*	-92 to -72
Scotland	226	-83*	-90 to -71	-17	-47 to 19
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	518	-46*	-67 to -21	26	-6 to 57
2 - Westerly lowlands (England/Wales)	166	-66*	-88 to -33	21	-43 to 146
3 - Uplands (England/Wales)	87	-47	-81 to 57	128	-8 to 526
4 - Lowlands (Scotland)	91	-87*	-94 to -70	-20	-52 to 22
5 - Intermediate uplands/islands (Scotland)	30	-46	-100 to 57	127	-99 to 454
6 - True uplands (Scotland)	105	-83*	-94 to -62	-27	-69 to 32
GOVERNMENT REGIONS					
South West	132	-53	-87 to 16	36	-29 to 169
South East	168	-65*	-81 to -39	-44*	-71 to -6
East of England	195	-43*	-72 to -3	35	-12 to 83
East Midlands	105	-55*	-72 to -38	42	-5 to 116
West Midlands	80	-24	-63 to 41	396*	28 to 1718
North West	43	-78	-94 to 1	-13	-77 to 323
Yorkshire and Humber	105	-14	-66 to 32	84*	1 to 199
North East	30	39	-83 to 377	185	-65 to 1472

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.2 Brown Hare *Lepus europaeus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1128	7	-7 to 17	19	-9 to 44
COUNTRIES					
England	858	9	-2 to 19	23	-1 to 47
Wales	34			-76*	-88 to -70
Scotland	226	-12	-31 to 14	-17	-44 to 17

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1128	31	-7 to 70	47*	1 to 95
COUNTRIES					
England	858	36*	1 to 80	53*	8 to 109
Wales	34	-80*	-95 to -72	-84*	-97 to -75
Scotland	226	-16	-47 to 22	-15	-42 to 26

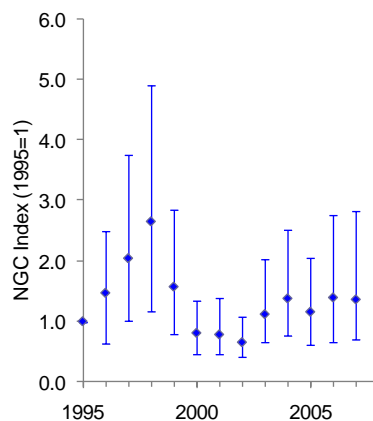
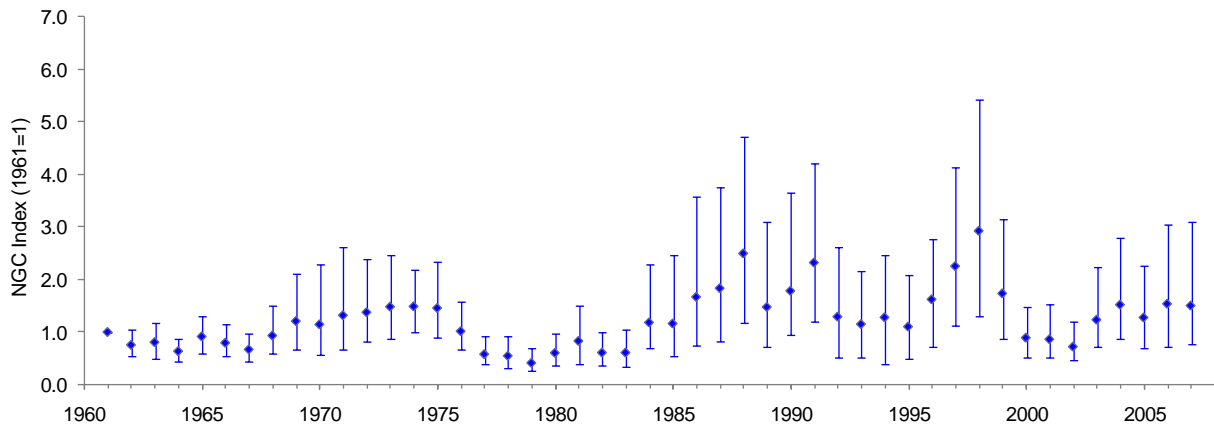
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1128	37	-11 to 87	4	-40 to 49
COUNTRIES					
England	858	50*	3 to 115	21	-23 to 80
Wales	34	-92*	-97 to -87	-96*	-98 to -93
Scotland	226	-46*	-65 to -19	-70*	-81 to -53

### 4.3 Mountain Hare *Lepus timidus*

**Summary:** A cyclic trend in the index of bag density in the UK between 1961 and 2007, with increases from 1967 to 1974, 1983 to 1988, 1995 to 1998, and 2002 to 2007 alternating with poor seasons. There were no significant overall long-term trends, but the bag index approximately doubled between 1995 and 2007 in the lowlands of Scotland.

a) Sample size and % change of Mountain Hare bags.	1961-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	186	70	-26 to 316	-20	-63 to 63
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	186	70	-26 to 316	-20	-63 to 63
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	Too few				
2 - Westerly lowlands (England/Wales)	Too few				
3 - Uplands (England/Wales)	Too few				
4 - Lowlands (Scotland)	29	30	-79 to 699	115*	4 to 275
5 - Intermediate uplands/islands (Scotland)	23	-43	-88 to 636	-23	-46 to 91
6 - True uplands (Scotland)	134	85	-27 to 347	-27	-69 to 74
GOVERNMENT REGIONS					
South West	Too few				
South East	Too few				
East of England	Too few				
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

- b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



### 4.3 Mountain Hare *Lepus timidus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	193	-4	-41 to 42	-18	-59 to 61
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	186	-4	-48 to 43	-18	-61 to 58

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	193	-21	-64 to 69	-11	-59 to 69
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	186	-21	-66 to 66	-10	-60 to 86

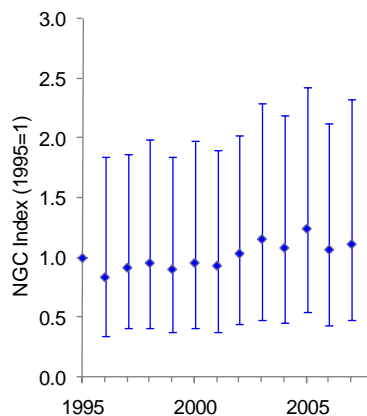
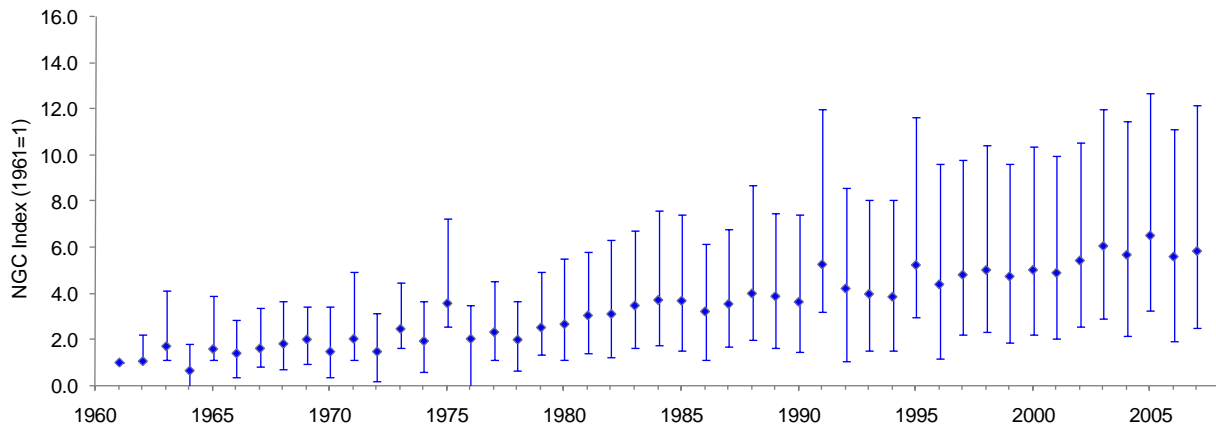
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	193	34	-32 to 140	42	-27 to 142
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	186	35	-35 to 159	43	-34 to 155

#### 4.4 Roe Deer *Capreolus Capreolus*

**Summary:** A significant and sustained increase in the index of bag density between 1961 and 2007 in England and Scotland. Regionally, increases in the bag index continue to be significant since 1995 in all but the uplands of Scotland. In Wales, one site reported Roe Deer in 1993, 1997, 2004, 2005. A second site joined it in 2007; both are close to the border with England.

a) Sample size and % change of Roe Deer bags.	1961-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	483	488*	231 to 873	33*	17 to 55
COUNTRIES					
England	75-07 232	328*	230 to 582	51*	30 to 82
Wales	Too few				
Scotland	245	360*	160 to 755	24	-1 to 48
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	77-07 146	328*	160 to 900	47*	22 to 82
2 - Westerly lowlands (England/Wales)	77-07 52	203*	80 to 636	27*	2 to 87
3 - Uplands (England/Wales)	95-07 34			187*	63 to 292
4 - Lowlands (Scotland)	77-07 64	91*	27 to 253	30*	0 to 83
5 - Intermediate uplands/islands (Scotland)	77-07 33	96*	5 to 285	-11	-41 to 36
6 - True uplands (Scotland)	77-07 144	205*	18 to 578	23	-7 to 66
GOVERNMENT REGIONS					
South West	77-07 59	175*	49 to 665	5	-10 to 39
South East	77-07 63	837*	371 to 1828	81*	27 to 160
East of England	77-07 37	343	-3597 to 4127	53*	23 to 106
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	84-07 34	618*	183 to 1505	106*	20 to 203
North East	95-07 13			164*	12 to 336

- b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.4 Roe Deer *Capreolus Capreolus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	483	11*	6 to 18	27*	14 to 43
COUNTRIES					
England	234	22*	12 to 30	44*	26 to 66
Wales	Too few				
Scotland	245	7	-3 to 15	19	-1 to 39

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	483	42*	21 to 67	63*	42 to 93
COUNTRIES					
England	234	64*	35 to 99	98*	60 to 144
Wales	Too few				
Scotland	245	32*	3 to 61	49*	19 to 85

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	483	96*	64 to 132	144*	85 to 205
COUNTRIES					
England	234	147*	89 to 231	252*	153 to 363
Wales	Too few				
Scotland	245	71*	33 to 121	93*	38 to 170

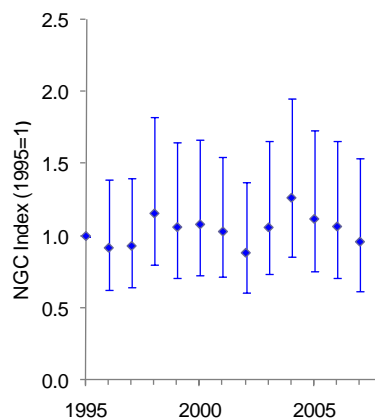
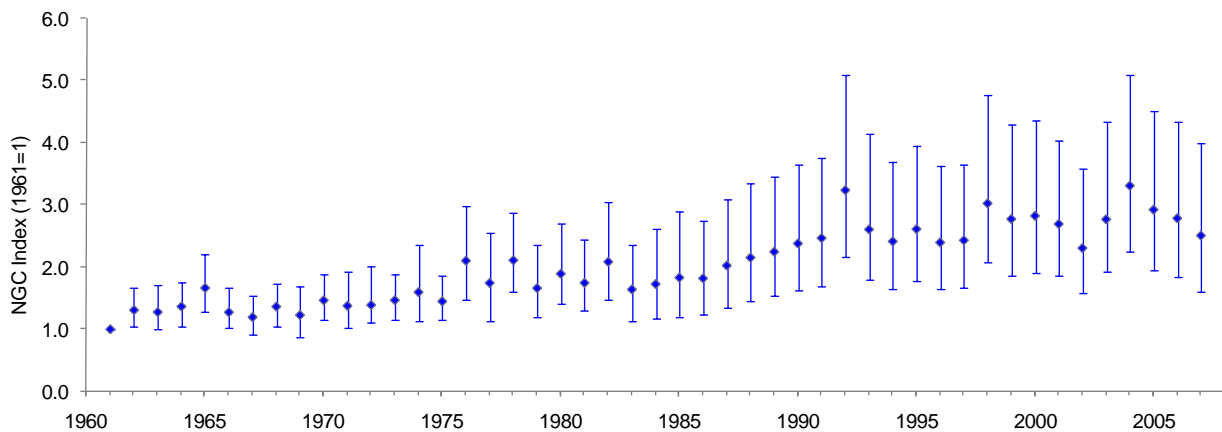
#### 4.5 Red Deer *Cervus elaphus*

**Summary:** A significant increase in the index of bag density across the UK between 1961 and 2007 with stabilisation between 1995 and 2007. The majority of sites reporting Red Deer are from Scotland and there is evidence of a small decline since 1995 in the intermediate uplands/islands. No sites in England reported Red Deer during the 1960s, although two sites reported the animal during the 1970s.

a) Sample size and % change of Red Deer bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	227	133*	58 to 271	6	-5 to 19
COUNTRIES					
England	83-07 32	160*	77 to 1221	10	-28 to 206
Wales	Too few				
Scotland	191	132*	53 to 266	6	-6 to 21
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	95-07 20			-7	-44 to 245
2 - Westerly lowlands (England/Wales)	Too few				
3 - Uplands (England/Wales)	Too few				
4 - Lowlands (Scotland)	17	368*	121 to 5043	-14	-42 to 43
5 - Intermediate uplands/islands (Scotland)	31	14	-68 to 273	-20*	-44 to -1
6 - True uplands (Scotland)	143	105*	27 to 231	12	-4 to 25
GOVERNMENT REGIONS					
South West	Too few				
South East	Too few				
East of England	95-07 17			127	-55 to 379
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.





#### 4.5 Red Deer *Cervus elaphus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	227	0	-4 to 5	4	-5 to 15
COUNTRIES					
England	32	-2	-24 to 53	14	-25 to 160
Wales	Too few				
Scotland	191	0	-5 to 6	4	-7 to 16

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	227	12	-2 to 26	32*	19 to 47
COUNTRIES					
England	32	19	-21 to 297	73*	28 to 468
Wales	Too few				
Scotland	191	12	-3 to 29	31*	12 to 52

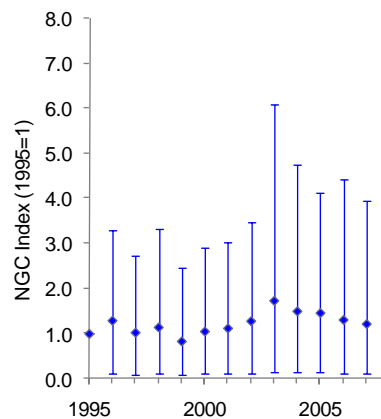
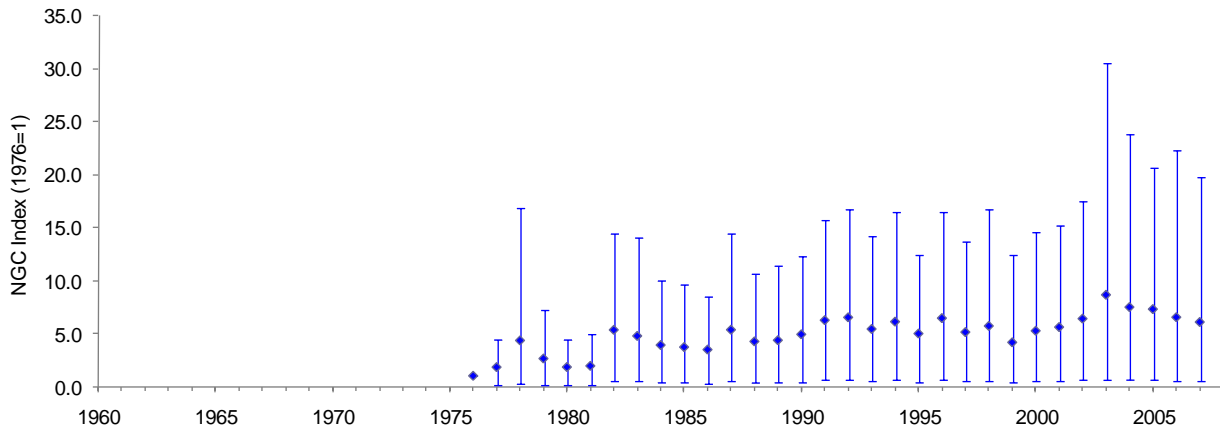
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	227	50*	31 to 74	62*	35 to 96
COUNTRIES					
England	32				
Wales	Too few				
Scotland	191	49*	19 to 77	60*	28 to 97

#### 4.6 Fallow Deer *Dama dama*

**Summary:** An increase in the index of bag density in the UK between 1976 and 2007, significantly so in south-west England and Scotland, and in south-east England between 1995 and 2007. Just seven sites in Scotland reported Fallow Deer between 1961 and 1975.

	Sites	1976-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	122	312	-7 to 788	22	-11 to 95
COUNTRIES					
England	76-07 100	110	-30 to 408	28	-11 to 129
Wales	Too few				
Scotland	76-07 17	508*	237 to 1690	-11	-39 to 367
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	76-07 85	109	-41 to 455	31	-9 to 141
2 - Westerly lowlands (England/Wales)	95-07 13			-16	-60 to 71
3 - Uplands (England/Wales)	Too few				
4 - Lowlands (Scotland)	Too few				
5 - Intermediate uplands/islands (Scotland)	Too few				
6 - True uplands (Scotland)	Too few				
GOVERNMENT REGIONS					
South West	84-07 19	63*	31 to 148	28	-15 to 61
South East	76-07 35	-2	-50 to 169	103*	8 to 231
East of England	84-07 26	35	-33 to 3406	3	-48 to 313
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

b) Change in relative bag density in the UK from 1976 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.6 Fallow Deer *Dama dama*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	122	6	-14 to 45	23	-9 to 90
COUNTRIES					
England	100	17	-11 to 68	36	-4 to 127
Wales	Too few				
Scotland	17	-38	-54 to 24	-31	-66 to 127

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	122	23	-12 to 112	50*	5 to 195
COUNTRIES					
England	100	19	-17 to 127	39	-5 to 185
Wales	Too few				
Scotland	17	23	-41 to 309	63	-33 to 609

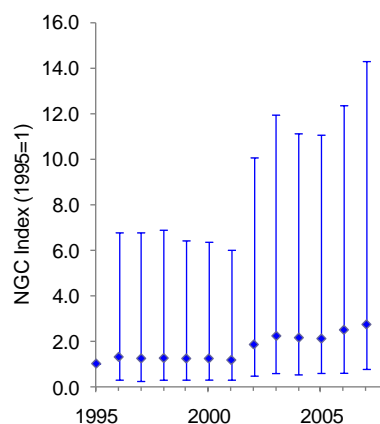
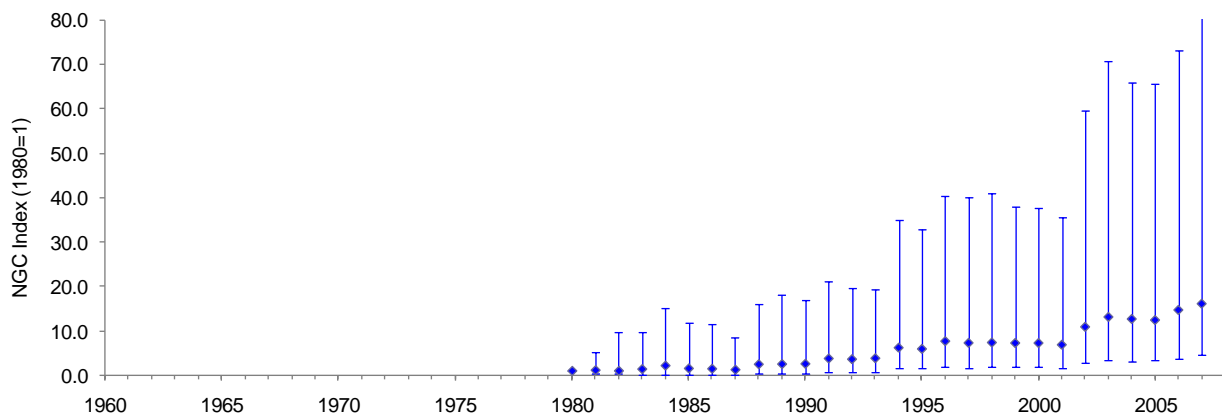
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	122	90*	17 to 308	234*	4 to 598
COUNTRIES					
England	100	71*	5 to 285	105	-17 to 345
Wales	Too few				
Scotland	17	168	-53 to 643		

#### 4.7 Muntjac *Muntiacus reevesi*

**Summary:** A rapid increase in the index of bag density between 1980 and 2007 in England, with average gains of 12% per annum across the period. The increase continued at a similar rate between 1995 and 2007. No muntjac was reported from Scotland or Wales. Regionally, the majority of muntjac reports were from the easterly lowlands of England.

a) Sample size and % change of Muntjac bags.			1980-2007		1995-2007	
	Sites		Change	95% CI	Change	95% CI
UNITED KINGDOM	80-07	120	1483*	256 to 4369	167*	109 to 282
COUNTRIES						
England	80-07	120	1483*	256 to 4369	167*	109 to 282
Wales		Too few				
Scotland		Too few				
ENVIRONMENTAL ZONES						
1 - Easterly lowlands (England/Wales)	80-07	109	1487*	315 to 3882	166*	111 to 279
2 - Westerly lowlands (England/Wales)		Too few				
3 - Uplands (England/Wales)		Too few				
4 - Lowlands (Scotland)		Too few				
5 - Intermediate uplands/islands (Scotland)		Too few				
6 - True uplands (Scotland)		Too few				
GOVERNMENT REGIONS						
South West		Too few				
South East	95-07	31			163*	79 to 286
East of England	84-07	57	884*	326 to 9741	158*	91 to 302
East Midlands	95-07	16			394*	136 to 628
West Midlands		Too few				
North West		Too few				
Yorkshire and Humber		Too few				
North East		Too few				

- b) Change in relative bag density in the UK from 1980 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.7 Muntjac *Muntiacus reevesi*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	120	55*	29 to 91	130*	83 to 216
COUNTRIES					
England	120	55*	29 to 91	130*	83 to 216
Wales	Too few				
Scotland	Too few				

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	120	290*	190 to 481	732*	359 to 2435
COUNTRIES					
England	120	290*	190 to 481	732*	359 to 2435
Wales	Too few				
Scotland	Too few				

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	120	1183*	303 to 2926		
COUNTRIES					
England	120	1183*	303 to 2926		
Wales	Too few				
Scotland	Too few				

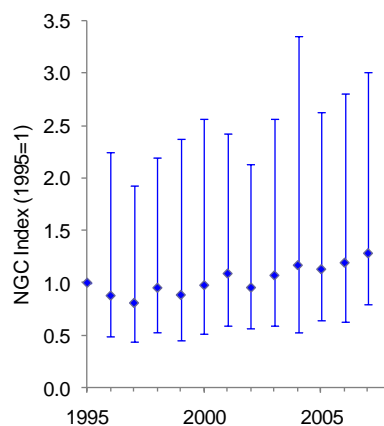
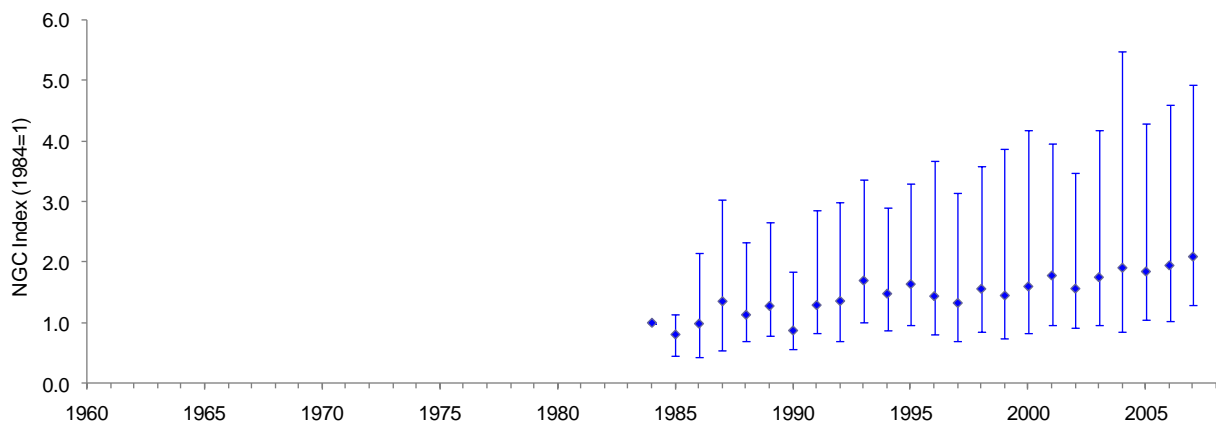
#### 4.8 Sika Deer *Cervus Nippon*

**Summary:** A significant increase in the index of bag density in the UK began in 1984, and is maintained in 1995-2007. Regionally, populations are disjunct and are restricted to the easterly lowlands of England and the true uplands of Scotland. Two sites reported Sika Deer in Scotland between 1961 and 1983, and no sites in England reported the animal between 1961 and 1975.

a) Sample size and % change of Sika Deer bags.

	Sites		1984-2007		1995-2007	
	84-07	53	Change	95% CI	Change	95% CI
UNITED KINGDOM	84-07	53	122*	41 to 424	36*	16 to 79
COUNTRIES						
England	95-07	12			8	-31 to 2301
Wales		Too few				
Scotland	84-07	38	390*	105 to 840	88*	33 to 177
ENVIRONMENTAL ZONES						
1 - Easterly lowlands (England/Wales)	84-07	9	20	-6 to 52	-6	-22 to 15
2 - Westerly lowlands (England/Wales)		Too few				
3 - Uplands (England/Wales)		Too few				
4 - Lowlands (Scotland)		Too few				
5 - Intermediate uplands/islands (Scotland)		Too few				
6 - True uplands (Scotland)	95-06	27			71*	27 to 115
GOVERNMENT REGIONS						
South West		Too few				
South East		Too few				
East of England		Too few				
East Midlands		Too few				
West Midlands		Too few				
North West		Too few				
Yorkshire and Humber		Too few				
North East		Too few				

b) Change in relative bag density in the UK from 1984 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.8 Sika Deer *Cervus nippon*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	53	21	-6 to 54	37*	14 to 72
COUNTRIES					
England	12	-24	-46 to 624	45*	6 to 1079
Wales	Too few				
Scotland	38	36	-13 to 95	59*	7 to 159

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	53	48*	21 to 129	86*	50 to 355
COUNTRIES					
England	12				
Wales	Too few				
Scotland	38	144*	48 to 261	327*	102 to 544

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	53				
COUNTRIES					
England	12				
Wales	Too few				
Scotland	38				

#### 4.9 Chinese Water Deer *Hydropotes inermis*

**Summary:** Just eleven sites reported Chinese Water Deer between 1990 and 2007, and all of these were from the easterly lowlands in England

a) Sample size and % change of Water Deer bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	Too few				
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	Too few				
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	Too few				
2 - Westerly lowlands (England/Wales)	Too few				
3 - Uplands (England/Wales)	Too few				
4 - Lowlands (Scotland)	Too few				
5 - Intermediate uplands/islands (Scotland)	Too few				
6 - True uplands (Scotland)	Too few				
GOVERNMENT REGIONS					
South West	Too few				
South East	Too few				
East of England	Too few				
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

b) Graphs suppressed owing to lack of data.

c) Tables suppressed owing to lack of data.



#### 4.10 Wild Boar *Sus scrofa*

**Summary:** Just five sites reported Wild Boar since 2000. Four of these were from the English lowlands and one from Aberdeenshire.

a) Sample size and % change of Wild Boar bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	Too few				
COUNTRIES					
England	Too few				
Wales	Too few				
Scotland	Too few				
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	Too few				
2 - Westerly lowlands (England/Wales)	Too few				
3 - Uplands (England/Wales)	Too few				
4 - Lowlands (Scotland)	Too few				
5 - Intermediate uplands/islands (Scotland)	Too few				
6 - True uplands (Scotland)	Too few				
GOVERNMENT REGIONS					
South West	Too few				
South East	Too few				
East of England	Too few				
East Midlands	Too few				
West Midlands	Too few				
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

b) Graphs suppressed owing to lack of data.

c) Tables suppressed owing to lack of data.

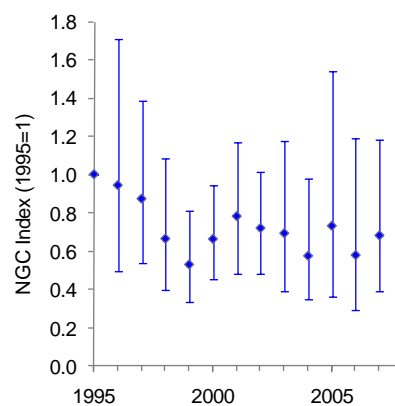
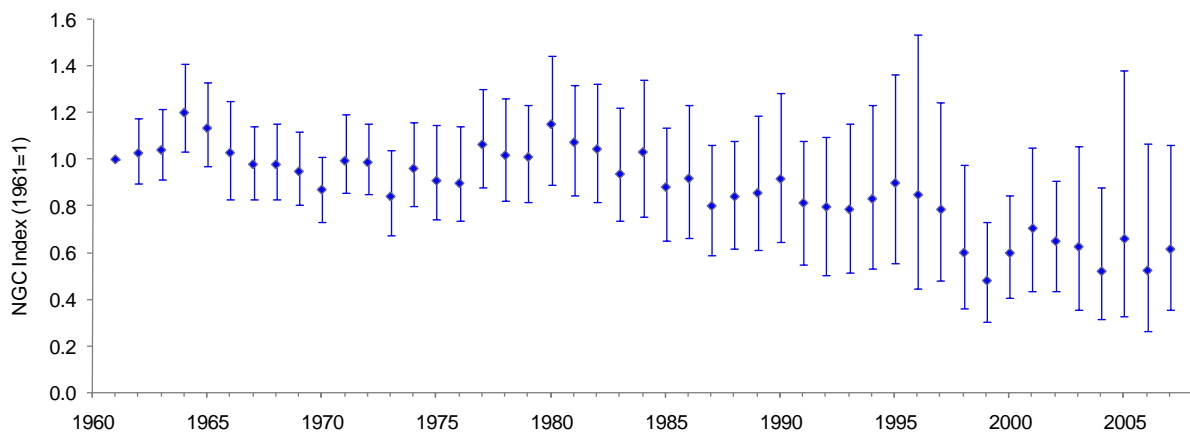
#### 4.11 Hedgehog *Erinaceus europaeus*

**Summary:** A significant decline in the index of bag density between 1961 and 2007 in Wales and generally across the UK. In particular the uplands and westerly lowlands of England and Wales and southern England show a significant decrease in bag index over this period. In southern England, no sites returned Hedgehog records in 2007.

a) Sample size and % change of Hedgehog bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	687	-48*	-72 to -4	-28	-54 to 2
COUNTRIES					
England	540	-49	-79 to 11	-23	-55 to 29
Wales	19	-80*	-88 to -72	-59*	-64 to -54
Scotland	126	-11	-55 to 69	-33	-54 to 0
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	327	-42	-77 to 23	-17	-56 to 42
2 - Westerly lowlands (England/Wales)	96	-68*	-85 to -10	120	-17 to 439
3 - Uplands (England/Wales)	59	-75	-88 to 21	-61*	-84 to -5
4 - Lowlands (Scotland)	47	-35	-80 to 60	-63	-86 to 16
5 - Intermediate uplands/islands (Scotland)	21	-34	-49 to 151	-42	-53 to 49
6 - True uplands (Scotland)	58	-7	-58 to 278	32	-26 to 100
GOVERNMENT REGIONS					
South West	61-06 70	-92*	-96 to -71	12	-20 to 312
South East	61-06 101	-88*	-95 to -78	-59*	-78 to -23
East of England	135	-25	-74 to 69	-9	-52 to 55
East Midlands	58	-38	-80 to 6	-53	-79 to 18
West Midlands	54	-87*	-94 to -78	-19	-32 to 22
North West	26	-98*	-100 to -67	-89	-100 to 73
Yorkshire and Humber	71	-83*	-91 to -10	-33*	-57 to -2
North East	20	-65	-93 to 50	-31	-65 to 387

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.11 Hedgehog *Erinaceus europaeus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	687	-10	-33 to 7	-23	-50 to 4
COUNTRIES					
England	540	-7	-33 to 24	-18	-50 to 31
Wales	19	-34*	-41 to -27	-51*	-57 to -45
Scotland	126	-16	-32 to 6	-28	-49 to 8

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	687	-32	-59 to 0	-39*	-64 to -1
COUNTRIES					
England	540	-27	-60 to 27	-36	-70 to 29
Wales	19	-67*	-71 to -63	-70*	-74 to -62
Scotland	126	-38*	-57 to -1	-37*	-54 to -1

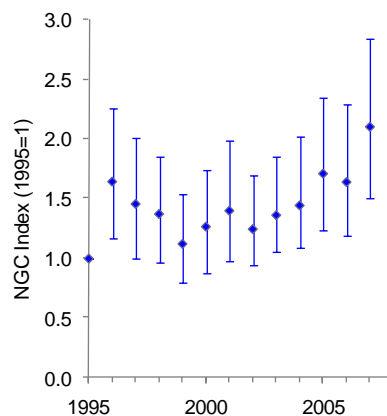
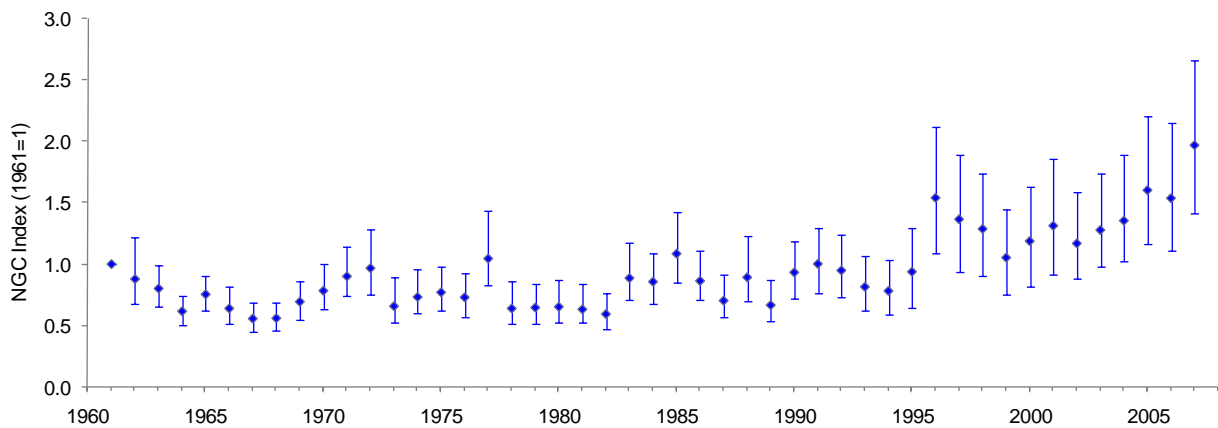
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	687	-44*	-69 to -1	-44	-69 to 3
COUNTRIES					
England	540	-43	-75 to 20	-44	-74 to 19
Wales	19	-62*	-69 to -54	-50*	-68 to -42
Scotland	126	-35	-57 to 14	-27	-56 to 28

#### 4.12 Grey Squirrel *Sciurus carolinensis*

**Summary:** A significant increase in the index of bag density across the UK between 1961 and 2007, with a noticeable step-up in the index post-1995. Regionally, the bag index has increased significantly across all parts of the UK between 1995 and 2007 except in the true uplands of Scotland. Between 1961 and 1976, there were just nine reports of Grey Squirrel bags from six sites in Scotland.

a) Sample size and % change of Grey Squirrel bags.	1961-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	835	101*	46 to 164	61*	40 to 85
COUNTRIES					
England	711	101*	50 to 173	59*	40 to 82
Wales	33	27	-51 to 329	88*	23 to 160
Scotland	77-07 82	310*	22 to 872	98*	52 to 162
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	414	103*	42 to 206	59*	40 to 87
2 - Westerly lowlands (England/Wales)	168	105*	25 to 205	54*	18 to 105
3 - Uplands (England/Wales)	86	65	-54 to 420	86*	50 to 128
4 - Lowlands (Scotland)	77-07 36	299*	54 to 1034	125*	67 to 241
5 - Intermediate uplands/islands (Scotland)	95-07 17			69*	5 to 110
6 - True uplands (Scotland)	84-07 28	281*	46 to 588	93	-1 to 197
GOVERNMENT REGIONS					
South West	140	99*	5 to 237	73*	28 to 139
South East	138	-20	-45 to 14	32*	8 to 82
East of England	147	382*	178 to 658	57*	19 to 85
East Midlands	77	229*	103 to 471	95*	33 to 187
West Midlands	73	101*	17 to 219	95*	26 to 185
North West	84-07 22	128*	6 to 834	64*	3 to 182
Yorkshire and Humber	88	304*	176 to 826	81*	51 to 117
North East	95-07 15			214*	78 to 529

- b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.12 Grey Squirrel *Sciurus carolinensis*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	835	25*	18 to 35	49*	33 to 69
COUNTRIES					
England	711	25*	16 to 35	48*	32 to 70
Wales	33	34*	11 to 53	78*	21 to 141
Scotland	82	71*	29 to 109	79*	30 to 122

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	835	80*	49 to 105	103*	64 to 153
COUNTRIES					
England	711	78*	51 to 109	102*	60 to 152
Wales	33	89	-4 to 170	72	-30 to 170
Scotland	82	148*	91 to 252	223*	150 to 350

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	835	122*	72 to 181	127*	63 to 197
COUNTRIES					
England	711	121*	71 to 190	126*	70 to 209
Wales	33	62	-39 to 185	53	-56 to 229
Scotland	82	191*	114 to 369	310*	22 to 872

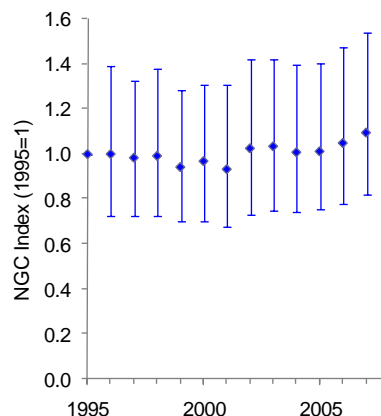
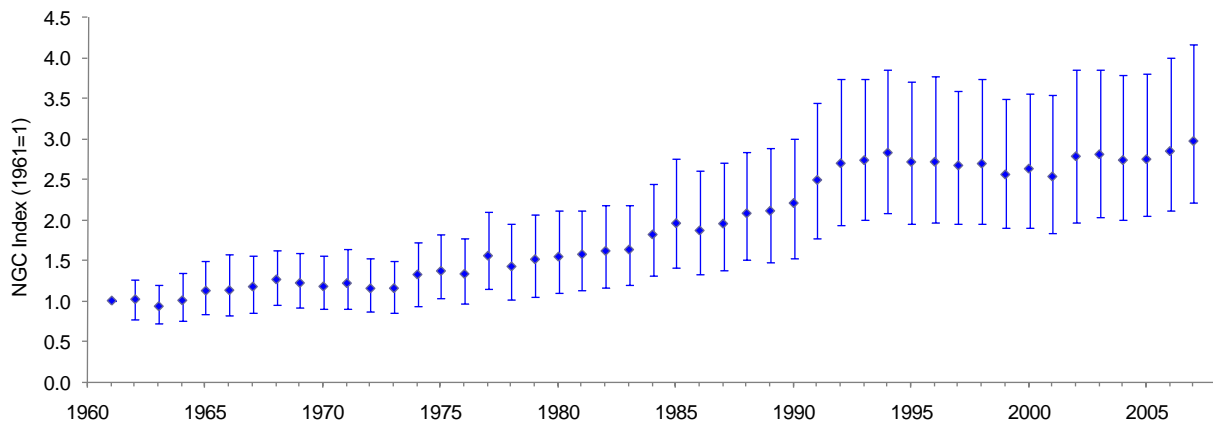
### 4.13 Fox *Vulpes Vulpes*

**Summary:** A significant increase in the index of bag density across the UK between 1961 and 1994, particularly in England and Scotland, continuing in England during the period 1995 to 2007. Regionally, increases continue to be significant over the last twelve years across the lowlands of England and Wales.

a) Sample size and % change of Fox bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1012	193*	127 to 287	8*	2 to 17
COUNTRIES					
England	678	238*	145 to 362	18*	9 to 31
Wales	34	16	-44 to 188	23	-14 to 67
Scotland	282	162*	56 to 287	-9	-24 to 9
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	406	373*	198 to 644	17*	3 to 37
2 - Westerly lowlands (England/Wales)	165	92	-4 to 218	40*	19 to 64
3 - Uplands (England/Wales)	111	81*	34 to 440	5	-9 to 23
4 - Lowlands (Scotland)	79	251*	8 to 491	3	-20 to 29
5 - Intermediate uplands/islands (Scotland)	46	4	-53 to 122	-9	-48 to 26
6 - True uplands (Scotland)	156	150*	46 to 301	-14	-33 to 13
GOVERNMENT REGIONS					
South West	121	108*	15 to 262	19	-12 to 55
South East	124	234*	109 to 535	17	-2 to 38
East of England	151	991*	334 to 1868	33*	3 to 73
East Midlands	66	134	-4 to 305	6	-17 to 37
West Midlands	57	278*	4 to 874	10	-13 to 52
North West	44	119*	74 to 351	31	-1 to 82
Yorkshire and Humber	82	-13	-26 to 13	7	-10 to 27
North East	31	265*	68 to 879	0	-18 to 31

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.13 Fox *Vulpes Vulpes*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1012	4*	0 to 9	6*	0 to 14
COUNTRIES					
England	678	7*	2 to 13	14*	6 to 25
Wales	34	12	-12 to 36	20	-14 to 64
Scotland	282	-3	-12 to 6	-8	-22 to 9

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1012	15*	7 to 25	39*	27 to 53
COUNTRIES					
England	678	29*	17 to 44	62*	44 to 85
Wales	34	32	-10 to 79	53*	1 to 109
Scotland	282	-8	-24 to 13	6	-14 to 28

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1012	71*	55 to 91	103*	79 to 129
COUNTRIES					
England	678	100*	76 to 130	129*	94 to 169
Wales	34	57	-4 to 122	36	-34 to 101
Scotland	282	31*	5 to 60	68*	31 to 113

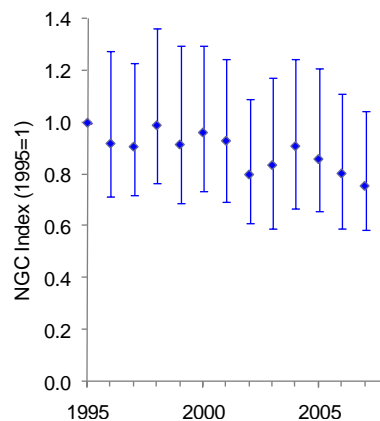
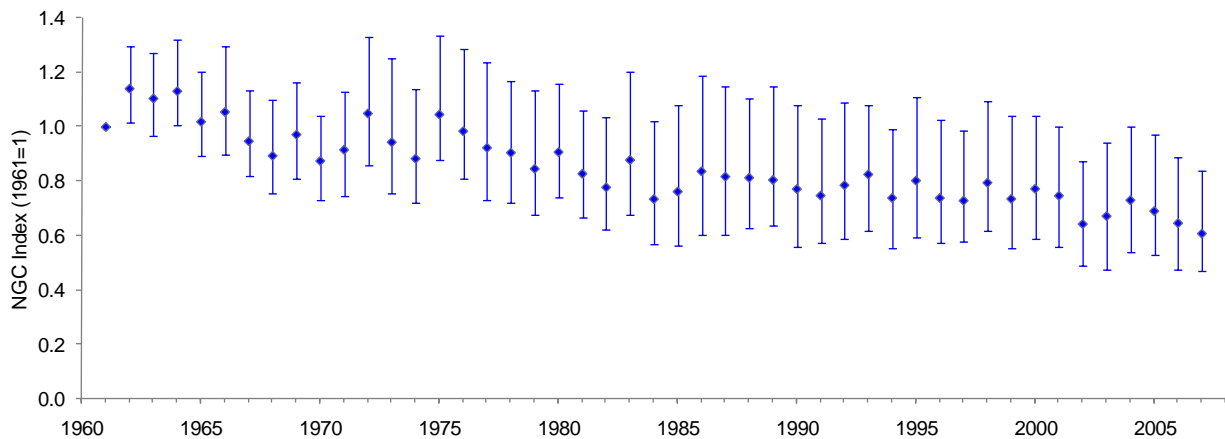
#### 4.14 Feral Cat *Felis catus*

**Summary:** A significant decrease in the index of bag density across the UK between 1961 and 2007. Regionally, the decrease has been significant in eastern England and in the Scottish true uplands. Since 1995 in the West Midlands, a significant increase has become apparent.

a) Sample size and % change of Feral Cat bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	756	-42*	-55 to -22	-17*	-29 to -4
COUNTRIES					
England	528	-41*	-55 to -15	-10	-27 to 6
Wales	24	-65	-101 to 49	6	-102 to 186
Scotland	191	-47	-69 to 5	-23*	-38 to -1
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	301	-55*	-67 to -35	-25	-44 to 5
2 - Westerly lowlands (England/Wales)	112	-32	-67 to 32	22	-18 to 59
3 - Uplands (England/Wales)	84	-41	-72 to 85	-6	-23 to 18
4 - Lowlands (Scotland)	57	-35	-59 to 25	-23	-47 to 33
5 - Intermediate uplands/islands (Scotland)	29	-68	-79 to 38	-5	-20 to 122
6 - True uplands (Scotland)	105	-63*	-81 to -50	-25	-51 to 0
GOVERNMENT REGIONS					
South West	80	-70	-95 to 68	-76	-91 to 22
South East	87	-61*	-76 to -30	-26	-58 to 19
East of England	121	-56*	-69 to -35	-16	-35 to 6
East Midlands	53	-83*	-88 to -80	-51*	-68 to -33
West Midlands	53	26	-58 to 152	87*	0 to 217
North West	35	16	-15 to 153	-11	-34 to 40
Yorkshire and Humber	70	-35	-66 to 43	-6	-31 to 28
North East	26	-37	-87 to 297	23	-64 to 82

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.





#### 4.14 Feral Cat *Felis catus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	756	-10*	-17 to -3	-16*	-27 to -4
COUNTRIES					
England	528	-6	-15 to 3	-9	-24 to 5
Wales	24	12	-104 to 74	19	-102 to 196
Scotland	191	-14*	-24 to -5	-21*	-35 to -4

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	756	-18*	-31 to -2	-20*	-34 to -6
COUNTRIES					
England	528	-13	-30 to 3	-20*	-36 to -3
Wales	24	-21	-101 to 125	-46	-101 to 80
Scotland	191	-22	-39 to 1	-15	-35 to 10

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	756	-24*	-36 to -9	-30*	-43 to -15
COUNTRIES					
England	528	-28*	-42 to -12	-34*	-46 to -18
Wales	24	-54	-101 to 97	-59	-101 to 94
Scotland	191	-9	-35 to 26	-17	-45 to 25

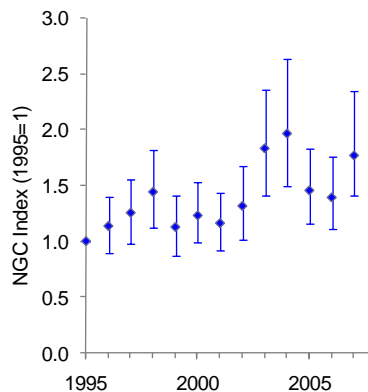
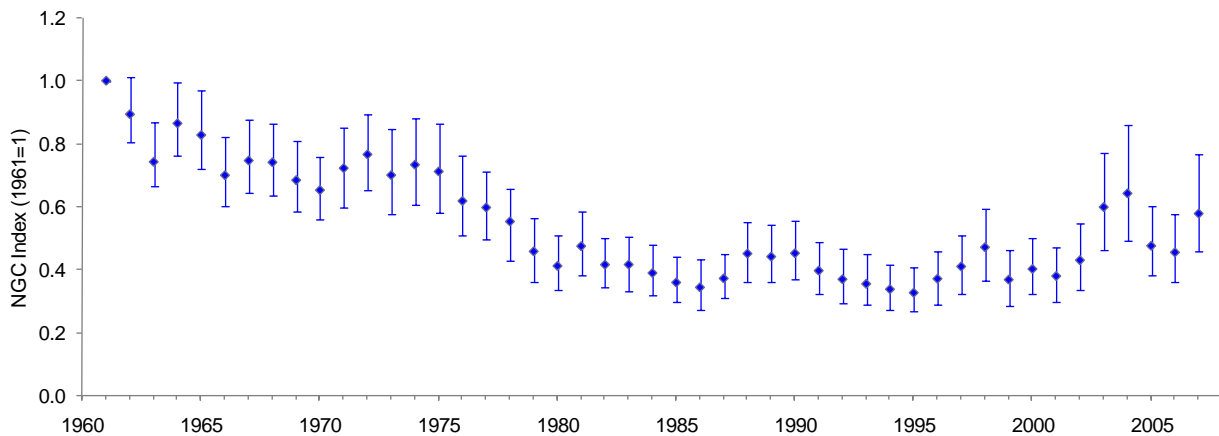
#### 4.15 Weasel *Mustela nivalis*

**Summary:** A significant decrease in the index of bag density across the UK between 1961 and 2007, but a significant increase since 1982. Regionally, the long-term decrease occurred across the lowlands of England, Wales and Scotland. Recent increases are most marked in upland areas.

a) Sample size and % change of Weasel bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	972	-40*	-51 to -26	45*	23 to 70
COUNTRIES					
England	707	-42*	-55 to -26	59*	30 to 101
Wales	29	-91	-95 to 31	-60	-91 to 22
Scotland	235	-10	-55 to 67	28*	0 to 59
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	405	-70*	-78 to -62	-17	-36 to 2
2 - Westerly lowlands (England/Wales)	146	-71*	-85 to -51	-14	-47 to 23
3 - Uplands (England/Wales)	102	-21	-69 to 990	157*	94 to 220
4 - Lowlands (Scotland)	72	-58*	-81 to -1	-34	-66 to 10
5 - Intermediate uplands/islands (Scotland)	31	-77*	-85 to -33	-8	-45 to 94
6 - True uplands (Scotland)	132	56	-14 to 188	62*	17 to 115
GOVERNMENT REGIONS					
South West	106	-85*	-92 to -69	-46*	-69 to -6
South East	133	-81*	-89 to -63	-30	-60 to 23
East of England	149	-60*	-73 to -47	-5	-32 to 23
East Midlands	79	-71*	-82 to -47	2	-31 to 60
West Midlands	65	-69	-92 to 3	-19	-65 to 37
North West	40	22	-63 to 794	101*	23 to 160
Yorkshire and Humber	95	7	-40 to 109	225*	132 to 317
North East	34	-30	-76 to 448	18	-24 to 92

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.15 Weasel *Mustela nivalis*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	972	18*	11 to 25	39*	20 to 59
COUNTRIES					
England	707	24*	14 to 34	52*	28 to 82
Wales	29	-44	-80 to 5	-57	-90 to 22
Scotland	235	10	-1 to 22	24	-1 to 51

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	972	47*	21 to 78	42*	18 to 76
COUNTRIES					
England	707	59*	27 to 111	50*	15 to 108
Wales	29	-64	-93 to 1	-66*	-94 to -14
Scotland	235	31*	3 to 69	29	-1 to 82

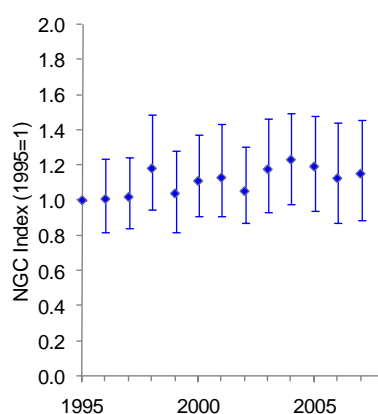
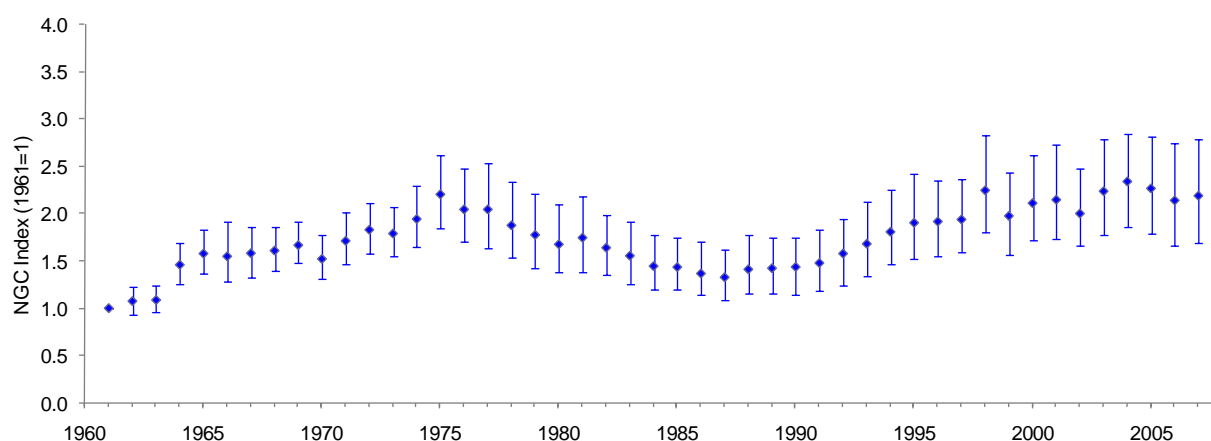
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	972	24*	4 to 55	-4	-18 to 20
COUNTRIES					
England	707	31*	2 to 75	0	-21 to 31
Wales	29	-74*	-93 to -5	-85	-94 to 16
Scotland	235	12	-18 to 60	-9	-33 to 29

#### 4.16 Stoat *Mustela erminea*

**Summary:** A significant increase in the index of bag density across the UK between 1961 and 2007 (although still less than half pre-myxomatosis levels), but with a notable broad-based dip during the 1980s followed by recovery during the 1990s. Since 1995, increases have been significant in upland areas. A persistent decline between 1977 and 2007 is apparent for Wales.

a) Sample size and % change of Stoat bags.	1961-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	1017	112*	71 to 162	25*	11 to 38
COUNTRIES					
England	737	132*	78 to 200	32*	14 to 56
Wales	30	-50	-63 to 197	-38*	-63 to -22
Scotland	238	61*	1 to 193	18	-3 to 39
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	426	51*	6 to 104	-2	-26 to 25
2 - Westerly lowlands (England/Wales)	150	10	-30 to 63	-5	-28 to 18
3 - Uplands (England/Wales)	106	285	-3 to 750	61*	39 to 91
4 - Lowlands (Scotland)	72	49	-32 to 242	-24	-46 to 17
5 - Intermediate uplands/islands (Scotland)	34	-6	-51 to 116	2	-43 to 81
6 - True uplands (Scotland)	132	82	-1 to 312	37*	19 to 62
GOVERNMENT REGIONS					
South West	116	-13	-58 to 79	-15	-46 to 31
South East	136	-28	-60 to 25	-22	-42 to 10
East of England	157	174*	94 to 286	6	-28 to 43
East Midlands	80	63*	23 to 147	14	-19 to 49
West Midlands	67	-25	-53 to 62	-30	-51 to 6
North West	99	251*	45 to 506	81*	49 to 115
Yorkshire and Humber	42	161	-13 to 539	71*	8 to 102
North East	34	304*	22 to 997	-3	-35 to 35

- b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.16 Stoat *Mustela erminea*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1017	5	-1 to 11	17*	6 to 29
COUNTRIES					
England	737	12*	5 to 19	26*	11 to 44
Wales	30	-28*	-44 to -10	-36*	-55 to -20
Scotland	238	-2	-11 to 6	8	-8 to 26

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1017	40*	21 to 56	54*	29 to 75
COUNTRIES					
England	737	43*	20 to 69	51*	24 to 82
Wales	30	-38*	-69 to -22	-31*	-76 to -10
Scotland	238	38*	10 to 68	66*	28 to 115

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	1017	38*	16 to 59	21*	2 to 40
COUNTRIES					
England	737	36*	8 to 67	21	-2 to 53
Wales	30	-27*	-72 to -6	-40*	-72 to -21
Scotland	238	52*	10 to 112	27	-12 to 97

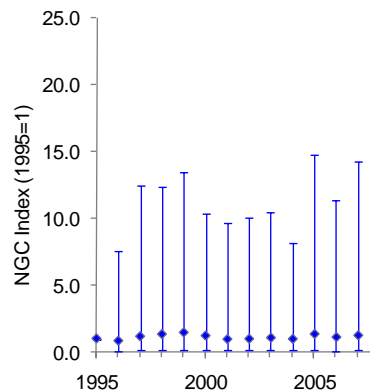
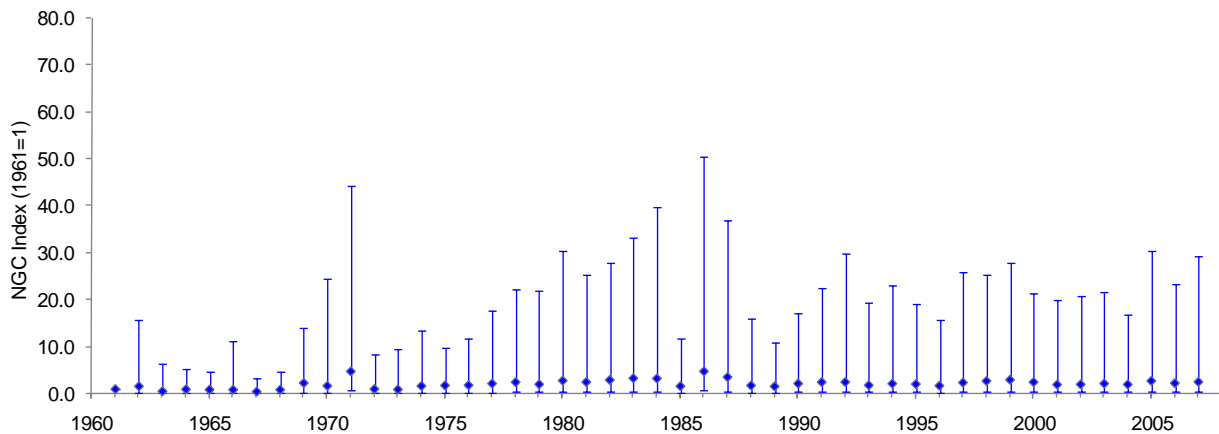
#### 4.17 Polecat *Mustela putorius*

**Summary:** No significant changes at the UK level, but a significant increase in England between 1992 and 2007. Significant declines were detected since 1987 in Wales (small sample size). No sites reported Polecat from Scotland between 1961 and 1978.

a) Sample size and % change of Polecat bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	170	178	-36 to 1409	6	-20 to 43
COUNTRIES					
England	76-07 93	50	-27 to 522	59*	4 to 166
Wales	76-07 19	24	-92 to 96	-8	-73 to 41
Scotland	84-07 48	-19	-64 to 57	-13	-49 to 22
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	76-07 42	138	-33 to 2061	20	-38 to 225
2 - Westerly lowlands (England/Wales)	76-07 29	-3	-58 to 115	16	-44 to 80
3 - Uplands (England/Wales)	76-07 41	116	-52 to 289	70	-12 to 329
4 - Lowlands (Scotland)	Too few				
5 - Intermediate uplands/islands (Scotland)	Too few				
6 - True uplands (Scotland)	95-07 23			-8	-59 to 40
GOVERNMENT REGIONS					
South West	Too few				
South East	Too few				
East of England	Too few				
East Midlands	Too few				
West Midlands	76-07 27	-26	-74 to 236	2	-46 to 204
North West	Too few				
Yorkshire and Humber	Too few				
North East	Too few				

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.17 Polecat *Mustela putorius*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	170	4	-13 to 21	6	-19 to 38
COUNTRIES					
England	94	32	-9 to 83	45	-7 to 129
Wales	19	-18	-62 to 7	-14	-68 to 24
Scotland	48	-11	-55 to 25	-19	-55 to 14

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	170	3	-24 to 44	-11	-36 to 25
COUNTRIES					
England	94	81*	21 to 234	65*	11 to 242
Wales	19	-18	-81 to 17	-48*	-92 to -26
Scotland	48	-25	-63 to 6	-43	-74 to 39

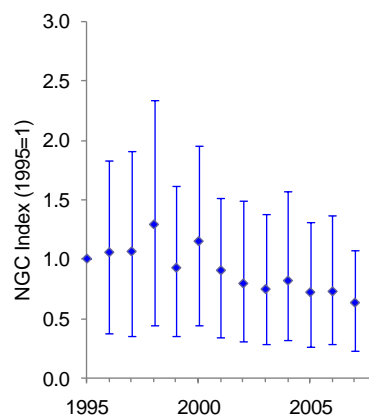
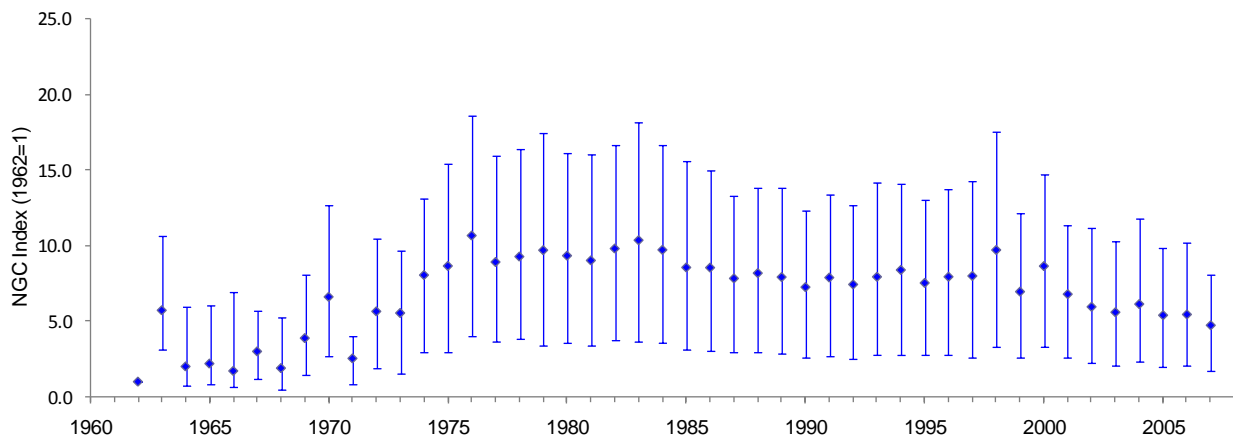
	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	170	-12	-36 to 27	6	-38 to 70
COUNTRIES					
England	94	35	-28 to 196	38	-35 to 322
Wales	19	-41*	-92 to -11	14	-89 to 95
Scotland	48				

#### 4.18 American Mink *Mustela vison*

**Summary:** A significant increase in the index of bag density across the UK between 1962 and 2007 (the increase was rapid between 1962 and 1976), but a significant decrease since 1982 across UK, England and Scotland. Regionally, adequate data for trend analysis were available only from 1976 or from 1980. This revealed a significant decline in bag index for northern England and Scotland excluding the true uplands between 1995 and 2007.

a) Sample size and % change of American Mink bags.	1962-2007			1995-2007	
	Sites	Change	95% CI	Change	95% CI
UNITED KINGDOM	62-07 491	167*	5 to 310	-38*	-47 to -28
COUNTRIES					
England	62-07 281	247*	11 to 442	-24*	-42 to -3
Wales	95-07 11			-32	-82 to 27
Scotland	76-07 189	-62*	-75 to -34	-53*	-62 to -41
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	76-07 135	29	-17 to 113	-12	-49 to 51
2 - Westerly lowlands (England/Wales)	76-07 73	-50	-73 to 5	-30*	-52 to -1
3 - Uplands (England/Wales)	80-07 73	-63*	-79 to -6	-44*	-61 to -22
4 - Lowlands (Scotland)	76-07 58	-70*	-83 to -19	-56*	-69 to -30
5 - Intermediate uplands/islands (Scotland)	80-07 25	-80*	-95 to -17	-59	-73 to 18
6 - True uplands (Scotland)	76-07 106	-49	-76 to 74	-49*	-63 to -31
GOVERNMENT REGIONS					
South West	Too few				
South East	76-07 42	-33	-72 to 45	-51	-79 to 42
East of England	95-07 37			-13	-51 to 108
East Midlands	95-07 15			63	-58 to 236
West Midlands	80-07 23	137	-6 to 591	-8	-38 to 56
North West	80-07 25	-71	-84 to 1	8	-27 to 196
Yorkshire and Humber	80-07 47	-29	-71 to 41	-47*	-66 to -23
North East	95-07 15			-40	-69 to 1

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.





#### 4.18 American Mink *Mustela vison*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	491	-26*	-32 to -17	-37*	-45 to -27
COUNTRIES					
England	281	-17*	-28 to -4	-24*	-40 to -5
Wales	11	-6	-47 to 38	-34	-74 to 17
Scotland	189	-37*	-48 to -22	-51*	-60 to -38

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	491	-39*	-48 to -28	-43*	-53 to -31
COUNTRIES					
England	281	-22	-42 to 0	-24	-43 to 1
Wales	11				
Scotland	189	-53*	-63 to -40	-58*	-67 to -42

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	491	-48*	-58 to -34	-44*	-55 to -28
COUNTRIES					
England	281	-27*	-46 to -3	-22	-44 to 2
Wales	11				
Scotland	189	-66*	-74 to -52	-64*	-75 to -41

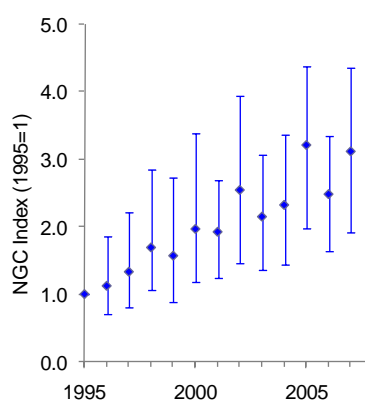
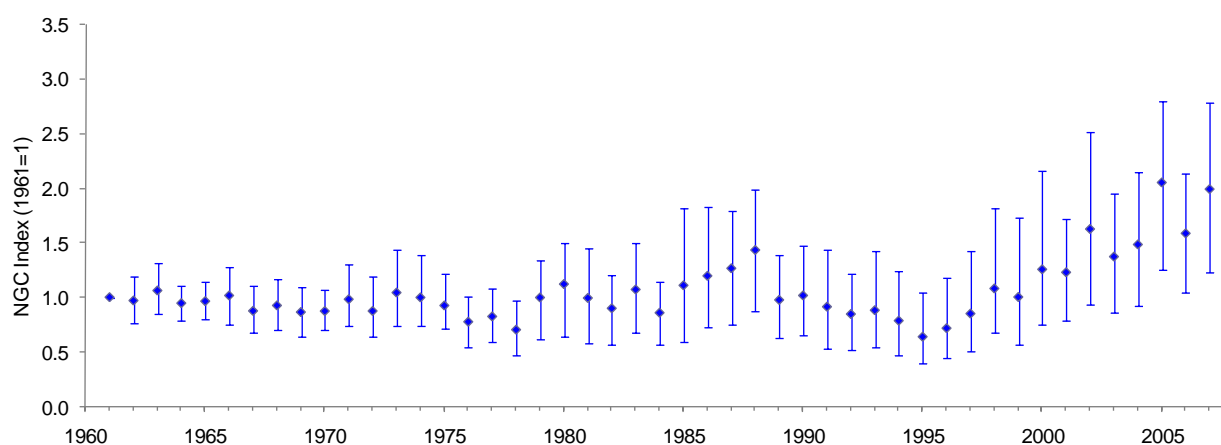
#### 4.19 Brown Rat *Rattus norvegicus*

**Summary:** Broad stability in the index of bag density across the UK between 1961 and 1990, but a significant increase in UK and England overall and since 1982 because of a doubling of the index since 1995. Numbers declined in Wales from the 1960s to the 1980s. Regionally, there have been recent significant increases in all parts of England except the south

a) Sample size and % change of Brown Rat bags.

	Sites	1961-2007		1995-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	867	89*	18 to 148	110*	44 to 168
COUNTRIES					
England	657	97*	38 to 158	128*	61 to 215
Wales	31	-87*	-96 to -64	-32	-71 to 12
Scotland	169	116	-30 to 527	5	-31 to 85
ENVIRONMENTAL ZONES					
1 - Easterly lowlands (England/Wales)	375	98*	35 to 168	128*	51 to 226
2 - Westerly lowlands (England/Wales)	146	38	-53 to 151	63	-23 to 210
3 - Uplands (England/Wales)	88			205*	93 to 373
4 - Lowlands (Scotland)	58	154	-39 to 1134	-30	-57 to 42
5 - Intermediate uplands/islands (Scotland)	32	1	-37 to 34	39	-11 to 70
6 - True uplands (Scotland)	79	12	-58 to 155	51	-23 to 231
GOVERNMENT REGIONS					
South West	112	50	-60 to 194	21	-24 to 86
South East	122	281*	71 to 596	42	-12 to 104
East of England	135	62	-20 to 127	210*	40 to 364
East Midlands	73	-80*	-94 to -11	109*	2 to 341
West Midlands	58	168	-28 to 431	419*	32 to 711
North West	38	318	-52 to 1303	86*	33 to 446
Yorkshire and Humber	87	21	-44 to 137	237*	100 to 395
North East	28	15	-90 to 622	154*	18 to 309

b) Change in relative bag density in the UK from 1961 to 2007 and from 1995 to 2007, respectively. Error bars represent 95% confidence intervals.



#### 4.19 Brown Rat *Rattus norvegicus*

- c) Percentage changes (with confidence limits) for the most recent 5-year, 10-year, 15-year, 20-year, 25-year and 30-year intervals at the UK level and for each of England, Wales and Scotland, where there are sufficient data.

	Sites	2002-2007		1997-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	867	38*	11 to 56	95*	35 to 149
COUNTRIES					
England	657	43*	16 to 70	110*	47 to 192
Wales	31	-26	-55 to 1	-26	-68 to 15
Scotland	169	1	-19 to 32	5	-28 to 72

	Sites	1992-2007		1987-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	867	106*	49 to 150	82*	41 to 121
COUNTRIES					
England	657	122*	68 to 202	90*	52 to 162
Wales	31	-43	-78 to 11	-61*	-87 to -4
Scotland	169	5	-34 to 106	18	-32 to 165

	Sites	1982-2007		1977-2007	
		Change	95% CI	Change	95% CI
UNITED KINGDOM	867	88*	51 to 130	105*	56 to 149
COUNTRIES					
England	657	96*	57 to 171	117*	69 to 184
Wales	31	-70*	-90 to -29	-77*	-93 to -46
Scotland	169	52	-21 to 189	61	-20 to 221

## 5 Temporal changes in UK geographical distribution for Hedgehog, Fox, Feral Cat and Brown Rat

Data were extracted for 1122 estates submitting bag records between 1960 and 1999 inclusive. The spatial and temporal changes in mammal bag density were examined by calculating the mean bag density for each vice-county and each of the ten decades 1960-69, 1970-79, 1980-89 and 1990-99. The mean was a weighted average of all corresponding annual density values, using annual estate area as the weight. The results of the analysis are reproduced on four maps, each corresponding to a decade. Within each map, the vice-counties are shaded according to their mean bag density in that decade; the palest shade represents the lowest density, the darkest one the highest density (on a logarithmic scale).

### 5.1 Hedgehog *Erinaceus europaeus*

The Hedgehog is found throughout the UK, with a preference for substantial hedgerow or wooded areas that provide cover for nesting and where the habitat contains a good supply of invertebrate food. The maps (Figure 5.1) indicate decreases in the bag densities across England and Scotland between 1960 and 1999. This reduction may be due to changes in arable farming such as tillage and loss of hedgerow cover, but also to an increase and spread in numbers of Badgers *Meles meles*, a major predator of Hedgehogs. Hedgehogs are usually caught by mistake in traps set for small mustelids, and a reduction in trapping effort over time would also lead to a temporal reduction in bag density

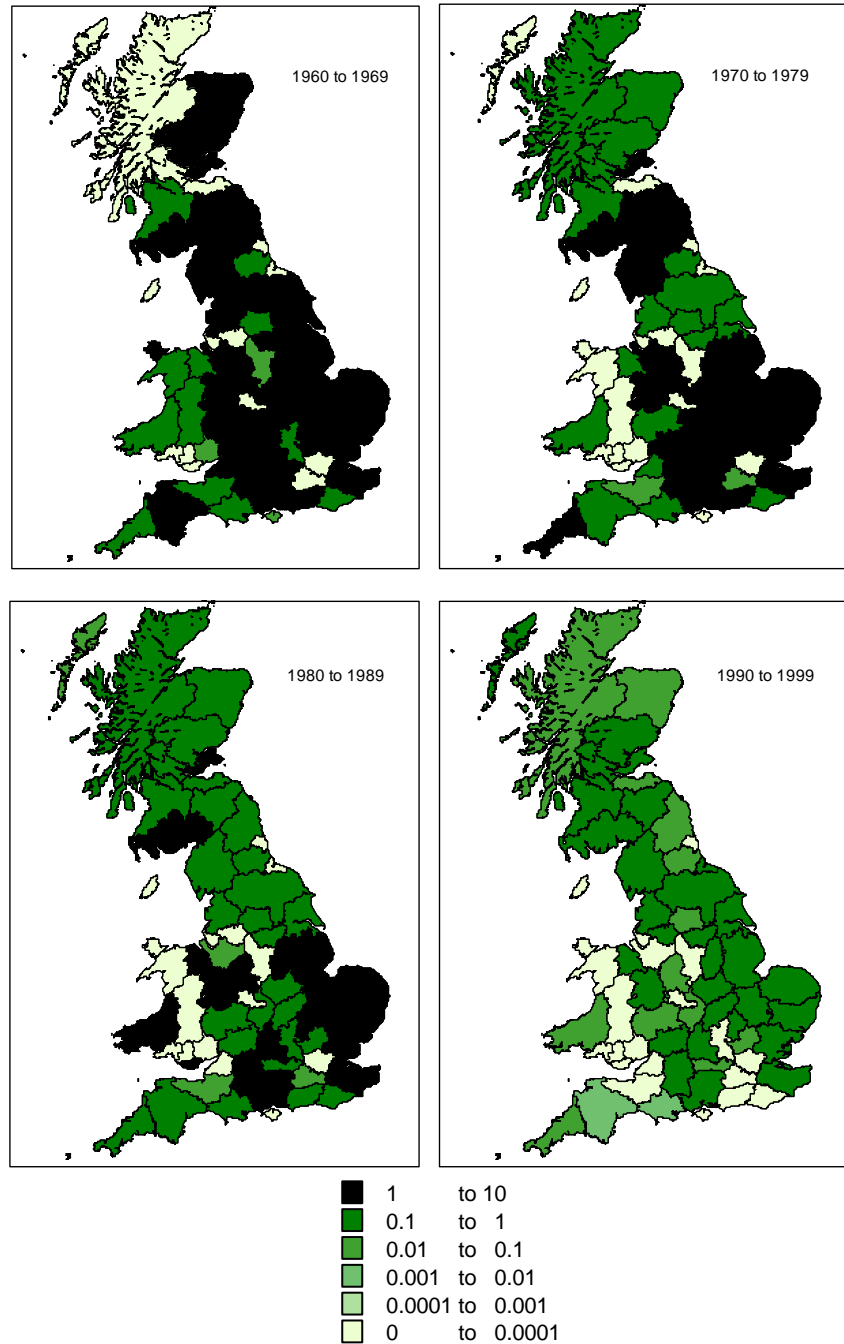


Figure 5.1. Hedgehog bag density (number shot per 100 ha) synoptically by county and by decade from 1960 to 1999.

## 5.2 Fox *Vulpes Vulpes*

The Fox is widespread and numerous across the UK. The maps (Figure 5.2) reflect an increase in Fox between 1960 and 1999. Originally the fox was largely absent from moorland areas, but the gaps in distribution have filled over time and bag densities increased throughout England and Wales. The increase is possibly due to increasing numbers in suburban districts spreading into rural areas. There have also been changes in fox culling methods over the 40-year period that may have influenced bag densities, specifically the banning of Cymag poison in the mid-1980s and the increased use of night shooting from the early 1980s.

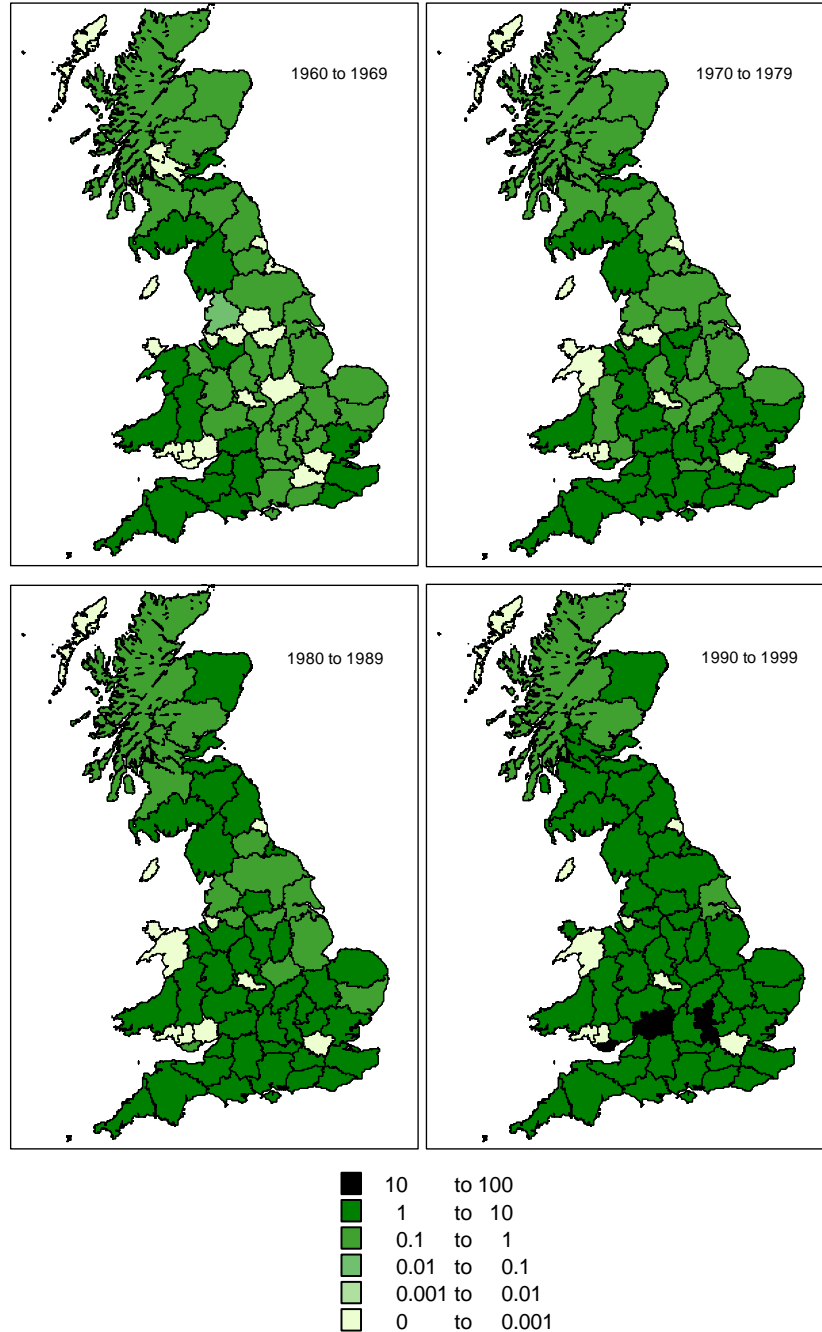


Figure 5.2. Fox bag density (number shot per 100 ha) synoptically by county and by decade from 1960 to 1999.

### 5.3 Feral Cat *Felis catus*

The feral cat derives from unwanted or lost domestic cats, indeed one in five of the UK's total cat population of more than six million is estimated to be feral. Cross-breeding poses a threat to native Wildcats through hybridisation as does the spread of diseases such as feline leukaemia virus. The Feral Cat occurs throughout the UK. The maps below (Figure 5.3), shows a decline in Feral Cat bags between 1960 and 1999, mostly in Wales and the southern half of England.

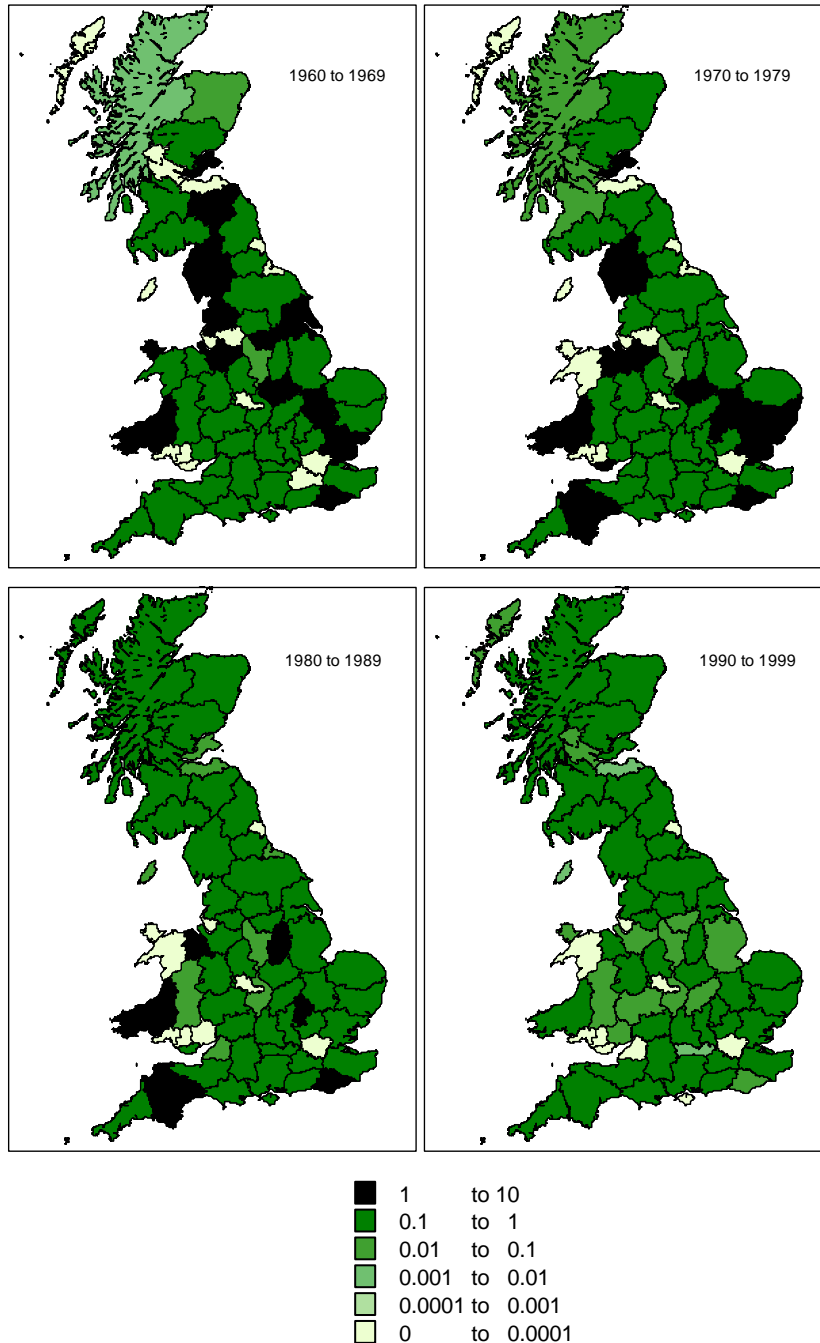


Figure 5.3. Feral Cat bag density (number shot per 100 ha) synoptically by county and by decade from 1960 to 1999.

#### 5.4 Brown Rat *Rattus norvegicus*

The Brown Rat became established in the UK in the middle of the 18<sup>th</sup> century, having its origin in Asia. The Brown Rat flourishes in farm environments and consequently is more frequent in arable situations than in upland or grassland areas. The maps below (Figure 5.4) show rather patchy changes in numbers of Brown Rat bags between 1961 and 1999. There is little overall change except in northern Scotland and Wales, where the range has expanded. The last map includes only five years of the 1995-2007 period of increase, so its influence is not readily apparent here.

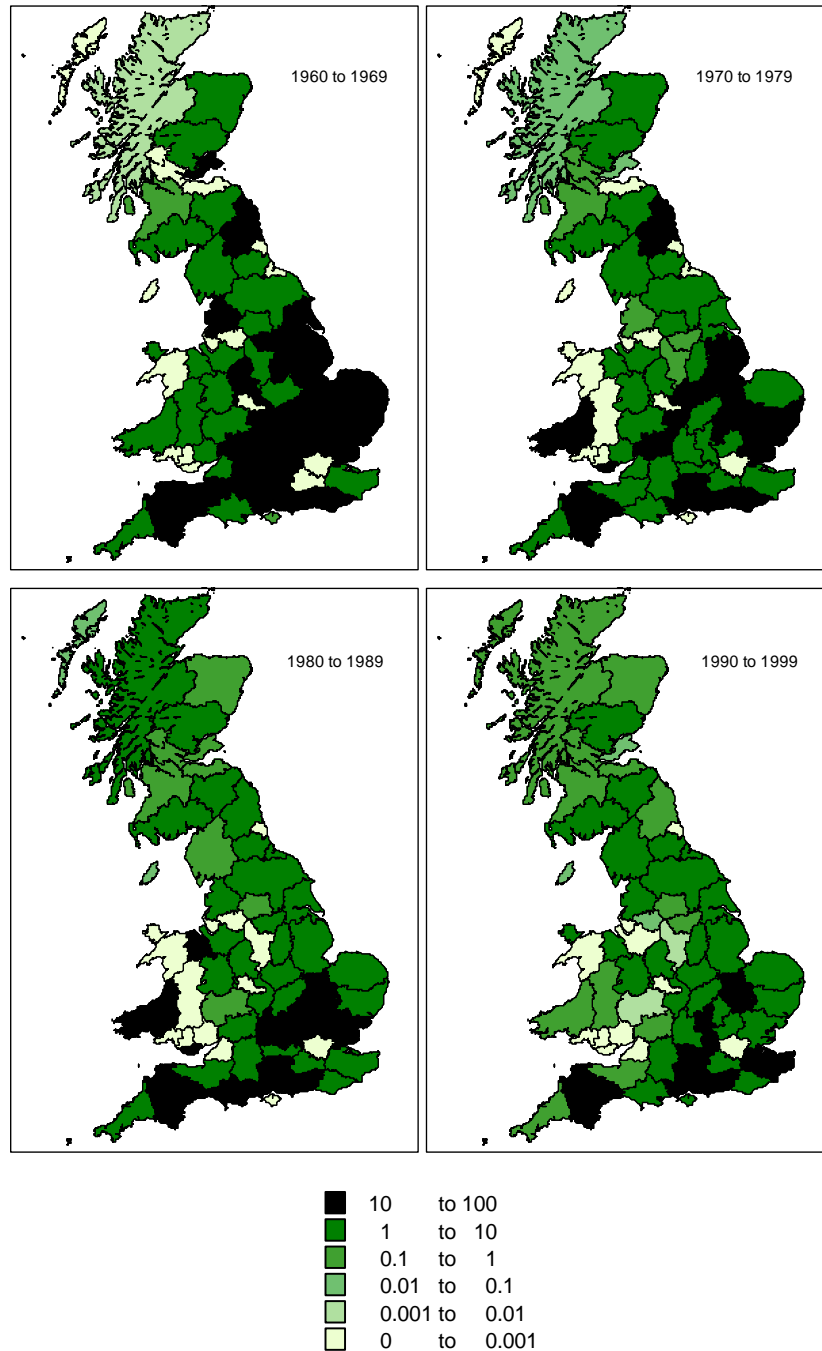


Figure 5.4. Brown Rat bag density (number shot per 100 ha) synoptically by county and by decade from 1960 to 1999.



## 6 Discussion

The question of whether species are increasing or declining in abundance is of central importance in species conservation and management. Surveillance or monitoring programmes should be capable of identifying long-term trends, and of distinguishing between long-term trends and short-term fluctuations that are the result of natural between-year variation in breeding success and mortality. In the case of bag data, use of a GLM framework incorporating the estimation of a set of site-specific factors in addition to year-specific factors allows average bags to vary between sites (shoots); annual variation is then modelled in a parallel fashion across locations on a logarithmic scale. In practice it is likely that annual trends differ between estates, and this variation is captured within the 95% confidence limits of the annual indices through the bootstrapping procedure.

Trends derived from bags are, however, unusual because the data analysed represent numbers of animals killed rather counts of live animals. It is important to understand this distinction, because there are potential biases associated with bag data that do not occur with count data, and that could obscure an underlying trend or create the appearance of a change in abundance where none has occurred. We review below the main potential sources of bias that need to be borne in mind when interpreting the trends presented in this report.

The most important one is the fact that the number of animals killed is a function both of the abundance of animals on the ground and of the amount of effort invested in culling them. These two factors are therefore confounded in bag data, so it is not necessarily true that the number of animals killed is a reliable index of population density. For game animals, there will be changes on an annual basis in the number of shooting days per site and number of shooters per day that will cause effort to vary over time. For predatory species, the number of gamekeepers per site, number of traps set, type of trap and duration of trapping will all influence effort and contribute to variation in numbers of animals killed. In practice, it appears that much of this variation adds noise to an underlying trend that reflects population density (Whitlock et al. 2003). The comparisons with trends obtained from other surveys such as the BBS, for species in common, are one way in which it is possible to be alerted to the possible onset of bias caused by changes in effort.

Legislation, which can vary in its implementation on a country basis, often initiates changes in shooting and culling practices. For instance, changes in legislation have progressively outlawed a number of Fox control methods over the last 100 years, primarily because they have been judged inhumane. Variability in pest control methods over time resulting from either changing legislation or improvements in efficiency influences effort, and hence bags, over varying timescales. Developments in predator control practice can also effect a change in the seasonality of culling. In recent decades, there has been a shift away from culling Foxes in the spring and summer using snares and terriers to autumn and winter culling by lamping with a rifle. This is likely to affect Fox bags because the culling period now coincides with an annual peak in Fox density and dispersal before high natural mortality occurs over the winter (Reynolds 2000). Legislation may also affect the reliability of NGC data for species afforded statutory protection, for example protection of the Wildcat and partial protection of the Hedgehog under the 1981 Wildlife and Countryside Act, by causing a systematic decrease in the numbers recorded on predator sheets.

Even if the direction and magnitude of changes in effort were known, another factor that may lead to exaggeration of trends is the possibility that the relationship between yield and effort may not be linear but density-dependent, i.e. effort may be related to abundance. This would occur if less effort is invested in culling in years of low density. This would lead to proportionally fewer individuals of a species being killed as numbers on the ground decline, and consequently a steeper decline in bags than in actual density. Hudson (1992) noted that bags of Red Grouse *Lagopus Lagopus* tended to under-emphasize the extent of any decline in grouse numbers, because estates where grouse stocks fell to a level where grouse shooting ceased in any one year may not provide bag records. For predators on shooting estates, less effort may also be invested in control if abundance is perceived to be lower in a particular year. However, predator control tends to be prophylactic, i.e. independent of predator density in a particular year. At high predator density, trap saturation may also be possible, especially for single-catch traps, although it is unlikely given the legislative requirement for daily checking of traps by keepers and typically low trapping rates.

Culling can itself be the cause of changes in the abundance of a species, which poses a problem because the method of data collection then has a direct impact on the quantity it intends to measure. It is impossible to assess the implications of this for population dynamics without some *a priori* knowledge of population size and demography. The proportion of a population removed by hunting may be considerable: Hutchings & Harris (1996) estimated that around 60% of a local Brown Hare population may be removed by February culls. Hunting can also alter the age and sex structure of a population: this is particularly well documented in the fisheries literature, where gear selectivity has resulted in lower mean size and mean age of sexual maturity (Cook et al. 1997, O'Brien 1999). It is, however, unlikely that such extreme effects would be observed in mammalian species in the UK, as harvesting pressure is generally lower than that of commercial fisheries. It is possible that hunting could affect the sex structure of mammal populations. For example, the catchability of mustelids using tunnel traps is dependent on their mass, which varies according to gender: females are the lighter sex and may not spring a trap unless it is lightly set (Anon. 1994).

More generally, there are two other issues that need to be taken into consideration when interpreting the trends arising from analysis of NGC bag data. The first is that for some pest species, it is impossible to record the numbers killed over a year accurately because mortality is unobserved and hence unquantifiable. In such cases numbers recorded on NGC forms are either best guesses or observed (i.e. minimum) numbers. This applies especially to Brown Rat and Grey Squirrel, for which poisoning is legal.

The second issue is representativeness. The sites contributing records to the NGC do so on a voluntary basis, and cannot be assumed to represent a random sample of shoots across the UK. Even if they were, shoots would also need to be typical of the British countryside in general. Landowners participating in field sports such as fox hunting and gamebird shooting were found to maintain more established woodland and plant more new woodland and hedgerows than non-participants (Oldfield et al. 2003), and in the uplands, moors managed for grouse shooting retained considerably more heather than non-managed moors (Robertson et al. 2001). Owing to these management practices, estates are likely to be atypical with respect to the densities of game and non-game species they support, as they offer good-quality habitat in terms of food resources, shelter and breeding requirements, but also carry out predator control. Nevertheless, any bias induced by non-randomness is probably reduced by the fact that the same sites contribute records over many years, and results from the same site are directly comparable between years. Toms et al. (1999) considered that using the same sites in consecutive surveys may avoid bias if there is a subjective element in the choice of sampling sites and this subjective element does not remain constant over time. They also emphasized the powerful advantage of historical continuity in improving the precision of estimates of change as it removes the component of error variance associated with site. The NGC thus benefits greatly from its historical continuity, which is reinforced by constant attempts to obtain historical records from new participants.

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